# ..LOGY OF THE WALTERSBURG QUADRANGLE POPE COUNTY, ILLINOIS

C. Pius Weibel • W. John Nelson
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Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY

BULLETIN 98 1993

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**Cover photo** Pounds Sandstone Member of the Caseyville Formation southwest of Rock in Pope County (photo by C. Pius Weibel)

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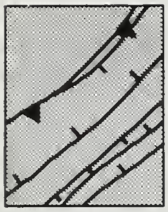
## ACKNOWLEDGMENTS


The U.S. Geological Survey (USGS), under the Cooperative Geological Mapping Program (COGEOMAP), provided significant support for the research reported in this publication. Annual grants from 1985 through 1991 provided partial funding for the project, Geologic Mapping Along the Southern Closure of the Illinois Basin. The geologic mapping of sixteen 7.5-minute quadrangles and the publication of quadrangle maps (1:24,000 scale) and the accompanying reports were the objectives of this project.

Joseph A. Devera (ISGS) mapped a part of the bedrock in the northwest corner of the quadrangle. Russel Peppers (ISGS) analyzed the palynology of the coals and provided biostratigraphic data. James W. Baxter (ISGS), Russell J. Jacobson (ISGS), and Charles M. Rice (USGS) carefully critiqued the geologic map. Heinz H. Damberger, as project leader of COGEOMAP, provided continuous encouragement and advice. Finally, we are grateful to the private landowners who allowed us to enter their property to examine outcrops and especially to those who allowed us to drill the stratigraphic tests.



## ABSTRACT


Bedrock outcrops of the Waltersburg 7.5-Minute Quadrangle in Pope County, southeastern Illinois, consist mainly of upper Mississippian (Chesterian) and lower Pennsylvanian (Morrowan to early Atokan) strata. The Chesterian strata consist of fine grained clastic rocks and limestones of the upper Pope Group and include the Golconda Formation up to the Kinkaid Limestone. The Pennsylvanian strata consist of the sandstone-dominated Caseyville and Tradewater Formations. Upper Valmeyeran limestones occur within thin fault slices. A petroleum exploration well reached the Devonian Lingle Limestone, the oldest known bedrock in the Waltersburg Quadrangle. The well also drilled through the New Albany Shale, several lower (Kinderhookian) and middle (Valmeyeran) Mississippian formations, and the lowermost Pope Group.

Extensive Pleistocene (Illinoian and Wisconsinan) deposits cover much of the bedrock. The uplands are covered by bedrock residuum (Oak formation) and loess (Roxana and Peoria Silts): the slopes by colluvium (Peyton Formation), and the valleys by lacustrine (Equality Formation) and alluvial deposits (Cahokia Alluvium).

Four northeast-trending parallel fault zones transect the quadrangle. These post-Pennsylvanian faults are part of a regional northeast-trending fault system in the west part of the Illinois–Kentucky Fluorspar District. The Lusk Creek Fault Zone bounds the northwest side of the Dixon Springs Graben, and the Hobbs Creek Fault Zone bounds the southeast side. The Raum Fault Zone parallels the Lusk Creek and Hobbs Creek Fault Zones and bisects the Dixon Springs Graben. The Flick Branch Fault (new name) occurs southeast of the Hobbs Creek Fault Zone. The geologic structure of the quadrangle is the result of several episodes of deformation. Rifting during the Cambrian Period resulted in normal faulting along the Lusk Creek Fault. Additional normal faulting may have occurred during the Early Pennsylvanian. A post-Atokan compressional episode resulted in reverse faulting along the Lusk Creek and Raum Fault Zones (which merge at depth). Final deformation was an extensional episode, during which normal faulting occurred along the same fault planes or along adjacent fault planes. Narrow slices of rock, which are older or younger than the strata on adjacent sides of the fault zones, occur between these two fault planes.

The principal mineral resources in the quadrangle are sandstone for construction and limestone for construction and agriculture. Small shallow deposits of fluorspar and associated minerals have been mined locally, suggesting that unknown deeper resources may occur along faults in the quadrangle. The amount of coal resources is small; coal beds are too thin and discontinuous to exploit economically, although a few small coal mines have operated in the past. Three exploration wells for oil and gas have been drilled and all were abandoned. Reservoir characteristics of buried, pre-upper Mississippian strata are unknown within the quadrangle.

Laterally extensive aquifers and economic deposits of sand and gravel aggregate are not present among the surficial materials. The geology of the area is unsuitable for landfills unless measures are taken to prevent migration of leachate. Properly designed construction projects can be sited throughout most of the quadrangle. The study area lies in a zone of high seismicity; structures built in valley bottoms are more at risk than structures having foundations in bedrock.

# INTRODUCTION

This study was conducted as part of the ongoing Cooperative Geologic Mapping Program (COGEOMAP), which is jointly supported by the United States Geological Survey (USGS) and the Illinois State Geological Survey (ISGS). This report is a companion to the Waltersburg Geologic Quadrangle of Weibel et al. (1992) and is one of a series of ISGS maps and reports on the geology of southern Illinois (fig. 1). This geologic mapping will increase our understanding of the region and provide data useful for land use planning, geologic hazard assessment, and mineral resource and groundwater exploration.

## Location

The Waltersburg 7.5-Minute Quadrangle is in extreme southeastern Illinois between latitudes 37°22'30" and 37°30'N and longitudes 88°30' and 88°37'30"W. Highway access to the area is provided by Illinois route 145 from Eddyville to Glendale in the northwest quarter, Illinois 146 from Dixon Springs to Golconda in the west half along the south edge, and the paved county road from Eddyville to Golconda in the east two-thirds of the quadrangle (fig. 2). The only incorporated village in the quadrangle is Eddyville, which straddles the north edge. Only a few buildings are present in the unincorporated villages of Raum, Rising Sun, Rock, and Waltersburg. About two-thirds of the land in the quadrangle is privately owned, and most of the rest is part of the Shawnee National Forest.

## Physiography

The quadrangle is within the Shawnee Hills Section (Leighton et al. 1948) of the Interior Low Plateaus Province (Fenneman 1938), an area that contains some of the most rugged topography in Illinois. The area consists of a dissected plateau, and within the quadrangle, the higher ridges are generally composed of Pennsylvanian sandstone, particularly of the Caseyville Formation. Streams eroding the Pennsylvanian and thick Mississippian sandstones have formed narrow valleys or canyons, whereas those eroding Mississippian limestones, shales, and thin sandstones have formed broad, open valleys. Thicker Mississippian limestones are locally characterized by a karst topography and drainage system.

The highest elevations in the quadrangle are more than 780 feet above mean sea level (msl) and are in the S 1/2 SE, Section 26, T12S, R6E; SE SW, Section 26, T12S, R6E; and E 1/2 SE, Section 11, T12S, R6E. Upland exposures of Mississippian strata are generally above 500 feet msl; exposures of Pennsylvanian strata are generally above 600 feet msl. Bottomlands are generally between 350 and 400 feet msl. The lowest elevation is less than 320 feet msl in the southeast corner of the quadrangle along Lusk Creek. Total relief is 460 feet, although local relief is typically only 150 to 300 feet.

Lusk Creek, flowing from the north edge to the southeast corner of the quadrangle, drains most of the quadrangle and joins the Ohio River

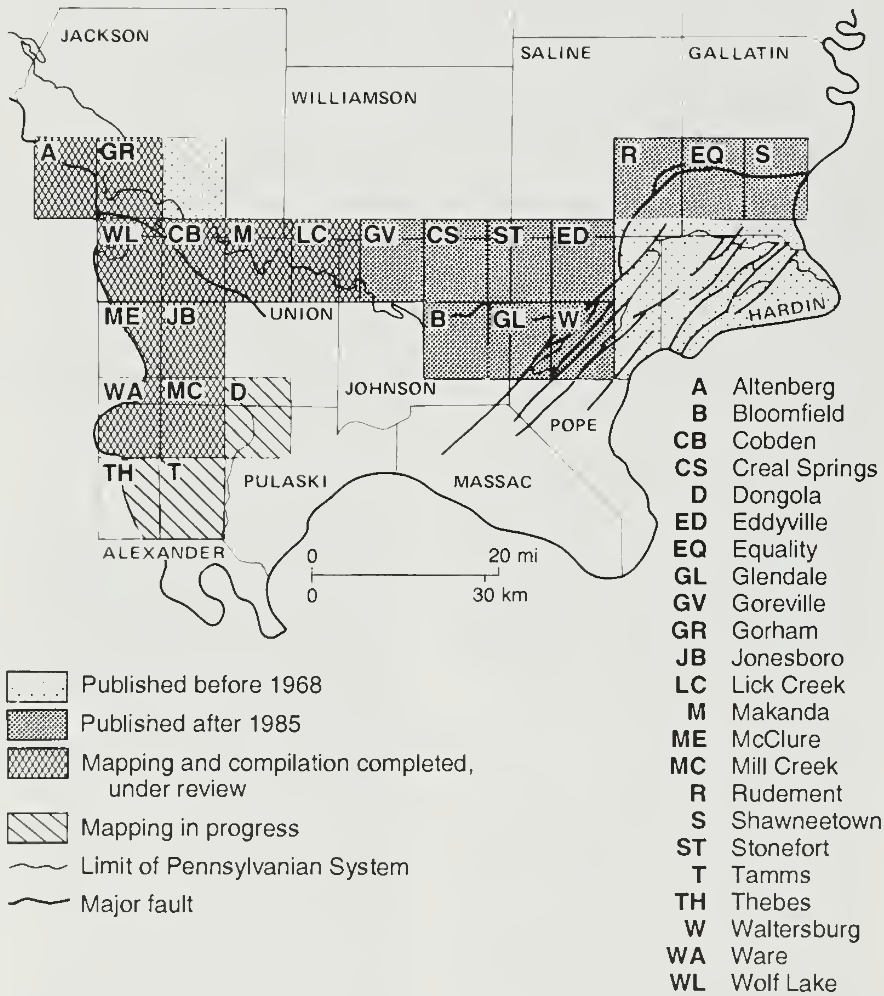



**Figure 1** Cooperative Geological Mapping Program (COGEOMAP), January 1993.

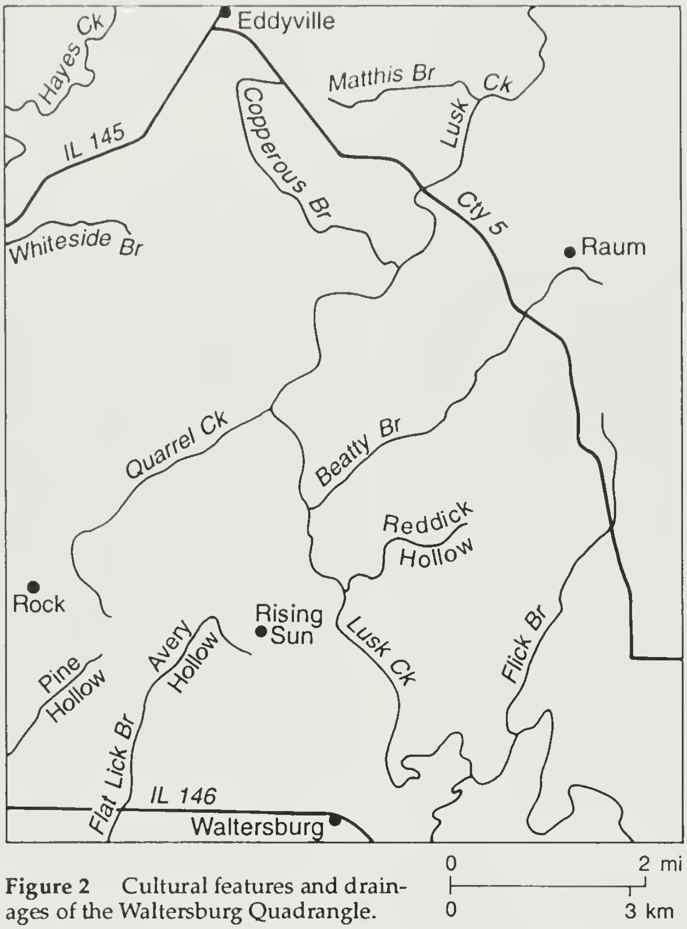



**Figure 2** Cultural features and drainages of the Waltersburg Quadrangle.

at Golconda, Illinois. Abrupt angular bends in the valley indicate that bedrock structure controls the course of Lusk Creek. A divide east of the creek extends from the northeast corner of the quadrangle southwest to Raum, and thence south-southeast to the southeast corner. Streams east of the divide flow into Big Grand Pierre Creek. A divide west of Lusk Creek separates Lusk Creek drainage from Bay Creek drainage. The valley of the Flat Lick Branch of Bay Creek occupies the extreme southwestern part of the quadrangle. Hayes Creek, in the northwest quarter, is part of the Bay Creek drainage. All three drainages flow into the Ohio River east or southeast of the quadrangle.

## Geologic Setting

The quadrangle is in the southernmost part of the Illinois Basin and in the western part of the Illinois–Kentucky Fluorspar District (fig. 3). Outcropping bedrock formations range from upper Mississippian (middle Chesterian) to lower Pennsylvanian (Atokan). The quadrangle lies south of the Illinoian glacial boundary as defined by Willman and Frye (1980). Unconsolidated material consists of Quaternary alluvium, bedrock residuum, colluvium, lacustrine sediments, loess, and talus. Strata generally dip gently to the northwest toward the Fairfield Basin part of the Illinois Basin. The quadrangle is transected by northeast-trending faults that are part of the Fluorspar Area Fault Complex.

## Previous Studies

The first geological reconnaissance of the study area was accomplished by geologists of the Geological Survey of Illinois under the leadership of Amos Worthen. Engelmann (1866a) described the areal geology north of Bay Creek in Pope County. The report remains useful because it contains many outcrop descriptions, although a geologic map was not included and the descriptions of lithologic subdivisions were cursory. The first systematic areal report on the stratigraphy, structure, ore deposits, and mines of the area included a generalized geological map (Bain 1905). The Waltersburg Quadrangle is depicted on this map, but Paleozoic rocks were mapped only as undifferentiated Mississippian or Pennsylvanian strata. S. Weller (1920a) described the geology of Hardin County and included detailed descriptions of upper Mississippian and lower Pennsylvanian strata. His geologic map included a part of Pope County just east of the Waltersburg Quadrangle, but only the geology of Hardin County was described. S. Weller (1920b) referred to localities within the Waltersburg Quadrangle in his report on the upper Mississippian strata of southern Illinois.

Bastin (1931) reported the types and origins of ore deposits and their mineralogical compositions in Hardin and eastern Pope County. He also discussed mining and milling methods. A preliminary geologic map of the Brownfield 15-Minute Quadrangle by S. Weller and Krey (1939) included the Waltersburg Quadrangle. The map was compiled from unpublished manuscripts. Although preliminary, S. Weller and Krey's geologic map was the most detailed of the quadrangle prior to this study. The report on the fluorspar deposits of Illinois by J. Weller et al. (1952) is a compilation of surveys undertaken in response to increased demand by war-related industries. The geologic map was largely adapted from S. Weller (1920a). The bulk of the report described exploration, mining, and milling methods, as well as the geology of the mining districts.

As part of a program to remap the Illinois portion of the fluorspar mining district, Baxter et al. (1967) mapped and described the areal geology of two 7.5-minute quadrangles adjacent to the Waltersburg: the Herod to the northeast and the Shetlerville to the east. Hook (1974) compiled a generalized geologic map that included the Waltersburg Quadrangle; he also described the structural geology of the Illinois–Kentucky Mining District. Pinckney (1976) summarized the geologic setting and mineral deposits of the Illinois–Kentucky mining district. His geologic map included the Waltersburg Quadrangle, but it also was compiled from previous publications. Nelson and Lumm (1990a, b) mapped the geology of the adjacent quadrangles to the north (Eddyville) and to the northwest (Stonefort). The geology was described in

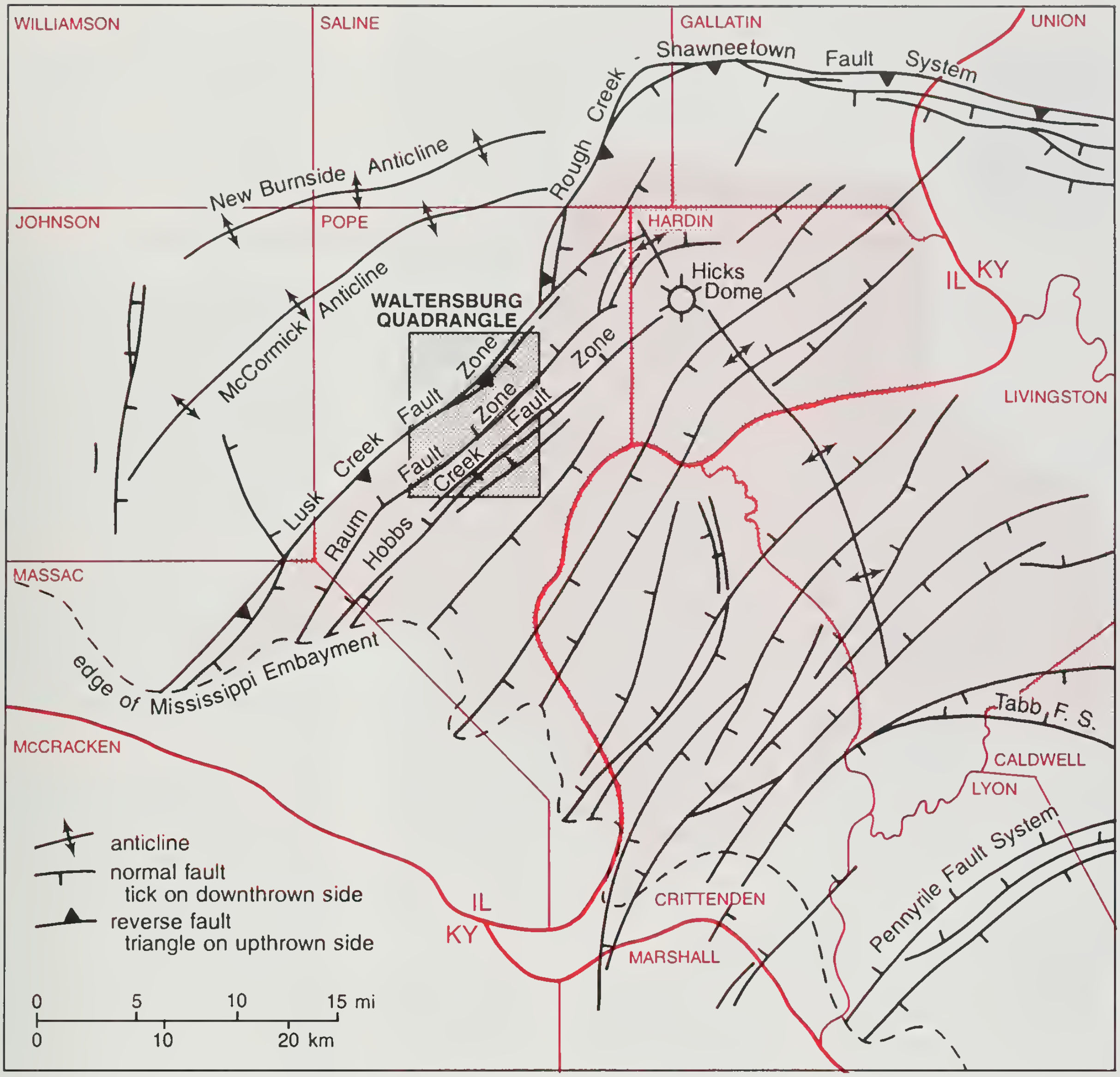



**Figure 3** Map showing major structural features and the Illinois–Kentucky Fluorspar District (light red) in the vicinity of the Waltersburg Quadrangle (gray).

Nelson et al. (1991). The Glendale Quadrangle, which borders on the west of the Waltersburg Quadrangle, was also mapped as part of COGEOMAP (Devera 1991).

## Method of Study

Bedrock mapping for this study began in the fall of 1985 and was completed in the fall of 1989. Outcrop data were recorded in field notes and on topographic maps. Field notes were typed and are available for examination in the ISGS library. Subsurface data consist of geophysical logs and cores from three stratigraphic tests drilled as part of COGEOMAP and logs and samples from petroleum and mineral exploration wells. The logs and cores are available for examination in the ISGS Geological Records and Samples Library. The methods used for mapping of the surficial geology are described in the section on surficial geology.

# BEDROCK STRATIGRAPHY

The oldest known bedrock stratum in the Waltersburg Quadrangle is the Devonian Lingle Limestone. The youngest bedrock strata belong to the Pennsylvanian Tradewater Formation. The upper Mississippian Golconda Formation is the oldest outcropping formation, except for small outcrops that may include upper Valmeyeran rocks.

The Austin Roberts No. 1 Well penetrated 462 feet of Lingle Limestone (well locations are given in table 1). Core descriptions indicate the Lingle is a tan to light gray, fine grained limestone that contains chert.

The Lingle is overlain by the New Albany Shale. The middle to upper Devonian Blocher Shale Member of the New Albany is 57 feet thick and consists of a silty, calcareous shale. The upper Devonian Sweetland Creek Shale and Grassy Creek Shale Members are 132 and 124 feet thick, respectively. Both members are characterized by black shale, but the older Sweetland Creek also contains gray shale. These members are overlain by the upper Devonian Saverton Shale Member, which is not differentiated from the younger Hannibal Shale Member on geophysical logs of the Austin Roberts No. 1 Well.

## MISSISSIPPIAN SYSTEM

The lowermost Mississippian (Kinderhookian) strata in the quadrangle is the Hannibal, the uppermost member of the New Albany Shale. The undifferentiated Saverton and Hannibal Shales are 11 feet thick. The Kinderhookian Chouteau Limestone, a light gray, fine grained limestone, is only 6 feet thick in the Austin Roberts No. 1 Well. The overlying middle Mississippian (Valmeyeran) strata consist of the following formations, in ascending order: Springville Shale, Fort Payne Formation, Ullin Limestone, Salem Limestone, St. Louis Limestone, and Ste. Genevieve Limestone. The total thickness of Valmeyeran strata is 1,915 feet. Overlying the Valmeyeran is the upper Mississippian (Chesterian) Pope Group, described in a following section.

### Undifferentiated

Undifferentiated Mississippian rocks in the Waltersburg Quadrangle occur in several small fault slices. These rocks include poorly exposed or deformed rocks that lack the diagnostic characteristics used for referral to a specific formation. This category also includes rocks that can be assigned to specific formations but the map scale precludes delineation of individual units.

A small fault slice along the Lusk Creek Fault Zone in the SW, Section 30, T12S, R6E, consists of poorly exposed, steeply dipping limestone. The limestone is a gray to dark gray, coarse grained biocalcarenite that contains oolites and rudaceous bioclasts. The absence of diagnostic lithologic characteristics and the small, isolated exposure preclude referral to a specific unit. The limestone is probably an Upper Valmeyeran to Middle Chester formation.

A long fault-slice block in the center of the Lusk Creek Fault Zone from the east edge of Section 20 to Section 3, T12S, R6E at the north edge of the quadrangle is mapped as undifferentiated Mississippian. Strata within this block range from St. Louis(?) Limestone up to Kinkaid Limestone, but a complete succession is probably not present. The best exposure occurs at an abandoned quarry at the Clay Diggings Mine, NW NE SE, Section 16, T12S, R6E. Bain (1905) briefly described this locality and considered the limestone to be St. Louis. Diffenbach (personal communication, 1985), a geologist at a fluorspar mining company, interpreted the limestone to be Ste. Genevieve and/or St. Louis. Cores of several angled exploratory holes drilled through the fault block at the mine indicated the block to be about 200 feet wide and entirely composed of limestone (Bain 1905). The quarry exposes about 50 to 100 feet of limestone dipping steeply to the southeast. The exposure is extensively faulted, fractured, and mineralized, and the bedding is obscure. On the southeast side of the exposure is a light gray, well indurated calcilutite containing numerous light colored chert nodules. Northwest of this unit is light to medium gray limestone that weathers medium to dark gray. It is a fine to medium grained biocalcarenite with a sparite cement and is locally oolitic. Macrofossils include pelmatozoan fragments and rugose corals, which are not age diagnostic. Conodonts (*Cavusgnathus unicornis*, *Kladagnathus tenuis*, and *Lambdagnathus fragilidens*) extracted from this limestone range from late Valmeyeran to Chesterian Age (Norby, personal communication, 1989). This lithologic succession does not occur in the upper Mississippian Pope Group. Several formations in the lower part of the group contain light colored bioclastic and oolitic limestone, but they are less than 50 feet thick or contain shale. The lithologic succession is characteristic of the St. Louis Limestone and the overlying lower part of the Ste. Genevieve.

White to light gray, bioclastic, and oolitic calcarenite also occurs within this fault slice between the Clay Diggings Mine and Copperous Branch. This limestone is stratigraphically below the Glen Dean Limestone and is probably part of the Ste. Genevieve.

Rocks provisionally assigned to Vienna, Palestine, Menard, and Kinkaid Formations crop out in a northeast-trending ravine in the NW NE, Section 10, T12S, R6E in this fault slice. A Vienna-to-Kinkaid sequence is probably not present because of small displacements by several faults. The limited extent and intermittent exposures preclude mapping of individual formations. A small area of undifferentiated Mississippian rocks occurs north of the Clay Diggings Mine and adjacent to the Lusk Creek Fault Zone. These strata consist of the uppermost Clore, Degonia, and lowermost Kinkaid. This sequence probably is compressed as a result of drag folding along the Lusk Creek Fault Zone.

## Pope Group

The Pope Group comprises strata from the base of the Aux Vases Sandstone to the top of the Kinkaid Formation. The Pope Group is a lithostratigraphic unit distinct from its chronostratigraphic counterpart, the Chesterian Series. The lower boundary of the Chester Series (Swann 1963, Maples and Waters 1987) differs slightly from the Pope Group. The group is about 1,425 feet thick in the quadrangle, but the lowermost Pope formations, from the Aux Vases Sandstone up to the Fraileys Shale, do not crop out in the Waltersburg Quadrangle. This interval is 384 feet thick in the Austin Roberts No. 1 Well.

**Golconda Formation** Butts (1917) named the Golconda Formation for exposures near Golconda, Illinois, just southeast of the Waltersburg Quadrangle. McFarlan et al. (1955) elevated the Golconda to a group, but herein it is referred to as a formation. The formation consists of the basal Beech Creek Limestone Member, the Fraileys Shale Member, and the Haney Limestone Member. Only the Haney is exposed in the Waltersburg Quadrangle.

### *Haney Limestone Member*

McFarlan et al. (1955) originally named the Haney Limestone Member as a formation for exposures along Haney Creek, in Hardin County. The upper part of the Haney is mapped only in the extreme southeast corner of the quadrangle. Its occurrence was extrapolated from the map of Baxter et al. (1967) because the bedrock is covered at this locality. Baxter et al. described the Haney as a 15- to 50-foot-thick limestone containing interbedded shale and, in some places, 10 feet of green gray calcareous shale at the top. The upper contact with the Hardinsburg is not exposed in the quadrangle. Baxter et al. (1967) described the contact as ranging from transitional to a disconformity.

### Hardinsburg Sandstone

Cliff-forming sandstone that crops out only near the southeast corner of the quadrangle is referred to as the Hardinsburg Sandstone. Brokaw (1916) first used the name Hardinsburg in a stratigraphic column; the name was based on descriptions and measurements by S. Weller. Butts (1917) formally introduced the name "Hardinsburg Sandstone" for exposures near Hardinsburg in Breckinridge County, north-central Kentucky.

The Hardinsburg is predominantly a fine grained sandstone consisting of subrounded, well sorted quartz grains. Dark minerals and mica are rare and probably constitute less than 1% of the rock. A few grains have clay coatings. The well indurated sandstone is white and light gray and weathers orange brown to gray. Low-angle trough crossbeds are prevalent, and ripple marks and soft-sediment deformation structures also occur. Bedding planes are generally wavy, and beds are often lenticular. Beds generally range from 0.3 to 1 foot thick.

The lower part of the unit crops out in ledges 5 to 15 feet high,

**Table 1** Location of wells used for bedrock study.

| Well and company | Location[a] | Sample base and well type | ISGS county no. and total depth (ft) |
|---|---|---|---|
| Abner Field No. 1<br>Abner Field | NWc, SE, SE,<br>Sec. 19, T13S, R6E | Core<br>Petroleum test | Co. 108<br>TD 777 |
| Austin Roberts No. 1<br>C. E. Williams | NW NE SE, SE,<br>Sec. 10, T13S, R6E | Cuttings/geophysical logs<br>Petroleum test | Co. 244<br>TD 3,802 |
| Harold Clanahan No. 1<br>F. Bolin and N. B. Butler | NW, SW SW<br>SE, Sec. 25, T13S, R5E | Drillers log<br>Petroleum test | Co. 182<br>TD 1,100 |
| COGEOMAP W-1<br>ISGS | 2070 FSL, 1590 FEL,<br>Sec. 14, T12S, R6E | Core<br>Stratigraphy test | Co. 20419<br>TD 166 |
| COGEOMAP W-2<br>ISGS | 2320 FNL, 350 FEL,<br>Sec. 15, T12S, R6E | Core<br>Stratigraphy test | Co. 20420<br>TD 166 |
| COGEOMAP W-3<br>ISGS | 15 FWL, 70 FNL, NE, NE,<br>Sec. 9, T12S, R6E | Core<br>Stratigraphy test | Co. 20424<br>TD 280.1 |
| Minton-Baker No. 1<br>Robert L. Minton | NW NW NE, NE,<br>Sec. 24, T13S, R5E | Core<br>Petroleum test | Co. 206<br>TD 610 |
| U.S. Government No. 1<br>Eddleman and McKee | 250 FWL, 20 FSL, NW, SW,<br>Sec. 1, T13S, R6E | Core<br>Mineral test | Co. 206<br>TD 141.4 |
| Voslow No. 1<br>Rodger, Barger, et al. | NEc, SE, SE,<br>Sec. 18, T13S, R6E | Cuttings log<br>Petroleum test | Co. 107<br>TD 1,000 |
| Truebger No. 3<br>— | 400 FSL, 1600 FEL<br>Sec. 35, T12S, R6E | Core<br>Mineral test | Co. 209<br>TD 159.5 |
| U.S. Forest Service-<br>Eddyville Guard Station<br>Floyd Ingram | 132 FSL, 396 FWL, SE<br>Sec. 6, T12S, R6E | Cuttings log<br>Water well | Co. 77<br>TD 257 |

[a] NWc: northwest corner; 2070 FSL, 1590 FEL: 2070 feet from the south line and 1590 feet from the east line.

whereas the upper part is poorly exposed. In the adjacent Shetlerville and Herod Quadrangles, Baxter et al. (1967) similarly characterized the formation as having a lower unit of "a prominent ridge-forming sandstone" and an upper unit containing poorly exposed shale. The upper contact with the overlying Glen Dean Limestone is not exposed in the Waltersburg Quadrangle, but Baxter et al. (1967) described it as an "abrupt change" from gray shale in the uppermost Hardinsburg to limestone of the Glen Dean.

The best exposures of the Hardinsburg are in bluffs northeast of Lusk Creek and in a southwestward flowing tributary to the creek (SW, Section 13; SE, Section 14; NW, Section 24, T13S, R6E). In this area, the lower part of the sandstone forms the bluff facing Lusk Creek.

Wells within the quadrangle were either drilled through the formation in areas where faulting is prevalent or did not penetrate the entire formation. Baxter et al. (1967) reported a thickness of 90 to 115 feet in the adjacent Shetlerville and Herod Quadrangles. About 6 miles north of the quadrangle, the Mary L. Streich No. 1 Well drilled through 105 feet of Hardinsburg Sandstone.

**Glen Dean Limestone** Limestone succeeding the Hardinsburg Sandstone and overlain by the Tar Springs Sandstone is referred to as the Glen Dean Limestone. Butts (1917) named the formation for exposures along the railroad at Glen Dean in Breckinridge County, north-central Kentucky. The Glen Dean, like the Hardinsburg, crops out only near the southeast corner of the quadrangle.

The Glen Dean Limestone is gray to dark gray and weathers gray. It is bioclastic to locally oolitic limestone and is a moderately sorted, fine to very coarse grained biocalcarenite. Common fossils, often fragmented, include pelmatozoans, rugosan corals, *Pentremites*, bryozoans, and brachiopods, including *Composita*. Bedding ranges from 0.2 to 2 feet thick and rarely includes low-angle crossbeds. Baxter et al. (1967) differentiated three units within the formation: a lower unit of fossiliferous limestone, a middle calcareous shale, and an upper interbedded limestone and shale. These units are not differentiated in this study

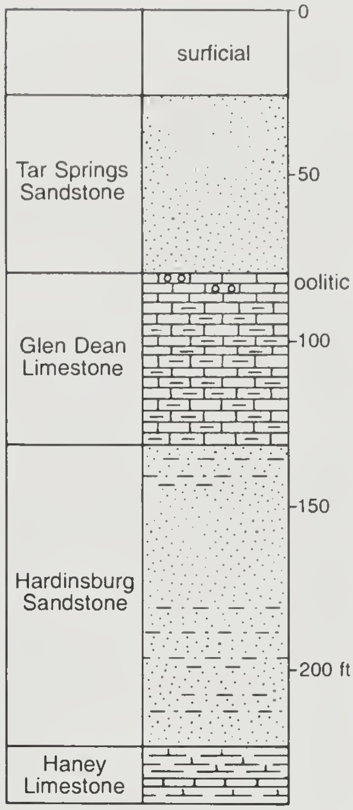



**Figure 4** Graphic column of upper part of core from Abner Field No. 1 Well, located south of Waltersburg Quadrangle.

because the formation is poorly exposed and generally covered by vegetation and talus from the overlying Tar Springs Sandstone. The best of the few exposures are in the SE, Section 14, T6E, R13S, at the foot of large talus blocks and high ledges on the northeast side of Lusk Creek. The limestone is susceptible to dissolution by groundwater; thus, sinkholes are common. Sinkhole occurrences were used as reference points to map the unit in the SW, Section 13, T6E, R13S, where exposures are absent.

The upper contact of the Glen Dean is not exposed in the Waltersburg Quadrangle. Baxter et al. (1967) described it as an unconformity, with the Tar Springs extending downward in places into the Glen Dean. The thickness is estimated to be about 50 to 60 feet. In the subsurface, thicknesses are more variable, probably because of the nature of the upper contact. The drillers' log of the Minton-Baker No. 1 Well, located in Section 24, T13S, R5E, indicated a thickness of 59 feet. A geophysical log of the Austin Roberts No. 1 Well recorded a thickness of 79 feet. The core from the Abner Field No. 1 Well, just south of the quadrangle, contains 52.6 feet of Glen Dean Limestone (fig. 4). The geophysical log of the Harold Clanahan No. 1 Well, about 1.5 miles south of the quadrangle, recorded 90 feet of Glen Dean.

**Tar Springs Sandstone** The Tar Springs Sandstone crops out above the Glen Dean Limestone in a series of cliffs and forms an outcrop belt 1 to 2 miles wide near the southeast corner of the quadrangle. Owen (1857) first referred to outcrops south of Cloverport in Breckenridge County, Kentucky, as the "Tar Spring sandstone." The name "Tar Springs Sandstone" was introduced by Brokaw (1916) in a description of a stratigraphic column; he based the name on descriptions and measurements by S. Weller. The formation was formally defined by Butts (1917).

The Tar Springs is predominantly a very fine to fine grained sandstone, composed of subangular to subrounded, well sorted, quartz grains. Medium to coarse grains are present locally. Siever (1953) petrographically analyzed four samples of the Tar Springs and determined that the dominant constituent was quartz (80–95%). He also found clay (1–10%), carbonate (1–2%), chert (1–2%) feldspar (0–2%), and traces of heavy minerals. The generally well indurated sandstone is white to tan and weathers light orange brown to brown. Ripple marks are common, and low-angle crossbeds are locally abundant. Bedding varies from 0.1 to more than 2 feet thick and is locally lenticular with wavy bedding planes. The lower part of the Tar Springs is generally well exposed and forms bluffs up to 30 feet high. The heights of sandstone ledges decrease and the percentage of interbedded shale and siltstone increases upward through the formation.

The upper half of the Tar Springs contains interbedded fissile, noncalcareous, gray shale and light gray to light brown, quartzose siltstone that weathers gray to yellow brown. The silt occurs in beds up to 0.1 foot thick and, in some places, contains prevalent mica, carbonaceous plant fragments, and ripple marks. Baxter et al. (1967) characterized the upper part of the formation as shale containing some carbonaceous beds and rare thin coals in the Shetlerville and Herod Quadrangles. A coal near the top of the Tar Springs crops out in a ravine near the NW corner of NE NW, Section 21, T13S, R6E (Baxter, personal communication, 1991).

The best exposures of the lower part of the formation are in Section 14; S1/2, Section 15; NE, Section 21; and N 1/2 N 1/2, Section 22, T13S, R6E. The best exposures of the upper part are a cut bank and an outcrop adjacent to the road on the northwest side of a ravine near the southwest corner of Section 12, T13S, R6E. The upper contact of the Tar Springs is not exposed. Baxter et al. (1967) described the conformable contact with the overlying Vienna Limestone as relatively sharp. The Tar Springs ranges from 100 to 130 feet thick, an estimate based on outcrop study and subsurface data. The drillers' log of Minton–Baker No. 1 Well recorded a thickness of 115 feet. A geophysical log of the Austin Roberts No. 1 Well recorded 110 feet. South of the quadrangle, the geophysical log of the Harold Clanahan No. 1 Well recorded 100 feet of Tar Springs Sandstone.

**Vienna Limestone** The thin, cherty limestone separating the Tar Springs Sandstone and the Waltersburg Formation is referred to as the Vienna Limestone. S. Weller (1920b) introduced the name for exposures of interbedded limestone and shale near Vienna in Johnson County, southern Illinois. Swann (1963) revised the formation, restricting the unit to include only the middle limestone part, and assigning the underlying and overlying shale to the Tar Springs and the Waltersburg, respectively. The outcrop pattern of the limestone is a thin stripe in the southeast quarter of the quadrangle.

The Vienna Limestone consists of generally fine grained limestone; it is bioclastic and contains abundant chert nodules. The gray to gray brown limestone weathers gray to light gray and varies locally from calcilutite to coarse grained calcarenite. Chert is a diagnostic characteristic of the formation. In outcrops, it occurs as gray to brown, irregular to lenticular nodules and commonly weathers to tripoli. Pelmatozoan and bryozoan fragments are common fossils. Beds range from 0.4 to 1.2 feet thick. In this quadrangle, outcrops of the Vienna are generally poor and typically recognized by the presence of float. The float generally consists of brown chert and tripoli nodules that contain abundant fossil fragment molds. The best exposure is in a ravine, just south of Illinois 146, in the NE NW NE NE, Section 20, T13S, R6E. In this area, the limestone marks the edge of low plateaus formed on the underlying Tar Springs Sandstone and is generally slumped. North of Lusk Creek, the Vienna crops out in poor exposures on the dip slope of the Tar Springs and is recognized only on the basis of its distinctive float.

The upper contact is not exposed in the quadrangle. The core from U.S. Government No. 1 Well indicates that the contact is abrupt; however, Baxter et al. (1967) described the upper contact as transitional. An incomplete exposure of the limestone in the Waltersburg Quadrangle is 12 feet thick. Mapping of exposures and associated float indicate this limestone is 15 to 25 feet thick. Subsurface data indicate, however, that the formation locally attains thicknesses of more than 30 feet. The drillers' log from the Voslow No. 1 Well recorded 30 feet of Vienna Limestone. The Vienna in the U.S. Government No. 1 Well is 19.6 feet thick (fig. 5); however, the well was drilled close to a fault.

**Waltersburg Formation** The poorly exposed interval of fine grained sandstone, siltstone, and shale overlying the Vienna Limestone and underlying the Menard Limestone is referred to as the Waltersburg Formation. S. Weller (1920a) first recognized the "Waltersburg sandstone" as one of two formations (Vienna Limestone is the other) that are intercalated between the Tar Springs Sandstone and Menard Limestone. S. Weller referred to exposures at Waltersburg as the type area. S. Weller (1920b) later described the formation as "a conspicuous sandstone formation" in Pope and Johnson Counties and specified the type locality as exposures "in the road just north of Waltersburg." Presumably, this locality (west edge, NW SW SW, Section 16, T13S, R6E) is the abandoned road bed west of and parallel to the present road. The outcrop is completely covered by vegetation. Swann (1963) listed, without clarification, the descriptive term of the Waltersburg as

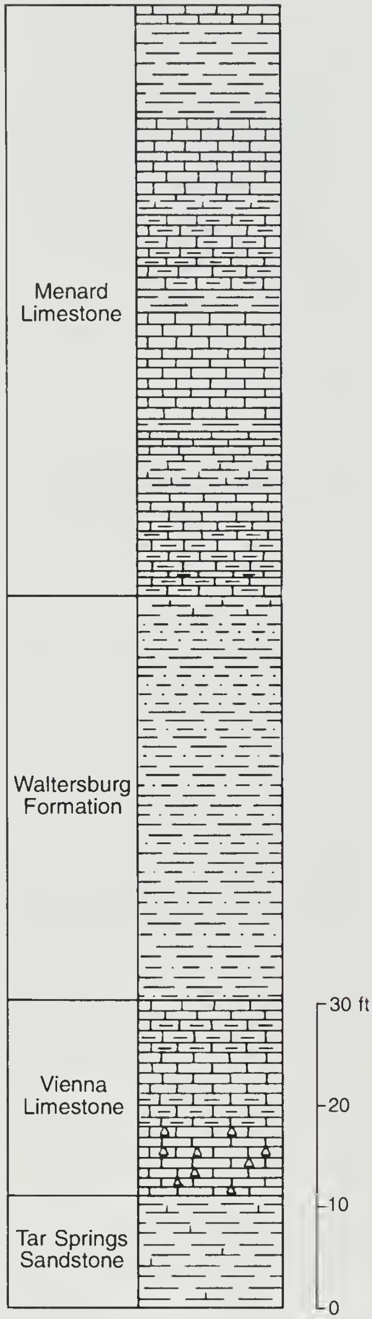



**Figure 5** Graphic column of core from U.S. Government No. 1 Well in Section 1, T13S, R6E.

Formation, Shale, or Sandstone, but appeared to favor Formation. Outcrop study and subsurface data indicate that the lithology is variable and Formation is the appropriate descriptive term in the Waltersburg Quadrangle.

Outcrops of the Waltersburg are predominantly light tan to light brown, very fine to fine grained sandstone that weathers gray to dark orange brown. The moderately to well indurated sandstone is composed of subangular to subrounded, moderately sorted, quartz grains, and is locally silty. Siever (1953) petrographically analyzed three samples of the Waltersburg and determined that the dominant constituent is quartz (75–95%). He also found clay (trace to 15%), carbonate (0–5%), chert (trace to 3%), feldspar (trace to 1%), and traces of heavy minerals. Low-angle crossbeds and ripple marks are common in some places. Bedding is tabular to somewhat lenticular. Beds are from 0.1 to 3 feet thick, and bedding surfaces are wavy or irregular.

The formation is poorly exposed overall; sandstone ledges in the upper part are less than 5 feet high. The lower part is generally covered and probably consists of shale and siltstone. The best exposures of the upper part are in the SE, Section 30, T12S, R6E and in the NW, Section 29, T12S, R6E. Sandstone beds in the Waltersburg Formation are discontinuous (Swann 1963). The core recovered from the U.S. Government No. 1 Well consists of only siltstone and shale (fig. 5), but it is possible that part of the section is absent as a result of faulting.

The upper contact of the formation is not exposed in the Waltersburg Quadrangle. The core from U.S. Government No. 1 Well indicates that the upper contact with the Menard Limestone is transitional. Surface mapping indicates that the Waltersburg is about 50 feet thick, whereas subsurface data indicate a range of 40 to 65 feet in the quadrangle. The drillers' log of Minton–Baker No. 1 recorded a thickness of 65 feet. A geophysical log of the Austin Roberts No. 1 recorded 64 feet. The core from the U.S. Government No. 1 Well recovered 40 feet of Waltersburg, but it is possible that the thickness was affected by the nearby Flick Branch Fault.

**Menard Limestone** The relatively thick sequence of limestone and shale overlying the Waltersburg Sandstone and underlying the Palestine Sandstone is referred to as the Menard Limestone. S. Weller (1913) introduced the name "Menard Limestone" for exposures near Menard (Randolph County), southwestern Illinois. Swann (1963) described the Menard Limestone as "three well-marked limestone units separated and overlain by units that are largely shale but contain thin limestone beds." He named the limestones, in ascending order, Walche, Scottsburg, and Allard Limestone Members. In the Waltersburg Quadrangle, poor and only partial exposures of these three members prevent explicit identification, although scattered exposures indicate that all three members and the intervening shales are present. The Menard crops out within and adjacent to the Lusk Creek Fault Zone and in the southeast quarter of the quadrangle north of Waltersburg and along a southwest-trending tributary of Lusk Creek.

The lower part of the formation is dark gray, very fine to fine grained calcarenite that weathers gray, is locally medium grained, and has scattered, coarse grained bioclasts. The limestone is interbedded with very dark gray, fissile, calcareous shale and is fossiliferous, dominated by gastropods and pelmatozoans. Bedding ranges from 0.7 to 2 feet thick, and bedding surfaces are wavy to irregular. Outcrops typically form low ledges 3 to 10 feet high, and they are often slumped. This lower part is roughly equivalent to the Walche Limestone Member.

The middle part of the Menard is dark gray to gray brown limestone that weathers gray to gray brown. It varies from poorly to moderately sorted, very coarse to coarse grained calcarenite that has scattered to abundant coarse grained bioclasts. This unit is commonly interbedded with poorly indurated, light gray to dark gray, fissile, calcareous shale up to 5 feet thick. The bedding surfaces, which are locally argillaceous, and the shale are abundantly fossiliferous with brachiopods, bryozoans, pelmatozoans, and rugosan corals. The middle part locally contains 4 to 5 feet of buff, dolomitized limestone. Near the top part, the limestone contains layers of dark brown chert nodules. Bedding ranges from 0.4 to 2 feet thick, but it is generally 0.5 to 1 foot thick. Outcrops form rounded ledges that reach heights of up to 15 feet. Sinkholes and springs are common in some places. This middle part is roughly equivalent to the Scottsburg Limestone Member.

The upper part of the Menard is dark gray limestone that weathers gray to buff and is light brown to brown in some places. It varies from a fine to medium grained calcarenite to a calcilutite with scattered coarse grained bioclasts. It is interbedded with gray to dark gray, fissile, noncalcareous shale up to 3 feet thick. A few limestone beds are argillaceous. The limestone beds are abundantly fossiliferous, including brachiopods (*Spirifer*, *Composita*, *Mucrospirifer*, and atrypids), gastropods, fenestrate bryozoans, rugose corals, and pelmatozoans, particularly *Pentremites*. Light gray to light brown, small, lenticular chert nodules locally occur in layers 0.2 to 0.4 foot thick. Bedding is 0.1 to 2 feet thick, generally 0.5 foot thick, and bedding planes are rough and irregular. Outcrops form generally slumped benches 3 to 10 feet thick. Sinkholes are common in some places. This upper part is equivalent or partially equivalent to the Allard Limestone Member. The contact with the overlying Palestine Sandstone is sharp and probably disconformable. Baxter et al. (1967), however, described the upper contact with the Palestine as an unconformity.

Exposures of the Menard are poor overall. The limestone beds typically form ledges, whereas intervening shale intervals form benches and are often covered by colluvium. The only locality where all three parts are recognizable is in the SE SW, Section 1, T13S, R6E. Another good exposure of the upper part of the Menard is along a Lusk Creek tributary in the NW NW SE, Section 30, T12S, R6E and along Copperous Branch in the NW NE, Section 20, T12S, R6E and NW NW, Section 21, T12S, R6E.

Mapping of exposures indicates that the Menard is 85 to 110 feet thick, but lack of exposed contacts precludes an accurate measurement. Subsurface data indicate thicknesses of 125 to 142 feet. The drillers' log of Minton–Baker No. 1 Well recorded 125 feet of the Menard; the drillers' log of the Voslow No. 1 Well recorded 142 feet. The core of U.S. Government No. 1 Well retrieved the lower 60 feet of the Menard (fig. 5).

**Palestine Sandstone** The ledge-forming, sandstone-dominated unit overlying the carbonate-dominated Menard Limestone is referred to as the Palestine Sandstone. It was named for exposures in Palestine Township in Randolph County, southwestern Illinois (S. Weller 1913). It crops out on the northwest side of the Lusk Creek Fault Zone and in the south-central part of the quadrangle, southeast of the Hobbs Creek Fault Zone.

The Palestine Sandstone consists of the following succession: fine to medium grained, thick bedded sandstone, and very fine grained, thin bedded sandstone, siltstone, and shale. The sandstone is light tan to gray green to gray and weathers gray to olive brown to brown. Grain size ranges from very fine to medium. It is composed of well sorted, subangular, rarely subrounded, quartz grains, ranging in size from very fine to medium. Siever (1953) petrographically analyzed six samples of the Palestine and determined that the predominant constituent is quartz (63–97%). Clay (0–10%), carbonate (0–34%), chert (trace to 2%), and traces of feldspars and heavy minerals also are present. Field study indicates that mica and calcareous cement are rare and the sandstone is locally silty. The sandstone generally crops out as several ledges or forms high bluffs in some places. The upper part contains interbedded shale and siltstone. The shale is light gray to light brown, fissile, and noncalcareous; it is poorly indurated and locally silty. The siltstone is gray to dark gray, thin bedded, and contains oscillation ripple marks and trace fossils. A thin, soft bituminous shale near the top of the Palestine crops out in a small stream bed in the NW SE SE, Section 17, T12S, R6E. This shale probably is equivalent to the thin coals that locally mark the top of the Palestine in western Illinois (Swann 1963).

Fossils are sparse throughout the formation; only rare carbonaceous plant fragments are present. Stigmarian root casts and *Planolites*, a trace fossil, occur in the sandstone below the bituminous shale along Copperous Branch (fig. 2). Ripple marks and low-angle crossbeds are common. Bedding ranges from 0.1 to 5 feet thick, but it is generally 0.5 to 2 feet thick. Bedding surfaces are locally irregular or wavy. Sandstone of the lower Palestine generally forms bluffs 5 to 35 feet high, whereas the upper part is poorly exposed.

The upper contact of the Palestine Sandstone and the Clore Formation is not exposed, except at one site in a small northeast-trending ravine in the SW NW SE, Section 16, T12S, R6E. At this outcrop, siltstone and silty shale grade upward to dark gray shale of the Palestine, which is conformably overlain by olive gray calcareous mudstone interbedded with dark gray, shaley limestone of the Clore. Baxter et al. (1967) also reported a conformable upper contact. In the northwest part of the quadrangle, the uppermost Palestine and lowermost Clore are so poorly exposed that the contact was not mapped, and the formations are not differentiated on the geologic map (Weibel et al. 1992). In the southeast part, the upper Palestine is faulted out of sequence and does not crop out.

The best exposures of the lower Palestine are along Copperous Branch and in the NE, Section 17, T13S, R6E, where the sandstone forms a prominent bluff that faces southeast. The sandstone caps a northwest-dipping cuesta for several miles to the southwest of Copperous Branch. The upper part of the Palestine generally is poorly exposed, but it also crops out intermittently along this creek.

The thickness of the Palestine, based on outcrop study, ranges from 50 to 70 feet. The thickness is approximated because the upper contact is conformable and poorly exposed. Well data from adjacent quadrangles indicate the Palestine is 45 to 70 feet thick.

**Clore Formation** The complex sequence of shale, limestone, and sandstone overlying the Palestine Sandstone and underlying the Degonia Formation is referred to as the Clore Formation. S. Weller (1913) named the formation for exposures near Clore School in Randolph County, southwestern Illinois. Swann (1963) divided the Clore into three members: the lower Cora Member, consisting of shale and limestone; the middle Tygett Member, consisting of sandstone and shale; and the upper Ford Station Member, consisting of shale and limestone. All three members of the Clore are recognized in the Waltersburg Quadrangle, although they are not differentiated on the geologic map (Weibel et al. 1992). The Clore crops out in ravines south of Matthis Branch, along Copperous Branch, and near the west edge of the quadrangle. It also crops out along several streams and in a narrow fault block in the Raum Fault Zone at the east edge of the quadrangle, as well as in a belt southeast of the Hobbs Creek Fault Zone.

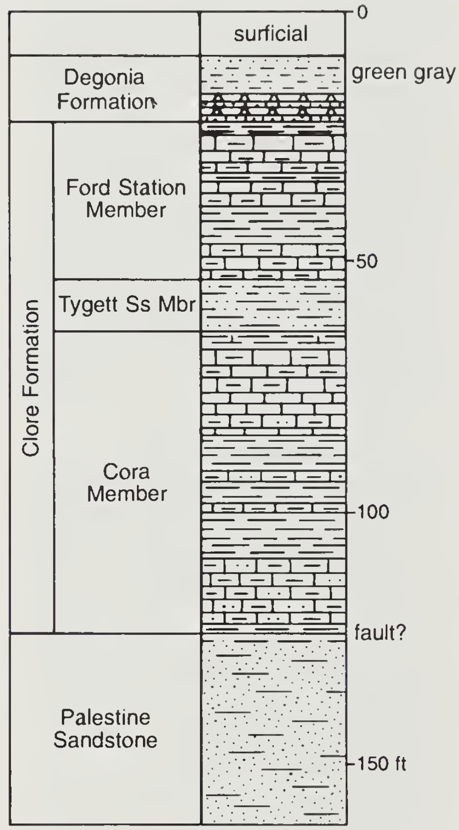



**Figure 6** Graphic column of core from Truebger No. 3 Well, Section 35, T12S, R6E. Thicknesses are corrected to compensate for angled drilling.

### *Cora Limestone Member*

Swann (1963) proposed the name "Cora Limestone Member" for the lower shale and limestone part of the Clore exposed near Cora (Jackson County), southwestern Illinois. The member consists of limestone, argillaceous limestone, and shale interbeds (fig. 6). The limestone is gray to dark gray and weathers light gray to light brown. It is a fine to coarse grained calcarenite or a calcilutite and has coarse grained bioclasts. Argillaceous limestone beds and shale interbeds are common and siltstone beds occur in some places. The shale shows a variable composition. It is gray to dark gray, fissile, and noncalcareous in some places and green gray to olive gray, poorly fissile, and calcareous in others. The shale ranges from 1 to 6 feet thick. The siltstone is brown gray to green gray, argillaceous, and calcareous.

The Cora is moderately to abundantly fossiliferous and has abundant brachiopods (*Spirifer, Composita,* and productids) and pelmatozoans. Gastropods, fenestrate, and ramose bryozoans are common, and rugosan corals are rare. Limestone beds range from 0.3 to 3 feet thick and are generally 0.5 to 1.5 feet thick. The limestone forms low subtle benches and beds, and commonly weathers to an hourglass shape. The unit generally is poorly exposed and beds are often slumped. The Cora ranges from 50 to 60 feet thick and is 57 feet thick in the Truebger No. 3 Well (fig. 6).

***Tygett Sandstone Member***

Swann (1963) proposed the name "Tygett Sandstone Member" for the middle clastic part of the Clore Formation exposed near Tygett School in Union County, southern Illinois. The generally well indurated member is dominated by a light gray green to light tan sandstone that weathers light brown to brown to gray brown. It is composed of very fine to fine grained quartz that is well sorted and subangular to subrounded. Dark minerals are rare, and the sandstone is silty and micaceous in places. Plant molds, siltstone interbeds, carbonaceous plant fragments, trace fossils (*Rhizocorallium, Cochlichnus,* and *Phycoides*-like tubes), and shale clasts are rare. Ripple marks and low-angle crossbeds are common. Bedding ranges from 0.1 to 2 feet thick, but it is generally less than 0.8 foot thick. Bedding planes are planar and rarely irregular. In the southeast corner of the quadrangle, the member is estimated to be more than 60 feet thick, although outcrops form ledges only 5 to 15 feet high. The member is only 9 feet thick at the Truebger No. 3 Well (fig. 6).

The Tygett is probably present throughout the area, but it is thinner in the north-central and northwestern parts of the quadrangle. In these areas, it consists of a gray, fissile shale and a sandstone bed. The 1-foot-thick sandstone contains abundant steinkerns of brachiopods (including *Spirifer*), pelecypods, and pelmatozoan fragments. Near the west edge of the quadrangle, the Tygett is thicker, forms small ledges, and contains a thin limestone bed 2 feet thick. The limestone, a calcilutite containing abundant pelmatozoan fragments, crops out in the ravine at the north edge of N 1/2 SE, Section 23, T12S, R5E; it separates 7 feet of well sorted, fine grained, crossbedded sandstone above it from 3 feet of very fine grained, thin to medium bedded sandstone below. Stigmarian root casts occur in the lower sandstone. This Tygett limestone bed also occurs in quadrangles to the west and northwest of the Waltersburg (Nelson et al. 1991, J. Devera, personal communication, 1990).

In a fault slice within the Lusk Creek Fault Zone (NE NW NE, Section 5, T13S, R6E), 32 feet of Tygett Sandstone crop out along Lusk Creek. Beds in the upper 20 feet are tabular and thin, ripple marked, and crossbedded; in the lower 12 feet, beds are thin and interbedded with ripple marked, laminated siltstone.

***Ford Station Member*** Swann (1963) proposed the name "Ford Station Member" for the upper carbonate part of the Clore Formation exposed near Ford Station in Randolph County, southwestern Illinois. The member consists of limestone, argillaceous limestone, siltstone, and shale interbeds; it is lithologically similar to the Cora Member. The limestone is light gray to dark gray, and weathers gray to orange brown to brown. It varies from calcilutite to medium grained calcarenite to a fine grained calcarenite that has coarse grained bioclasts. Argillaceous limestone beds and shale interbeds are common. The poorly indurated shale is light gray to dark gray, fissile, noncalcareous, and up to 2 feet thick. Moderately indurated siltstone in the upper part is gray green to light brown, noncalcareous quartzose, and it has rare carbonaceous plant fragments and mica flakes. Siltstone exposures are up to 7 feet thick, and bedding ranges from laminae to 4 feet thick. The limestone is fossiliferous and brachiopods and pelmatozoans are abundant; bryozoans are common and rugosan corals are few. Bedding ranges from 0.1 to 2.5 feet thick, and it is generally 1 to 1.5 feet thick. The limestone beds are generally slumped and often weather to an hourglass shape. Outcrops of limestone form benches 5 to 15 feet thick. The member ranges from 30 to 50 feet thick and is 32 feet thick in the Truebger No. 3 Well (fig. 6).

The upper contact of the formation is gradational, as indicated by the core of the COGEOMAP W-3 Well (fig. 7), although Baxter et al. (1967) considered it unconformable. The basal chert is distinctive, readily recognized in float or outcrop, and used as the mapping boundary of the Clore–Degonia contact. The Clore ranges from 95 to 120 feet thick, and it is 100 feet thick in the Truebger No. 3 Well.

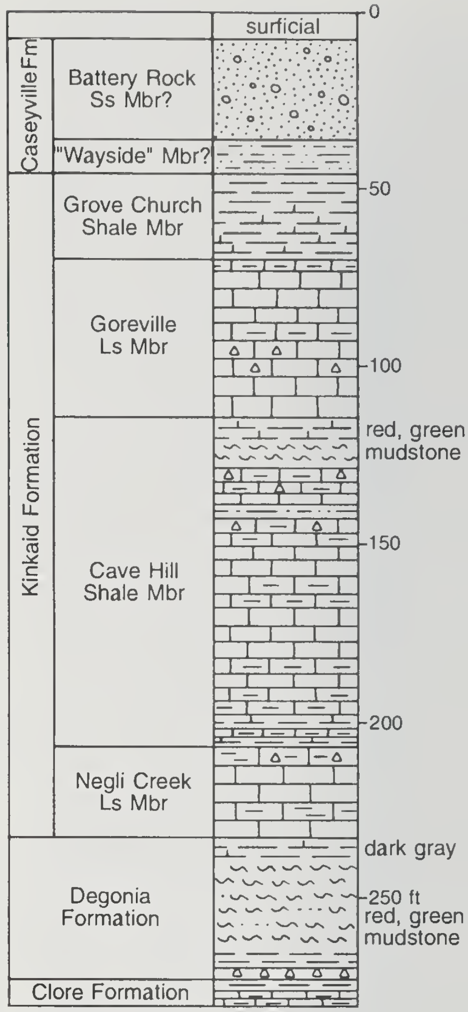



**Figure 7** Graphic column of core from COGEOMAP W-3 Well in Section 9, T12S, R6E.

**Degonia Formation** The generally poorly exposed clastic unit overlying the carbonate-dominated Clore and underlying the Kinkaid Limestone is referred to as the Degonia Formation. The formation was originally designated as the Degonia Sandstone by S. Weller (1920b) for outcrops in Degonia Township in Jackson County, southwestern Illinois. Swann (1963) referred to the unit as either the Degonia Sandstone or Shale. In the Waltersburg Quadrangle, it consists of variable lithologies and therefore is herein referred

**Figure 8** Basal chert bed of Degonia Formation forming a very resistant ledge in Whiteside Branch, near the northwest corner of Section 24, T12S, R5E. Scale is indicated by geologic hammer in the right center of the photograph.

to as the Degonia Formation. It is a relatively thin, nonresistant formation that underlies gentle slopes in the center of the area between the Pennsylvanian escarpment and the Lusk Creek Fault Zone in the northwest quarter of the quadrangle. It also crops out along the Hobbs Creek Fault Zone in the southeast quarter of the quadrangle and in several ravines at the east edge of the quadrangle. The complete succession can only be seen in the core of COGEOMAP W-3 Well (fig. 7).

The Degonia Formation consists of shale, mudstone, siltstone, sandstone, and chert. At or near the base of the formation are several prominent, well indurated chert beds. The chert is gray to gray brown and weathers white to yellow brown. It occurs in beds that are 0.3 to 1.5 feet thick and contain rare ripple marks. The total thickness of the chert is 2 to 5 feet. The chert is generally fractured and slumped, but locally it forms a resistant ledge (fig. 8). The chert is locally underlain by 0.3 to 2 feet of either (1) gray green to gray to light brown, silty, fissile, noncalcareous shale or (2) gray green, well sorted, weakly calcareous, quartzose siltstone. In the core of COGEOMAP W-3 Well (fig. 7), the chert is weakly calcareous (and unusually thin), indicating that the original lithology was at least in part composed of limestone.

Above the basal chert is an interval of interbedded sandstone, siltstone, and shale. The moderately to well indurated sandstone is light gray green to gray green and weathers to light orange brown. It is composed of very fine grained, well sorted quartz grains and is locally silty or argillaceous. Siever (1953) petrographically analyzed seven samples of Degonia sandstone and determined that the predominant constituent is quartz (70–92%). He also found clay (trace to 10%), carbonate (0–23%), chert (1–2%), feldspar (trace to 5%), and traces of heavy minerals. Bedding ranges from 0.1 to 0.5 foot thick. The sandstone portion of the formation is 2 to 10 feet thick and has shale interbeds and interference ripple marks in some places. The siltstone is gray green and weathers light brown; it is noncalcareous and well indurated. Both sandstone and siltstone contain mica. Beds range from 0.1 to 0.8 foot thick, and ripple marks and trace fossils are locally present. The shale is gray to dark gray and weathers to light brown; it is poorly fissile, noncalcareous, and thin bedded (less than 0.5 foot thick).

The upper part of the Degonia is dominated by gray to gray green, variegated (blue gray, maroon, and red brown) noncalcareous shale and claystone that weathers to a variegated color. The unit is massive, has a blocky fracture, and ranges from 2 to 14 feet thick.

The upper contact is not well exposed, but in the core of the COGEOMAP W-3 Well (fig. 7), the shale at the top of the Degonia grades rapidly to the overlying Kinkaid Limestone. Mapping indicates the formation is about 25 to 50 feet thick. In the COGEOMAP W-3 core, the Degonia is 39 feet thick.

**Kinkaid Limestone** Limestone and shale overlying the variable lithologies of the Degonia Formation and underlying the cliff-forming sandstones of the Caseyville Formation are referred to as the Kinkaid Limestone. S. Weller (1920b) proposed the name for exposures along Kinkaid Creek in Jackson County, southwestern Illinois. As originally defined by S. Weller, the Kinkaid included all strata from the top of the Degonia to the base of the Pennsylvanian. Swann (1963) divided the formation into three members: the Negli Creek Limestone Member at the base, the Cave Hill Shale Member in the middle, and the Goreville Limestone Member at the top. The Grove Church Shale was separated from the Kinkaid Formation by Swann (1963) but was revised as the uppermost and fourth member of the Kinkaid by Nelson et al. (1991).

The Kinkaid underlies steep slopes below the Pennsylvanian escarpment in a narrow west-southwest-trending belt in the northwest quarter of the quadrangle and in a wide belt roughly bracketed by the Raum Fault Zone and the Hobbs Creek Fault Zone. The formation is often covered by talus from the overlying Pennsylvanian sandstones.

*Negli Creek Limestone Member*
The Negli Creek Limestone Member was originally named a formation by Malott (1925), a name derived from strata exposed along Negli Creek in Perry County, southern Indiana. In the Waltersburg Quadrangle, it is predominantly a gray to dark gray limestone that weathers dark gray to gray brown. It ranges from a calcilutite that contains scattered bioclasts to a coarse grained biocalcarenite. Poorly exposed shale interbeds occur in some places in the upper part. The shale is gray green, fissile, noncalcareous to weakly calcareous, and up to 3 feet thick. Argillaceous beds are fossiliferous: pelmatozoans (*Pentremites* and *Agnastocrinus*), gastropods, and brachiopods (chonetids and spirifers) are abundant; bryozoans (*Archimedes* and trepostomes) are common; and corals and cephalopods are rare. *Girvanella* oncoids, bellerophontid gastropods, and the coral, *Chaetetella*, are diagnostic of the Negli Creek. Trace fossils include *Chondrites*, *Zoophycus*, and horizontal burrows. Layers of gray to dark gray, lenticular chert nod-

ules are common. Low-angle cross-beds are rare. Outcrops are generally slumped and bedding is locally wavy. Bedding thickness varies from 0.1 to 3 feet, but it is generally 0.5 to 1.5 feet thick. The limestone crops out as rounded ledges that are generally 10 to 25 feet high and are often the site of springs. The member is generally about 25 to 30 feet thick; it is 26 feet thick in the COGEOMAP W-3 Well (fig. 7).

*Cave Hill Shale Member*
Swann (1963) named the Cave Hill Shale Member for exposures near Cave Hill in Saline County, southern Illinois. The member generally consists of a basal shale, middle limestone, and upper claystone.

The basal shale is 5 to 10 feet thick, dark green gray, fissile, and weakly calcareous. Brachiopods, bryozoans, and pelmatozoan fragments are common fossils. Near the top of the basal shale are olive gray calcareous siltstone interbeds 0.1 to 0.2 foot thick; the siltstone crops out in a small ravine just east of the Eddyville–Golconda road (SE NE NW, Section 35, T12S, R6E).

The middle part of the Cave Hill is 60 to 75 feet thick and consists of limestone containing thin shale interbeds. The limestone is a well indurated, gray to dark gray calcilutite to very coarse grained calcarenite that weathers light gray to gray brown. A dolomitic limestone bed, which weathers to buff, occurs locally. Layers of gray to black chert nodules are common in the limestone beds. Argillaceous interbeds are 0.7 to 0.8 foot thick and locally laminated. Brachiopods, bryozoans, and pelmatozoans are common fossils. Limestone beds are generally 1 to 2 feet thick. Outcrops are poorly exposed, and the limestone beds are generally slumped.

The upper part of the Cave Hill consists of 10 to 15 feet of variegated (green gray, ocher, and maroon to red brown) claystone. The claystone contains thin beds and lenses of biocalcirudite that have abundant *Archimedes*, *Rhombopora*, *Composita*, and pelmatozoan fragments.

The best exposures of the Cave Hill are in and adjacent to small ravines in the SE SE, Section 4 and NE NE, Section 9, T12S, R6E, and in a short southeast-trending ravine in the SE NE SE, Section 34, T12S, R6E. The upper part of the Cave Hill crops out along Ramsey Branch, near the north edge of the quadrangle. The Cave Hill Member is about 80 to 100 feet thick; it is 92 feet thick in the COGEOMAP W-3 Well (fig. 7).

*Goreville Limestone Member*
Swan (1963) named the Goreville Limestone Member for exposures near Buncombe, south of Goreville in Johnson County, southern Illinois. The member predominantly consists of limestone. It is a gray to dark gray, fine to coarse grained biocalcarenite (commonly crinoidal) that weathers light gray to gray brown. Locally, the limestone is argillaceous and intercalated with gray to dark olive gray calcareous shale. The diverse fauna includes brachiopods (*Chonetes*, *Spirifer*, *Punctospirifer*, *productids*), bryozoans (fenestrates, trepostomes and rhomboporoids), gastropods, *Pterotocrinus*, *Trilophyllites*, *Chaetetella*, and shark's teeth. Layers of gray chert nodules are locally common in the limestone beds. Bedding ranges from 0.2 to 2 feet thick. The limestone crops out as low ledges that are generally slumped and poorly exposed. The best exposure is a nearly complete section of the Goreville in an abandoned quarry (fig. 9). The Goreville Member is up to 45 feet thick; it is 43 feet thick in the COGEOMAP W-3 Well (fig. 7).

*Grove Church Shale Member*
Swann (1963) designated the uppermost shale the Grove Church Shale and separated it from the Kinkaid, based on the study of exposures near Cedar Grove Church in Johnson County, southern Illinois. Nelson et al. (1991) reduced the rank of the Grove Church to a member of the Kinkaid Limestone because the rare exposures of the Grove Church render it impractical as a surface mapping unit and it is lithologically related to the Kinkaid in a sequence of alternations of limestone and shale. Nelson et al. (1991) recognized, however, the member in several wells in their study area, a fact that suggests the Grove Church is useful as a subsurface mapping unit. The Grove Church is identifiable in the subsurface, if cores and a good set of samples are available. Geophysical logs alone are not always sufficient for identification of the member. The four members of the Kinkaid are not differentiated on the geologic map of Weibel et al. (1992).

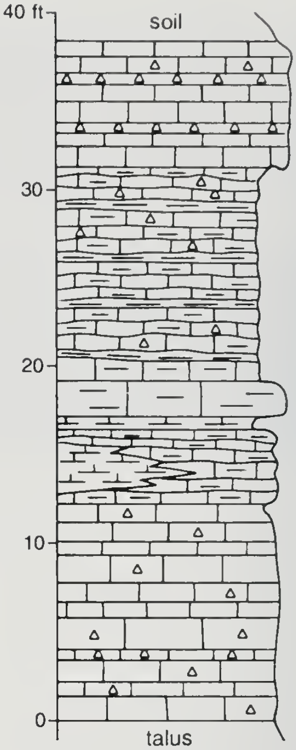


**Figure 9** Graphic column of Goreville Limestone Member of Kinkaid Limestone from an abandoned quarry in Section 7, T12S, R6E. Note the intertonguing of shale and limestone in the lower middle part.

The Grove Church consists of gray to gray green, fissile shale and is locally silty and calcareous. Several lenticular limestones, 0.1 to 0.2 foot thick, occur in the upper part. These limestones are light gray and weather yellow brown to green gray, and they consist of argillaceous calcilutite and fine grained calcarenite. Brachiopods and bryozoans are common fossils. The unit is very poorly exposed. The best exposures of the Grove Church are in ravines in the SE SE, Section 4, T12S, R6E. A complete core of the shale was recovered from COGEOMAP W-3 Well (fig. 7) near those ravines. The Grove Church also crops out near the top of small, south-trending ravines in the N 1/2 NE NW, Section 9, T12S, R6E, in a small ravine just south of Illinois 145 in SW SE NE, Section 13, T12S, R5E, and in the center of NW SE, Section 8, T12S, R6E. The Grove Church is 24 feet thick in the core.

The upper boundary of the Kinkaid is the Mississippian–Pennsylvanian unconformity. The Grove Church has been eroded in most places at the Mississippian–Pennsylvanian unconformity; the Goreville and Cave Hill Members are eroded in some places as well. The Kinkaid ranges from less than 100 feet to at least 186 feet thick. The thickest section in the Waltersburg Quadrangle is in the core of COGEOMAP W-3, which contains all four Kinkaid members.

### Mississippian–Pennsylvanian Unconformity

In the Waltersburg Quadrangle, the Mississippian–Pennsylvanian contact is an irregular surface overlying the Kinkaid Formation. The strata underlying the contact extend from the Grove Church Shale Member down to the Cave Hill Shale Member, and perhaps to the Negli Creek Limestone Member. The topographic lows on this surface are occupied by the basal member of the Caseyville Formation.

Previous studies concur with the interpretation of widespread erosion prior to deposition of Pennsylvanian strata. J. Weller (1939) concluded that pre-Pennsylvanian erosion explained the variable thicknesses of the Kinkaid Formation in the Dongola, Vienna, and Brownfield 15-Minute Quadrangles. Siever (1951), Wanless (1955), Bristol and Howard (1971), and Droste and Keller (1989) constructed detailed sub-Pennsylvanian paleogeologic maps of the Illinois Basin. The maps showed predominantly southwestward-flowing drainage systems of valleys ranging from a few feet to more than 300 feet deep and up to 20 miles wide.

## PENNSYLVANIAN SYSTEM

### Caseyville Formation

The Caseyville Formation comprises the cliff-forming, quartz-pebble-bearing sandstone and the associated siltstone, shale, and coal overlying Mississippian strata. Owen (1856), named the formation the "Caseyville Conglomerate," for strata exposed along the Ohio River near Caseyville in western Kentucky. Lee (1916) formally defined the Caseyville Formation and designated and described its type section in detail.

The Caseyville is dominated by fine to coarse grained, quartzose sandstone, characteristically containing subrounded quartz pebbles and granules. These pebble- and granule-bearing sandstones are readily distinguishable from Pope Group sandstones. Caseyville sandstones lacking pebbles and granules are generally coarser grained than Pope Group sandstones.

No complete exposure of the Caseyville is found in the Waltersburg Quadrangle because of erosion and faulting; thus, the total thickness is estimated from composite sections. The thickness is variable primarily because the formation was deposited on an uneven surface. A U.S. Forest Service well near Eddyville started below the top of the Caseyville and drilled through 257 feet of the formation without reaching its base (fig. 10). Core and outcrop studies near the northeast corner of the quadrangle indicate that the formation attains a thickness of 375 feet. Nelson et al. (1991) estimated the thickness of Caseyville to range from 200 to 400 feet in the adjacent Eddyville Quadrangle.

Since 1960, most geologic map makers in southern Illinois have divided the Caseyville Formation into the "Wayside" Member (oldest), Battery Rock Sandstone Member, "Drury" Member, and Pounds Sandstone Member (Desborough 1961, Baxter et al. 1963, 1967, Baxter and Desborough 1965, Nelson and Lumm 1990a, 1990b, Nelson et al. 1991). Nelson and Lumm (1987) recognized a basal Lusk Shale Member (equivalent to the "Wayside" Member), the Battery Rock Sandstone (a poorly exposed shaley interval), and the Pounds Sandstone. Because most Pennsylvanian outcrops in the Waltersburg Quadrangle consist of sandstone, only "Wayside" sandstone lentils, the Battery Rock Sandstone Member, and the Pounds Sandstone Member were mapped.

The "Wayside" and "Drury" Members are poorly defined and described in both their respective type areas and in the Waltersburg Quadrangle. These members consist of a variety of intergrading and intertonguing rock types that are dominated by fine grained clastics. Both members are poorly exposed and their contacts are generally concealed by talus and surficial sediments. The "Wayside" and "Drury" cannot be differentiated from each other in areas where the intervening Battery Rock Sandstone is absent. Mapping and correlation of units within the Caseyville is further complicated by faulting. These members are referred to

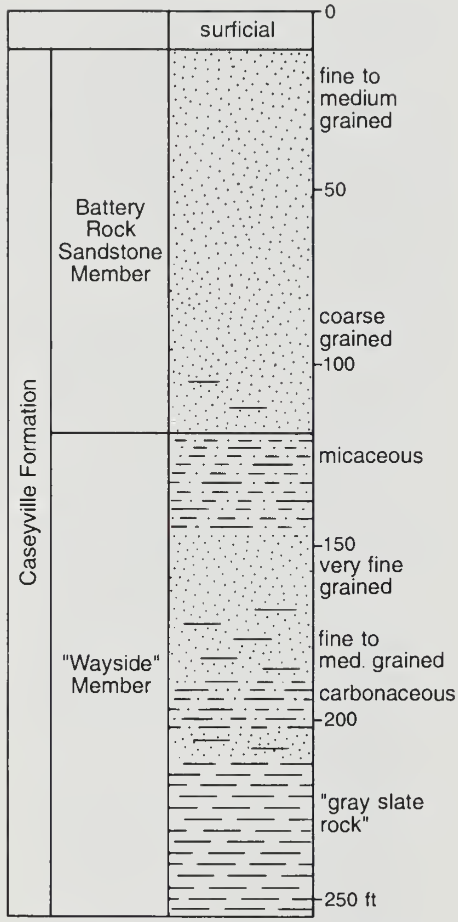



**Figure 10** Graphic column of U.S. Forest Service Eddyville guard station well in Section 6, T12S, R6E.

in this text as "Wayside" and "Drury" Members because of their questionable status as valid lithostratigraphic units in the Waltersburg Quadrangle.

**"Wayside" Member** Strata overlying Mississippian rocks and underlying the massive bluff-forming Battery Rock Sandstone are referred to as the "Wayside" Member. Lamar (1925) originally proposed the name "Wayside sandstone and shale member" for strata exposed southeast of Wayside in Union County, Illinois. Kosanke et al. (1960), referred, without explanation, to the unit as the Wayside Sandstone Member. Nelson et al. (1991) redefined the unit as the Wayside Member. Lamar (1925) described the member as consisting of lithologically variable, lenticular beds that thicken and thin "with confusing abruptness." He further described sandstone beds that ranged from thin bedded to massive, fine to coarse grained, and "pure" to argillaceous. According to Lamar, the

Wayside contains shales having wide textural and compositional ranges, and rare, thin beds of argillaceous limestone, coal, and conglomerates of quartz pebbles. In the Waltersburg Quadrangle, sandstones within the member are of variable lithology, some of which lithologically resemble the overlying Battery Rock Sandstone. The "Wayside" Member consists of interlayered sandstone, siltstone, shale, and coal. Ledge- and cliff-forming sandstones of the "Wayside" are delineated on the geologic map of Weibel et al. (1992).

Sandstone lentils of the "Wayside" Member crop out near the northwest corner of the quadrangle, where they consist predominantly of ledge-forming sandstone, and in the southeast half of the Dixon Springs Graben, primarily between the Raum and Hobbs Creek Fault Zones, where they consist of thick bedded sandstone and thin bedded lithofacies.

In the northwestern area, the sandstone is light brown to tan and weathers light brown to gray; it ranges from very fine to medium grained but is generally fine grained. This unit is a quartz arenite containing rare dark accessory mineral grains. The grains are subangular to subrounded and well sorted. The moderately to well indurated sandstone contains rare shale clasts. Bedding ranges from 0.5 foot thick to massive, and bedding surfaces are irregular in some places. Ripple marks are common and low-angle crossbeds (generally oriented south-southwest) are common in some places. The sandstone splits into two or more tongues, or lentils, that are separated by mostly covered intervals and form ledges 5 to 40 feet thick. Intervals of poorly exposed shale 5 to 10 feet thick are intercalated with sandstone. The shale is gray to dark gray and weathers light gray to brown; it is moderately fissile and noncalcareous. In some places, it contains abundant carbonaceous plant fossils.

Lentils of thick bedded "Wayside" sandstone crop out in the southeast half of the Dixon Springs Graben, primarily between the Raum and Hobbs Creek Fault Zones. These lentils generally overlie thin bedded "Wayside" sandstones; however, at scattered localities along Beatty Branch and along Lusk Creek, the lentils rest on or occur just above Mississippian strata. The sandstone is white to gray and weathers light tan to brown and has rare Liesegang banding. The grain sizes range from fine to coarse, but they are generally medium sized and subangular.

The sandstone is a quartz arenite that contains rare dark accessory minerals. The medium to well indurated sandstone contains rare to abundant rounded to subrounded quartz pebbles and shale clasts in some places. The pebbles occur either as scattered clasts or in conglomeratic lenses that are up to 3 feet thick and contain a ferruginous cement. The sandstone is poorly to well sorted, depending upon the amount of quartz pebbles; generally, the sandstone is well sorted. Fossil plant casts are locally common, and ripple marks and planar crossbeds are present and locally abundant. Bedding ranges from 0.5 foot thick to massive. The sandstone usually crops out as a bluff that ranges from 10 to 40 feet high. In some places, the sandstone is 80 feet high or forms two ledges.

Between the Raum and Hobbs Creek Fault Zones, thick bedded "Wayside" sandstone containing quartz pebbles closely resembles the Battery Rock Sandstone. In some places, these pebbles are concentrated within the "Wayside" sandstone; pebbles within the Battery Rock are more uniformly distributed throughout the sandstone. These "Wayside" sandstones also contain iron-cemented conglomeratic lenses, which are characteristically rare in the Battery Rock.

The thin bedded lithofacies of the "Wayside" Member is poorly to moderately exposed and composed of sandstone, siltstone, shale, and coal. The sandstone is white to light gray and weathers light tan to brown. It is very fine to fine grained, well indurated, and generally well sorted, except where quartz pebbles are present. The sandstone is a quartz arenite that contains rare accessory dark minerals and mica. Bedding generally is tabular and less than 0.5 foot thick, but occasional lenticular beds are up to 3 feet thick. Low-angle crossbeds occur in some places. Ripple marks are common to abundant; their crest orientations are locally divergent. Small load casts, flute casts, and tool marks are locally abundant and trace fossils consisting of simple trails and burrows are locally common. Plant casts are also common.

The thin bedded sandstone is interlayered with siltstone and shale. The siltstone is gray, quartzose, noncalcareous, up to 20 feet thick, and wavy bedded. The shale, less than 10 feet thick, ranges from light gray to dark gray to light brown; it is noncalcareous, fissile, and poorly to moderately indurated. Locally, it contains silty interbeds or is silty and contains carbonaceous plant fragments. Conglomeratic sandstone lenses occur within this shale. Clasts in the conglomerate consist predominantly of quartz pebbles, but also include chert, siderite, sandstone, and shale. Shale clasts are up to 0.3 foot long. The matrix is sandstone and the cement is generally ferruginous. The conglomerate lenses are 1 to 3 feet thick. A good exposure of a lens is along Beatty Branch in the NW NE SW, Section 27, T12S, R6E. Black carbonaceous shale occurs in the "Wayside" along the stream bed that is parallel to the Raum Fault Zone in Section 13, T12S, R6E. Soft gray shale containing fragmentary plant impressions crops out in a roadcut along Illinois 145 in the NE SE SE, Section 14, T12S, R6E. Soft sediment deformation (slumped bedding) is common where the "Wayside" consists of interbedded shale and sandstone (fig. 11). The thin bedded "Wayside" lithofacies overlies, underlies, and laterally grades into the thick bedded "Wayside" sandstones. The lateral gradation is exposed near the east edge of the quadrangle between the Raum and Hobbs Creek Fault Zones.

The "Wayside" Member in the northwestern part of the quadrangle is up to 120 feet thick where it fills a pre-Pennsylvanian paleovalley. The outcrop pattern of the sandstone beds indicates the paleovalley trends northeast-southwest, nearly parallel to Illinois 145. In the east-central part of the quadrangle, the member is more than 120 feet thick. The best exposures of the thick bedded "Wayside" in this area are along Beatty Branch and in ravines along the east edge of the map area, particularly in the area around the SW Section 24, T12S, R6E.

Structural movements in the Dixon Springs Graben may have influenced deposition of the thin bedded "Wayside" lithofacies, which is

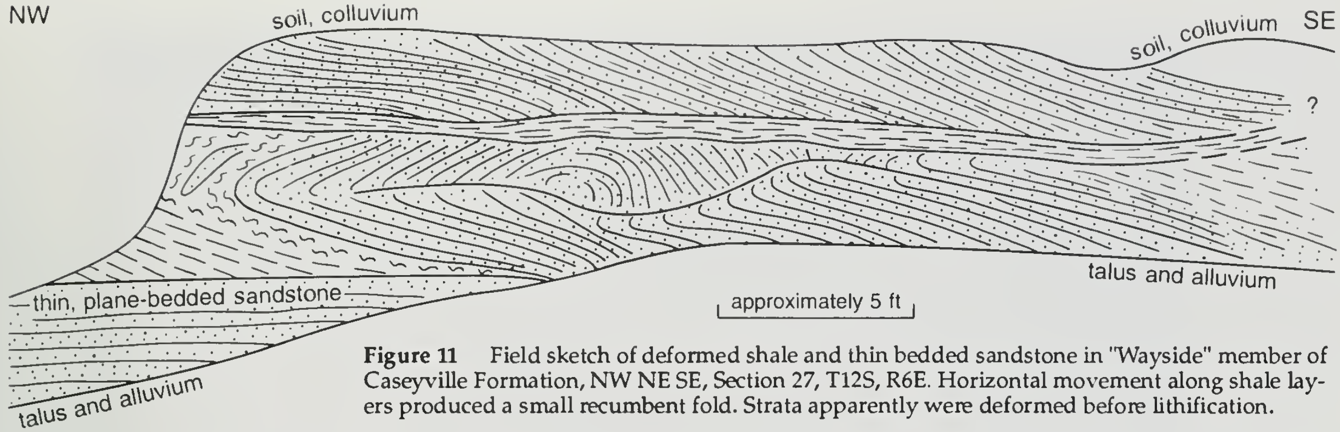



**Figure 11** Field sketch of deformed shale and thin bedded sandstone in "Wayside" member of Caseyville Formation, NW NE SE, Section 27, T12S, R6E. Horizontal movement along shale layers produced a small recumbent fold. Strata apparently were deformed before lithification.

thicker in the graben than in the area northwest of the graben, except in the paleovalley. Thin beds of conglomerate, particularly those containing cobble-sized clasts, suggest local periodic uplifts that either supplied clasts directly or diverted drainages; both actions accelerated downcutting. Paleoslumped beds outcropping along Beatty Branch may have been caused by penecontemporaneous tectonism. An alternative explanation is that the slumped bedding is the result of sediment loading on top of unstable, water-saturated deposits.

**Battery Rock Sandstone Member** The lower of two relatively widespread bluff-forming, quartz-pebble-bearing sandstones in the Caseyville Formation is referred to as the Battery Rock Sandstone Member. Cox (1875) named the member for Battery Rock, a massive sandstone bluff along the Ohio River in Hardin County, southern Illinois. It crops out extensively in the vicinity of Eddyville; smaller exposures are in Pine Hollow and along Beatty Branch near the Raum Creek Fault Zone, as well as in a large ravine northeast of Raum.

The Battery Rock is a white to light gray to light brown sandstone that weathers gray brown to brown. It is fine to very coarse grained, but generally coarse grained, and contains abundant quartz pebbles. Grains in this quartz arenite are subangular and poorly to moderately sorted. The quartz pebbles are gray to white, rounded to subrounded, and up to 0.1 foot in diameter. The pebbles occur in conglomeratic lenses, often aligned along bedding and crossbedding surfaces, or scattered throughout the rock. The Battery Rock generally contains more quartz pebbles and granules than other Caseyville members; Battery Rock strata lacking pebbles are rare. Dark accessory minerals are rare and mica is absent. Fossil plant casts, including lycopods and calamitids, and tabular crossbeds, both large and small scale, are common. Most crossbeds are oriented to the southwest, but along Frieze Branch, a few are oriented to the northwest. Bedding ranges from 0.5 foot thick to massive. The sandstone forms ledges and bluffs 5 to 40 feet high.

In the few places where it is exposed, the lower contact of the Battery Rock is generally sharp and lies at the base of the massive pebble-bearing sandstone. The upper contact is not exposed in any outcrop; it was mapped at the highest exposure of sandstone containing abundant pebbles, generally at the top of a ledge or bluff. In the core of COGEOMAP W-1 Well (fig. 12), the upper contact is gradational. In Sections 13 and 14, T13S, R5E (Pine Hollow and Avery Hollow), the Pounds Sandstone lies directly on top of the Battery Rock, and the two members cannot be readily differentiated. The Battery Rock Sandstone is generally 30 to 60 feet thick; it is more than 110 feet thick near Eddyville (fig. 10).

Through most of the quadrangle, the Battery Rock Sandstone consists of isolated tongues and lenses of thick bedded to massive conglomeratic sandstone, generally enclosed by the "Drury" and "Wayside" Members. Southwest of Eddyville, along Hayes Creek, the Battery Rock consists of several cliff-forming intervals, separated by bench-forming intervals of poorly exposed strata. The Battery Rock has been identified in a few small areas southeast of the Lusk Creek Fault Zone. The lenticular nature of the Battery Rock in this quadrangle contrasts with the nearly continuous, more tabular character of the formation in the adjacent Eddyville and Stonefort Quadrangles (Nelson and Lumm 1990a, b).

**"Drury" Member** The interval of fine grained, thin bedded strata between the Battery Rock and Pounds Sandstone Members is referred to as the "Drury" Member. Lamar (1925) originally proposed the name, Drury Shale and Sandstone Member, for strata cropping out along Drury Creek in Jackson County, southern Illinois. Lamar defined the member as "the unit of interbedded shale and sandstone lying above the Lick Creek and below the next persistent, thick, massive sandstone above, the Makanda." The Lick Creek and the thick, massive Makanda sandstone were considered to be equivalent or nearly equivalent to the Battery Rock and the Pounds Sandstones (Wan-

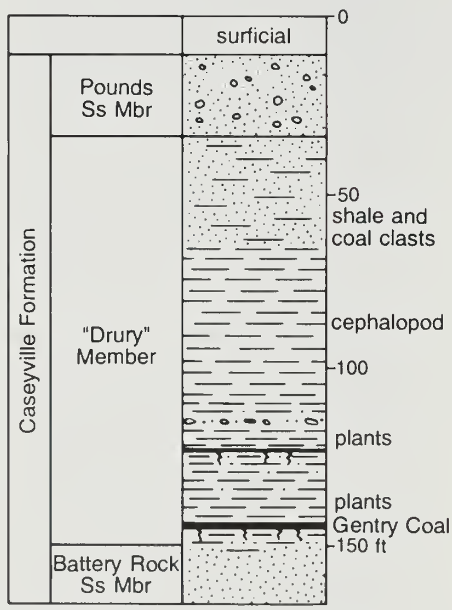



**Figure 12** Graphic column of core from COGEOMAP W-1 Well in Section 14, T12S, R6E.

less 1939, J. Weller 1940, Desborough 1960). Mapping now in progress indicates that the Battery Rock and Pounds Sandstone Members cannot be readily identified and differentiated in the "Drury" type area in the Makanda Quadrangle. The status of the "Drury" as a valid member is questionable because of its uncertain definition. In addition, the Drury and the "Wayside" Members cannot be differentiated where the Battery Rock Sandstone is absent.

The "Drury" Member is poorly exposed in the Waltersburg Quadrangle and was not mapped as a separate unit. The "Drury" has been generally faulted out of sequence and crops out only in a large ravine northeast of Raum and in a small area along the Raum Fault Zone in Avery Hollow. The unit generally forms a gentle slope beneath the Pounds Sandstone and is often covered by talus from the Pounds. A complete top-to-bottom core of the "Drury" was recovered from the COGEOMAP W-1 Well (fig. 12) and a partial core was recovered from the COGEOMAP W-2 Well (fig. 13).

The outcrop sequence of the "Drury" in the large ravine northeast of Raum (SW, Section 12, and NW, Section 13, SE, Section 14, T12S, R6E) is about 70 feet thick and displays variable lithologies (fig. 14). The lower coal is argillaceous and probably equivalent to the Gentry Coal Bed that was mapped to the east (Baxter et al. 1963, Baxter and Desborough 1965, Baxter et al. 1967) and to the north (Nelson and Lumm 1990a). A stream bed exposure (NE NW NW, Section 13, T12S, R6E) of the coal contains lycopod leaves and pteridosperm axes (W. A. DiMichele, personal communication, 1986). The dark gray to black shale above this coal contains abundant carbonaceous plant impressions. In the middle, the "Drury" contains an argillaceous coal bed 0.5 to 0.7 foot thick.

A lenticular body of siltstone, about 10 feet thick, in a ravine in the center E 1/2 E 1/2 SE, Section 12, T13S, R5E is tentatively included in the "Drury" Member. The siltstone is gray, micaceous, argillaceous, and contains plant fragments. The siltstone is overlain and underlain by a massive sandstone that bears quartz pebbles and is either Battery Rock or Pounds. Alternatively, the siltstone may occur entirely within the Pounds and not as part of the "Drury."

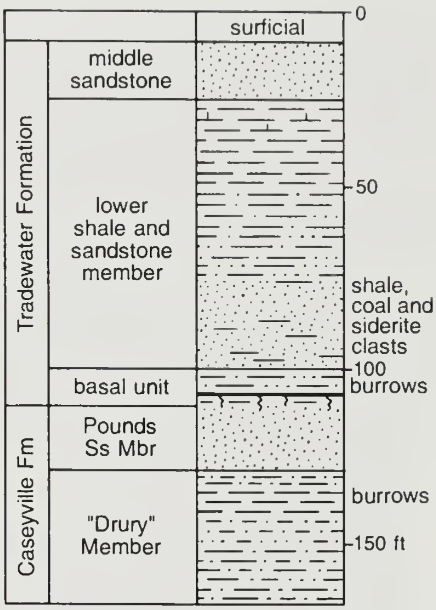



**Figure 13** Graphic column of core from COGEOMAP W-2 Well in Section 15, T12S, R6E.

The "Drury" in the COGEOMAP W-1 core (fig. 12) consists of more than 120 feet of interbedded siltstone, shale, thin conglomerate, and two thin coals. The lower contact with the underlying Battery Rock Sandstone Member is transitional. The thick, dark gray shale at the top contains scattered mollusks, including a small orthoconic cephalopod. The shale may correlate with a goniatite-bearing shale in the Eddyville Quadrangle (Devera et al. 1987).

The middle and upper parts of the "Drury" were recovered from the lowermost 37 feet in the core of COGEOMAP W-2 Well (fig. 13) where it is dominated by shale. The contact with the overlying Pounds Sandstone Member is gradational.

## Pounds Sandstone Member

The upper of the two sandstones in the Caseyville Formation is referred to as the Pounds Sandstone Member. The sandstone is widespread, forms bluffs, and bears abundant quartz pebbles. J. Weller (1940) named the member for strata in Pounds Hollow (Gallatin County), southern Illinois. The Pounds crops out south-southwest of Rock (figs. 2, 15), in a narrow northeast-trending belt on the northwest side of the Raum Fault Zone, and just west of Eddyville. A nearly complete top-to-bottom core of the Pounds was recovered from COGEOMAP W-2

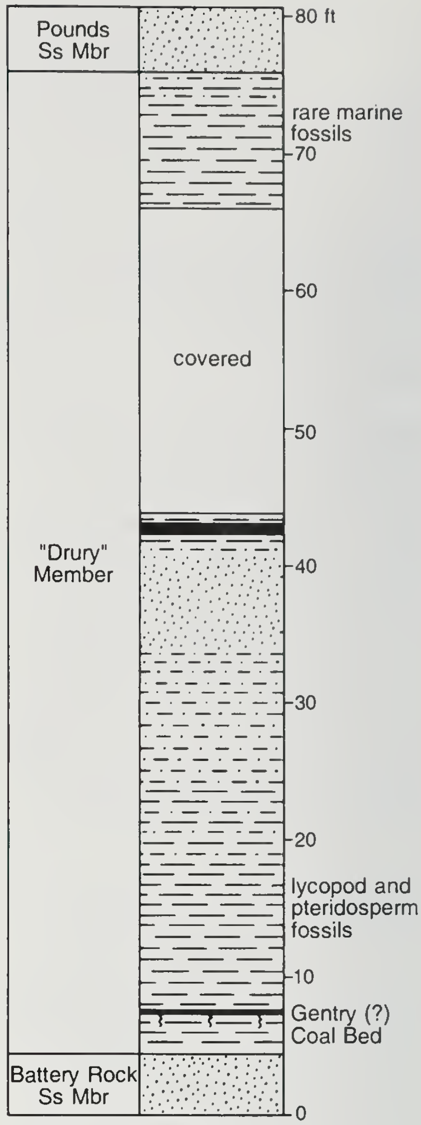



**Figure 14** Graphic column of "Drury" member of Caseyville Formation, from measured section in a ravine in E1/2 SW, Section 12, T12S, R6E.

Well (fig. 13) and the upper part from COGEOMAP W-1 Well (fig. 12).

The Pounds consists chiefly of quartz arenite that is white to light gray and weathers tan to light brown; it is medium to coarse grained and very coarse grained in some places. The quartz grains are subangular to subrounded; dark minerals and mica are rare, as are Liesegang banding and iron oxide grain coatings. Sorting ranges from poor to medium, depending upon the amount of quartz granules and pebbles present. Quartz granules and pebbles are rare to abundant. They are white to gray white, subrounded to rounded and generally scattered; they are aligned along bedding planes in some places. Pla-

**Figure 15** Pounds Sandstone Member of Caseyville Formation forming picturesque bluffs southwest of Rock, in SW SW SE SE, Section 2, T13S, R5E. The bluffs are typical in their massive appearance, rounded ledges, and honeycomb weathering. These strata dip about 4°NE.

nar crossbeds and ripple marks are common in the moderately to well indurated sandstone. Bedding ranges from 0.5 foot thick to massive. The member generally forms bluffs 10 to 40 feet thick. The member contains a few interbeds of shale and siltstone and a local, unnamed coal. The coal crops out in the NE SE SE SE, Section 32, T12S, R6E; it is up to 0.5 foot thick, lenticular, and argillaceous.

In general, the Pounds is lithologically similar to the Battery Rock Sandstone except that quartz pebbles are smaller and less numerous in the Pounds. Most pebbles are less than 0.1 foot in diameter, and they are scattered throughout the sandstone.

The Pounds ranges from 20 to 75 feet thick. The lower contact is not exposed but is sharp in the core of COGEOMAP W-2 Well. The upper contact is poorly exposed; the contact was mapped at the highest exposure of sandstone bearing quartz pebbles. The contact is often at the top of a massive bluff; however, the contact was slightly above a ledge or bluff in some areas.

## Tradewater Formation

Strata dominated by subgraywacke sandstones and fine grained clastics overlying the Caseyville Formation are referred to as the Tradewater Formation. The name, Tradewater Formation, was proposed by Glenn (1912a) for the interval between the top of the Caseyville Formation and the base of the Sebree Sandstone in western Kentucky. The upper boundary of the formation has been revised several times (Glenn 1912b, Lee 1916, Glenn 1922, Wanless 1939, Kehn 1963), but the lower boundary has not. Kosanke et al. (1960) abandoned the name Tradewater in favor of the Abbott and Spoon Formations. Jacobson (1991), citing problems with differentiating the latter formations on a regional basis, resurrected the name Tradewater Formation. In the Waltersburg Quadrangle, the Tradewater forms a wide northeast-southwest outcrop belt comprising most of the bedrock in the northwest half of the Dixon Springs Graben.

The Tradewater Formation is composed of sandstone, siltstone, shale, and thin coal beds. Sandstone, roughly 1/2 to 2/3 of the total interval, is very fine to coarse grained and contains local shale clasts and quartz granules; quartz pebbles are absent. Tradewater sandstones are mineralogically less mature than those of the Caseyville, and contain more mica, feldspar, lithic grains, and interstitial clay. Weathering of these accessory grains produced iron oxide grain coatings; Tradewater sandstones thus generally weather to a darker color than Caseyville sandstones. Tradewater sandstones appear progressively less mineralogically mature upward through the formation. The youngest Tradewater sandstone is distinguishable from the pebble-bearing quartz arenites of the Caseyville Formation, but it is difficult to distinguish from the underlying Tradewater sandstone.

The petrologic change between the Caseyville and younger Pennsylvanian rocks is gradational. Potter and Glass (1958) classified Pennsylvanian sandstones of the Illinois Basin into three groups: an orthoquartzitic group (Caseyville Formation), a transitional group (lower half of Tradewater Formation), and a subgraywacke group (upper half of Tradewater Formation and younger Pennsylvanian sandstones). They described the Caseyville sandstones as consisting primarily of quartz (95% detrital component). Carbonate is a secondary component, and feldspar, lithic fragments, matrix clay, and mica are rare. The transitional sandstones consist of quartz (83% detrital component) and secondary carbonate (dominated by siderite). They also have slightly more feldspar, lithic fragments, matrix clay, and mica than does the Caseyville. Potter and Glass (1958) characterized the transition group as being "somewhat less well sorted" and having more angular grains than the Caseyville.

The Tradewater Formation in this quadrangle generally consists of a composite sequence of three informal lithologic members: lower shale and sandstone member, middle sandstone member, and upper shaley member. The boundaries of these members are poorly exposed and poorly defined, and their lateral extent is not well known. The members, therefore, were not mapped individually for this report, although the tops of prominent ledge-forming sandstone are shown on the geologic map of Weibel et al. (1992).

**Lower shale and sandstone member** The lower member of the Tradewater Formation consists of a poorly exposed sequence that ranges from 50 to 85 feet thick. It is dominated by shale and contains lenticular sandstones and thin discontinuous coals.

The lower contact and base of the formation is not exposed; however, it is present in the core of COGEOMAP W-2 Well (fig. 13) where the top of the Caseyville Formation grades upward into a claystone containing root casts. The claystone is succeeded by a thin argillaceous coal and a dark gray, abundantly bioturbated siltstone. A similar succession is exposed in the large ravine east of the COGEOMAP well in the SW NW, Section 14, T12S, R6E, as described by H. Wanless (1934, unpublished ISGS field notes). The interval, at an abandoned mine site, is an upward succession of soft claystone, coal, dark gray shale containing plant fossils, micaceous shale, very fine grained sandstone with root casts, claystone with root casts, and dark gray to black shale. Coal that crops out in a small northeast-trending ravine, just east of the Eddyville–Golconda road (NW SE, Section 22, T12S, R6E), is also probably equivalent to the coal described by Wanless. At this site, the coal is overlain by gray silty shale. In the center of Section 28, T12S, R6E, the basal Tradewater interval consists of light gray to gray shale and siltstone with scattered thin sandstone beds. In the southwest quarter of the quadrangle, the basal part locally contains a coal that was mined in the center of the S 1/2 S 1/2, Section 12, T13S, R5E. The coal is interpreted, on the basis of palynological analysis (Peppers, unpublished ISGS data, 1970), to be younger than the Reynoldsburg Coal Bed, older than the Manley Coal Bed, and possibly equivalent to the Tunnel Hill Coal Bed (Nelson et al. 1991) and the Bell Coal Bed of western Kentucky. The coal mined in Section 12 reportedly was as much as 3.5 feet thick (Wanless, unpublished ISGS field notes, 1934, 1977, 1978) and underlain by soft claystone and overlain by up to 1 foot of claystone, friable sandstone, or a conglomerate of shale clasts and coal particles in a sandstone matrix.

The lower shale and sandstone member of the Tradewater contains lenticular sandstone bodies, generally in the middle part but also near the base. These basal Tradewater sandstones may directly overlie the Caseyville. The previously described basal interval in Section 28 is succeeded by a thick lenticular sandstone. The sandstone generally forms one or two thin ledges that overlie the basal shale sequence. This sandstone is approximately equivalent to the Grindstaff Sandstone Member, Abbott Formation, of Baxter and Desborough (1965) and Baxter et al. (1967). Nelson et al. (1991) mapped lower Abbott sandstone lentils at about the same stratigraphic position in adjacent quadrangles to the north and northwest.

The sandstone of the lower shale and sandstone member of the Tradewater is white to light gray and weathers buff to pink to brown; it is generally fine to medium grained and rarely very fine or coarse grained and well indurated. The grains are well sorted, subangular, dominated by quartz and have variable amounts of accessory dark minerals and mica, and rare clay coatings. Liesegang banding is locally common. Shale laminae and interbeds are rare. Bedding ranges from thin (less than 1 ft) to massive. Ripple marks are rare to common, particularly in the thinner beds. The sandstone crops out as either one or two ledges that have a total thickness ranging from 5 to 30 feet. The sandstone is similar to the Pounds Sandstone, except that quartz pebbles are absent and slightly more accessory minerals are present. A unit of fine grained sandstone and siltstone lies between the sandstone and the upper part of the member. The best exposures of these lenticular sandstones are in the large ravine in the NE SW, Section 28, T12S, R6E, and along Lusk Creek in the center, Section 32, T12S, R6E. The core of COGEOMAP W-2 Well includes 24 feet of this sandstone (fig. 13).

Laterally equivalent to the lenticular sandstone is a succession of interbedded, thin bedded sandstone, siltstone, and shale. The sandstone, up to 1 foot thick, is very fine to fine grained, and contains subangular quartz grains and some mica and dark minerals. It is formed in beds 0.3 to 0.7 foot thick, is resistant, and contains shale clasts. The siltstone is well sorted quartzose and contains abundant carbonaceous plant fragments. It is well indurated and has planar bedding less than 0.2 foot thick. The shale is gray to dark gray, noncalcareous, and fissile. It occurs in units up to 0.4 foot thick.

The upper part of the lower shale and sandstone member is lithologically variable (fig. 16) and consists of shale, siltstone, and thin coal. The shale is dark gray, fissile, carbonaceous, and commonly contains plant fossils. Coal crops out in the SE SE, Section 29, T12S, R6E, and in the center NE, Section 32, T12S, R6E. The coal is 2 to 2.5 feet thick, contains a 0.2-foot clay parting, and overlies a light gray claystone with root casts. At the site in Section 29, the upper 1 foot of the coal is argillaceous and underlies about 7 feet of dark gray shale that contains abundant plant compressions (unpublished ISGS field notes by M. Hopkins and R. Peppers, 1967, and R. Peppers and R. Jacobson, 1974). The coal at the site in Section 32 is partially exposed and 1 foot thick. It is palynologically similar to the Smith coal bed of the lower Tradewater Formation in western Kentucky (R. Peppers, written communication, 1974). The fossil flora are dominated by lycopods, including stems of *Lepidodendron aculeatum*, foliage, cones, and stigmarian root impressions (James Jennings, personal communication, 1989). This coal overlies gray massive claystone and underlies poorly indurated, silty, very fine grained sandstone that has shale interbeds (2 to 3 feet thick). Above the shale is a sandstone; it is orange brown to brown, medium grained, moderately indurated and sorted, and locally cemented with dark brown iron oxide. Bedding is 0.1 to 0.5 foot thick. The section is capped by a coarse grained sandstone of the middle sandstone member.

**Middle sandstone member** The middle sandstone member of the Tradewater Formation forms ledges and cliffs along Lusk Creek in the northern part of the Dixon Springs Graben and along Quarrel Creek in the southern part of the graben. This sandstone is lithologically

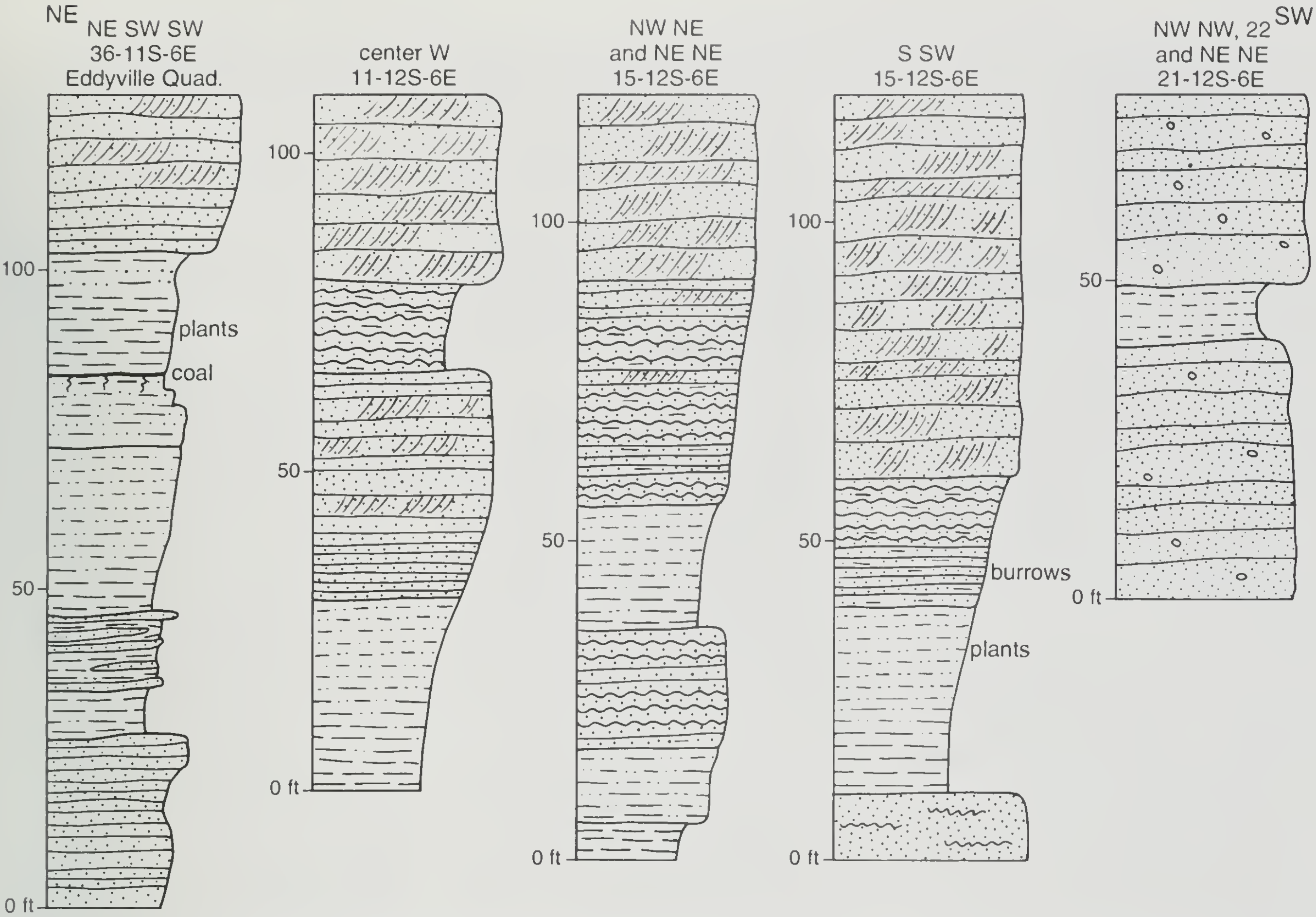



**Figure 16** Graphic columns of measured sections in the Tradewater Formation within the Dixon Springs Graben demonstrating complex lithofacies changes. Datum is the top of the sections and is approximate.

and stratigraphically similar to the Finnie Sandstone Member of the Abbott Formation of Baxter et al. (1967) and the middle Abbott sandstone of Nelson et al. (1991).

The middle sandstone member is light gray to buff and weathers brown gray to dark brown; it is medium grained, rarely fine or coarse grained, and moderately to well indurated. The grains are subangular, moderately to well sorted, and dominated by quartz. Mica and dark minerals are rare to common; lithic fragments and clay grain coatings are rare. This sandstone contains more nonquartz components than does Caseyville sandstone. Liesegang banding is common, and the unit locally contains scattered quartz granules and shale clasts. Bedding ranges from 0.25 to 1.25 feet thick and is generally planar; it is locally wavy to irregular. Low-angle crossbeds and ripple marks are common in some places. The sandstone forms ledges 5 to 35 feet high.

The sandstone is interbedded in places with very dark gray, noncalcareous, fissile shale or very dark gray to brown, well indurated, noncalcareous, laminated siltstone. Along Lusk Creek in Sections 21, 29, 31, and 32, T12S, R6E, the entire interval becomes shaley and thin to medium bedded, and it is not easily distinguished from adjacent units.

The middle sandstone member ranges from about 25 to 135 feet thick. It is thinner to the southeast where it is finer grained and grades into underlying strata. The sandstone is thickest adjacent to and southeast of the Lusk Creek Fault Zone. The lower contact is generally covered; where it is exposed, it cuts down into the underlying shale and sandstone member. The upper contact of the member is shown on the geologic map (Weibel et al. 1992).

**Upper shaley member** The youngest bedrock strata in the Waltersburg Quadrangle consist of interbedded shale, siltstone, and sandstone overlying the middle sandstone member of the Tradewater. These rocks are roughly equivalent to the middle-upper Abbott Formation of Baxter and Desborough (1965) and Baxter et al. (1967), and to the olive shale of Nelson et al. (1991).

The member is predominantly composed of light gray to buff, very fine to fine grained sandstone that weathers yellow brown to orange brown. The sandstone is dominated by quartz and contains mica. Bedding is generally less than 1 foot thick and bedding planes are irregular. Ripple marks and shale clasts and partings are common. The sandstone is generally interbedded with very dark gray to black, fissile shale, gray to dark gray laminated silty shale, and gray to brown quartzose siltstone. The member is poorly exposed and occurs only in the synclinal area of the Dixon Springs Graben adjacent to Lusk Creek. The thickest section exposed is about 100 feet.

# SURFICIAL GEOLOGY

## INTRODUCTION

The surficial geology of the Waltersburg Quadrangle was studied as part of a cooperative project between the Department of Geology, Southern Illinois University at Carbondale (SIUC), and the ISGS. The surficial materials studied include all the relatively soft, nonlithified sediments that cover the Paleozoic bedrock of the region. The deposits formed during the Quaternary Period, the most recent geologic time period. The Quaternary deposits cover a major unconformity, a break in the geologic record that represents almost 300 million years between the Paleozoic and Quaternary Periods. In the study area the surficial deposits consist of loess, alluvium, colluvium, lacustrine deposits, and weathered residual material derived from the bedrock.

Surficial geologic materials may contain natural resources, such as groundwater or sand and gravel aggregates. Their composition, thickness, and physical characteristics determine the suitability of a site for specific land uses, such as a municipal landfill or industrial complex. The characteristics of the surficial deposits also affect drainage, groundwater recharge, and the impact of certain environmental hazards, such as flooding and earthquakes on the region.

This investigation included (1) characterizing the surficial materials in terms of particle size distribution, clay mineralogy, and thickness; (2) summarizing the stratigraphy of the surficial deposits within the Waltersburg Quadrangle; (3) preparing a detailed stack-unit map of the surficial deposits (Oliver 1988); (4) assessing the resource potential of the Quaternary deposits, including shallow groundwater and aggregate; and (5) evaluating the suitability of the surficial materials for specific land uses.

## METHODOLOGY

### Field Methods

Because exposed Quaternary sections are rare in southern Illinois, samples of the surficial materials were collected with a hydraulic soil probe (Giddings Machine Company), which recovers core and auger samples 6 to 15 meters (20–50 ft) deep. Samples were generally collected with a slotted tube that yielded cores approximately 7.6 cm (0.25 ft) or 5 cm (0.16 ft) in diameter. Samples were also collected with a flight auger 5 cm (0.16 ft) in diameter. Drill sites were selected not only on the basis of landscape position and accessibility, but also on the basis of prospects for obtaining the most complete successions of unconsolidated surficial materials.

Cores were described in detail under field moisture conditions. Munsell color, mottles, soil structure, texture, presence or absence of carbonate minerals, manganese oxide, iron oxide concretions, and other features were described. Texture was determined following the U.S. Department of Agriculture textural classification. The weathering zone (soil horizons) terminology used is that of Soil Survey Staff (1975), with modifications by Follmer et al. (1985), and Soil Survey Staff (1992). Geologic samples were collected from the cores for laboratory analyses.

### Laboratory Methods

The particle size distribution of the samples was determined at the SIUC Department of Geology. A pipette method described by Graham (1985) was used. Particle size classes include clay (less than 0.002 mm), fine silt (0.002–0.02 mm), coarse silt (0.02–0.62 mm), and sand (0.62–2 mm).

Clay mineralogy of the samples was determined at SIUC by X-ray analysis of oriented slides of the less than 0.002-mm fraction. The clay fraction was placed on glass slides, dried, glycolated, and analyzed for diffraction spectra of the common clay and nonclay minerals. In this method, the instrument records peaks in the region of 17 Å as expandable clay minerals, 10 Å as illite, and 7 Å as kaolinite and chlorite.

Graham's (1985) method is modified from Hallberg et al. (1978) and is based on a routine method used by the ISGS to scan large numbers of samples for stratigraphic and classification purposes. This method yields useful clay mineralogy data for characterizing Quaternary sediments; however, many factors other than clay mineralogy may affect peak height, and the accuracy of the method is not well documented. Therefore, conclusions made on the basis of comparisons between clay mineralogy data from this report and clay mineralogy data determined by similar methods using different instruments should be used with caution.

### Construction of the Stack-Unit Map

The distribution of surficial deposits (lithostratigraphic units) is a function of the depositional conditions and the postdepositional erosional history of each unit. These two factors cause complex relationships among the stratigraphic units in the study area. A stack-unit map (Kempton 1981) illustrates the areal and vertical distribution of geologic materials to a given depth below the surface. A generalized stack-unit map was prepared by combining information obtained from 20 borings made in the area, field observations, and hand augering. Additional information on the distribution and nature of the near-surface materials came from the county soil survey report (Parks 1975). Soil reports provided information on the distribution and nature of near-surface materials. Maps included in the soil report show the distribution of particular soil series in the study area and are useful in distinguishing ma-

**Table 2** Relation between modern soil series and Quaternary map units.

Upland soils
- Grantsburg (generally slopes less than 12%)
- Robbs
- Zanesville (generally slopes less than 12%)

Sideslopes
- Beasely
- Muskingum-Berks
- Wellston
- Wellston-Berks
- Zanesville (generally slopes more than 12%)

Lowland (Cahokia)
- Belknap
- Ginat
- Sharon
- Weinbach

Lowland (Cahokia/Equality)
- Belknap
- Bonnie

Rock Outcrop
- Sandstone Rock Land

jor landscape and geologic boundaries. The surficial lithostratigraphic units were interpreted from the soil map units (table 2).

The preparation of a stack-unit map requires some subjective decisions; in some cases, boundaries cannot be drawn with certainty because of insufficient data. The vertical sequence of deposits from a borehole is first related to the soil series and landscape position; topographic features are then used as a guide to drawing map-unit boundaries. A boundary between geologic units crosses a soil-map boundary for two reasons: (1) the soil maps and the 7.5-minute topographic base of the stack-unit map are at different scales, and the topographic base does not show the subtle changes in slope identified on the soil maps; and (2) in geologic mapping, data from deep borings must be integrated with near-surface data. In general, geologic material more than 5 feet below ground surface has little effect on the type of soil series at a site.

A detailed stack-unit map of the Waltersburg Quadrangle was prepared at a scale of 1:24,000 (Oliver 1988). The boundaries for the stack-units should be considered transitional and used only for general evaluations of the surficial geologic materials. The maps do not provide sufficient data for site-specific interpretations. A copy of the map is available for inspection in the ISGS Library.

## STRATIGRAPHY

Stratigraphic studies facilitate understanding of the origin of the units and provide a framework for correlating and predicting their character and occurrence. The relationships of the surficial deposits is classified as (1) chronostratigraphic (time relationships), (2) lithostratigraphic (lithologic or compositional relationships), and (3) pedostratigraphic (soil development history or relationships of pedogenic attributes).

Most of the stratigraphic units in the area correlate with units described by Willman and Frye (1970) and Lineback (1979). The distribution of the lithostratigraphic units is controlled to a large extent by the geomorphic processes of erosion and eolian deposition. This explains the distinction between the sequence of surficial deposits in the present upland and lowland positions.

The nature and origin of the upland and valley lithostratigraphic and pedostratigraphic units observed in the Waltersburg Quadrangle (fig. 17) are described in this section. The upland deposits consist of loess overlying residuum on flat to moderately sloping surfaces that have not been substantially reworked by alluvial and colluvial processes. The valley deposits overlie bedrock in the bottomlands and consist of lacustrine strata or alluvial material or both.

### Lithostratigraphic Units: Upland Formations

**Oak formation** This is an informal unit (Nelson et al. 1991) used for classifying the unconsolidated material, primarily in stable upland areas in the Waltersburg Quadrangle, resting on bedrock and below loess. It is a sandstone residuum with abundant sandstone pebbles within a yellowish brown to brownish yellow matrix of clay, sandy clay, or clay loam. The Oak is oxidized and leached of carbonate material throughout its thickness, which ranges from 0.05 to 0.8 meter. The clay content of the unit (15–65%) often increases with depth at the expense of the silt fraction in thicker sections (more than 0.5 m) (figs. 18, 19a, b). In thinner sections, the sand content (10–45%) increases with

| CHRONOSTRATIGRAPHY | | | | LITHOSTRATIGRAPHY Uplands | LITHOSTRATIGRAPHY Valleys | PEDOSTRATIGRAPHY |
|---|---|---|---|---|---|---|
| QUATERNARY SYSTEM | Pleistocene Series | Holocene Stage | | Peyton Fm | Cahokia Fm | Modern Soil |
| | | Wisconsinan Stage | Valderan-Greatlakean Substage | | | |
| | | | Twocreekan Substage | | | |
| | | | Woodfordian Substage | Peoria Silt | Equality Fm | Buncombe soil |
| | | | Farmdalian Substage | | | Farmdale Soil |
| | | | Altonian Substage | Roxana Silt | Equality Fm | |
| | | Sangamonian Stage | | Oak formation | | Sangamon Soil |
| | | Illinoian Stage | | | | |
| | | Pre-Illinoian | | | | |

Figure 17 Stratigraphic classification of the Quaternary deposits in the Waltersburg Quadrangle.

depth at the expense of the silt fraction (figs. 19c–e). The kaolinite plus chlorite content increases with depth, which shows the influence of the bedrock as a source of sediment for the residual material.

Nelson et al. (1991) suggested that most of the Oak formation consists of material that is older than pre-Illinoian (300,000 to 2 million years) because of its stratigraphic position below correlated Illinoian units (Loveland Silt, Glasford Formation, and Teneriffe Silt) in the Eddyville, Stonefort, and Creal Springs Quadrangles. In the Waltersburg Quadrangle, the Oak formation was found below the Roxana Silt of Wisconsinan age. The Oak formation contains pedogenic features; where overlain by the Roxana Silt, this paleosol is correlated with the Sangamon Soil.

**Roxana Silt** The Roxana Silt overlies the Oak formation and is the result of loess deposition during late Altonian time of the Wisconsinan. This unit is generally a silt loam that ranges from 0.2 to 1.35 meters (0.66–4.43 ft) thick. It has a yellowish brown to dark yellowish brown matrix and light brownish gray mottles. The Roxana is oxidized and leached of carbonate minerals in all sections described in the study area. Clay content remains fairly constant (20–30%) with depth and any elevated clay content near the top of the Roxana probably resulted from clay elluviated from the Peoria Loess during modern pedogenesis. The expandable clay minerals that dominate the upper Roxana Silt (figs. 19a–e) indicate a northwestern source for the loess (Frye et al. 1962). The kaolinite plus chlorite fraction and the sand content increase toward the base of some sections (figs. 19a–d) and may indicate mixing of the Roxana with the underlying Oak formation. The Farmdale Soil developed in the Roxana Silt has a distinct platy structure and a slightly different color and particle size distribution that differentiates the Roxana from the overlying Peoria Silt.

**Peoria Silt** The Peoria Silt, also called the Peoria Loess, overlies the Roxana Silt and was deposited during Woodfordian Substage of the Wisconsinan Stage by eolian processes (McKay 1979). It is the surficial


**Figure 18** General locations of borings (see table 3 for specific information).

deposit on the stable upland positions. The Peoria Silt is oxidized to a yellowish brown matrix with light gray mottles, and leached of carbonate minerals. Its physical appearance is dominated by features associated with modern pedogenesis. In the study area, the Peoria Silt ranges from 0.90 to 1.75 meters (2.95–5.74 ft) thick; it is thicker than previously reported for locations farther north (Nelson et al. 1991). This increased thickness is a result of the proximity of the Waltersburg Quadrangle to the ancient Ohio River channel (Cache River, Bay Creek). Nelson et al. (1989) suggested that the valley now containing the Cache River and Bay Creek was used by the ancient Ohio River between 25,000 and 12,500 years ago.

The texture of the Peoria Silt ranges from silty clay loam to silt loam and has a relatively uniform sand content. The clay content ranges from 15% to 40% and greater values are found in the lower part (Bt horizon) of the modern soil (fig. 19). Near the ground surface, the Peoria contains more illite than expandable clay minerals. The percentage of expandable clay minerals increases with depth and the kaolinite plus chlorite decreases. This vertical trend is probably a function of pedogenesis, provenance change, and mixing with the Roxana Silt. The elevated illite content (figs. 19b–e, 20) indicates that at least a portion of the loess originated from a northeastern source (Wabash and Ohio River valleys) (Frye et al. 1962). The vertical trends in clay mineralogy and texture for the Peoria and Roxana Silts are typical for the southern Illinois region (Graham 1985, Hughes 1987, Nelson et al. 1991).

**Table 3** Locations of borings.

| Well | Location | | Elev. (ft) |
|---|---|---|---|
| W1 | SE NE | 13-12S-5E | 650 |
| W2 | SW NW | 19-12S-6E | 550 |
| W3 | NE NE | 12-13S-5E | 700 |
| W4 | SW SE SW | 26-12S-6E | 780 |
| W5 | NE NW NE | 9-12S-6E | 680 |
| W6 | NE NE | 25-12S-5E | 600 |
| W7 | NW NE | 11-12S-6E | 690 |
| W8 | NE NW | 23-12S-6E | 720 |
| W9 | NE SE | 9-13S-6E | 350 |
| W10 | SE SE | 18-13S-6E | 360 |
| W11 | SW SW | 28-12S-6E | 570 |
| W12 | NE SW SE | 13-13S-5E | 350 |
| W13 | SE SW | 12-13S-6E | 470 |
| W14 | NE SE | 8-12S-6E | 670 |
| W15 | NE SW | 11-13S-6E | 390 |
| W16 | NW NE | 6-13S-6E | 680 |
| W17 | NE SW | 6-13S-6E | 680 |
| W18 | NW NW | 20-13S-6E | 420 |
| W19 | SW SE | 23-12S-6E | 740 |
| W20 | NW SE | 7-12S-6E | 620 |

**Peyton Formation** The Peyton Formation includes all sediment deposited at the base of slopes by mass wasting and slope wash that has accumulated from the end of the Wisconsinan to the present. The Peyton consists of reworked loess, residuum, and bedrock clasts. The unit, generally thin, displays textural and mineralogic characteristics of the source material. In larger valleys the Peyton colluvial material grades laterally into alluvium that is stratified and better sorted. An arbitrary vertical line separates deposits that originated mostly from fluvial processes (Cahokia Formation) from those derived mainly from colluvial processes (Peyton Formation). The Flat Lick transect (fig. 20) shows the physical relationship between the Peyton Formation, the loess units, and the valley deposits in the study area.

## Lithostratigraphic Units: Valley Formations

**Equality Formation** Willman and Frye (1970) interpreted the Equality Formation as Wisconsinan-age lacustrine deposits. Shaw (1915), Frye et al. (1972), and Heinrich (1982) developed a conceptual model for deposition of the Equality Formation in the Saline River drainage

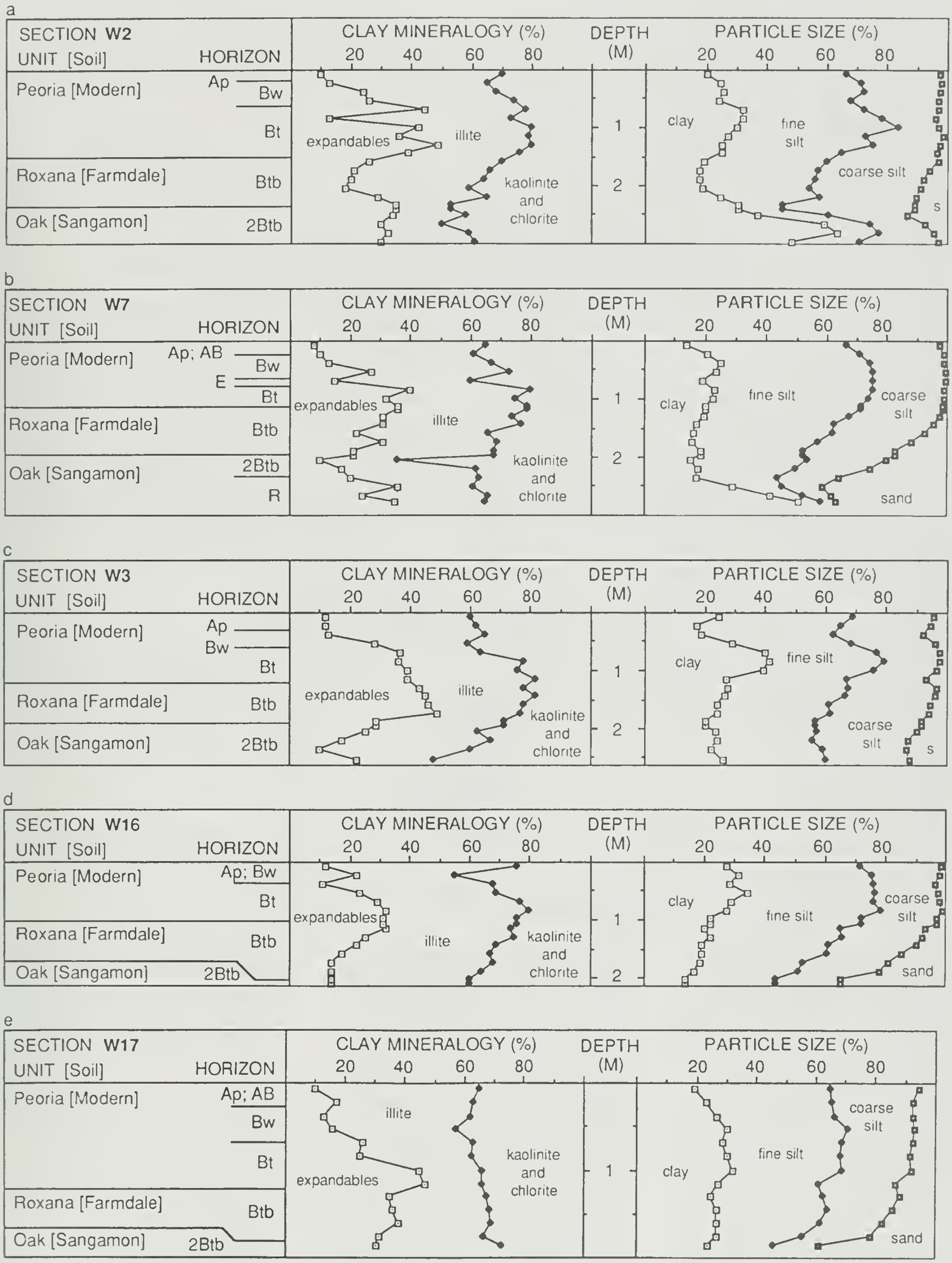



**Figure 19** Vertical distribution of clay minerals and particle sizes for borings (a) W2, (b) W7, (c) W3, (d) W16, and (e) W17 (for locations see fig. 18 and table 3).

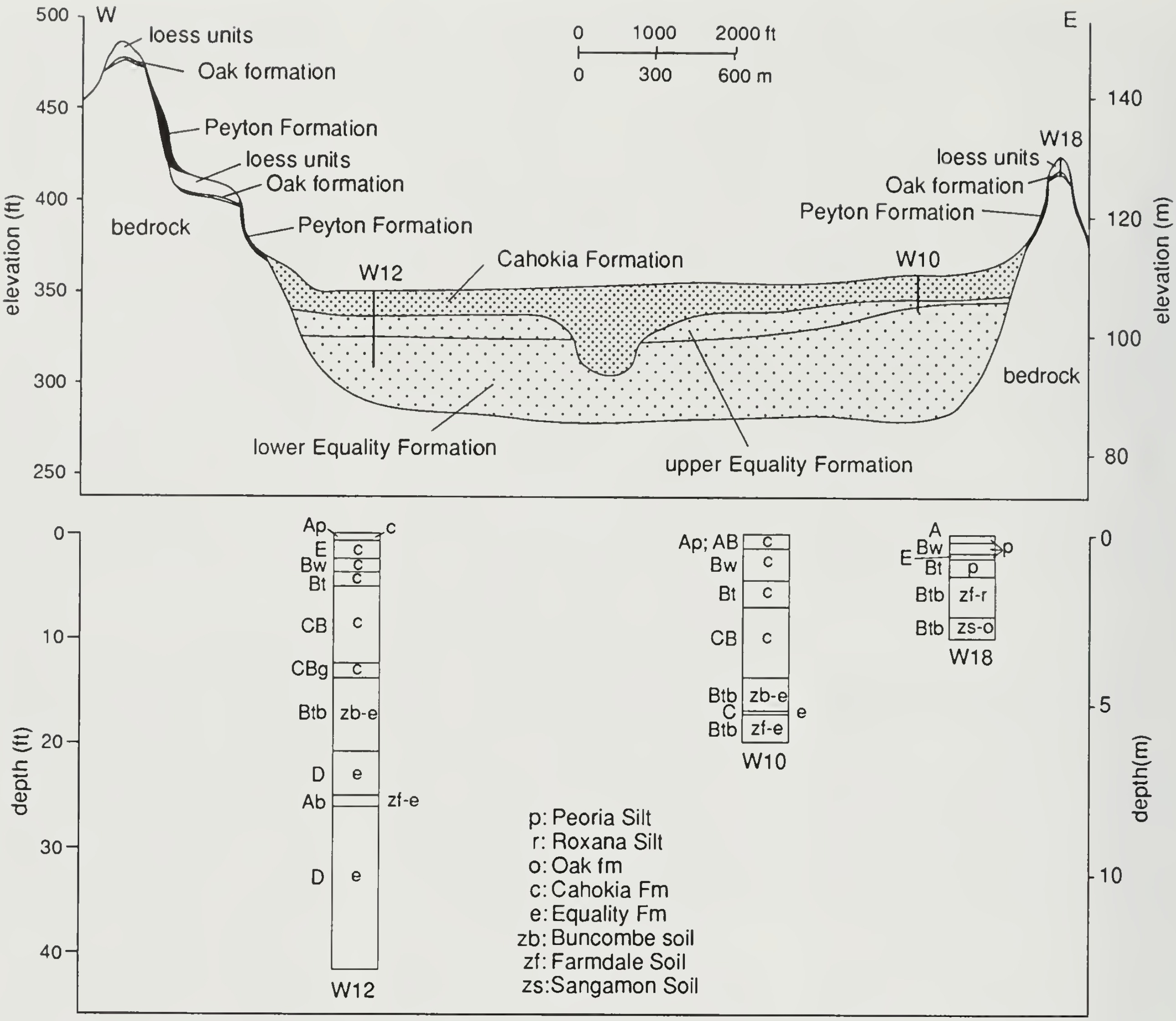



**Figure 20** Cross section showing the distribution of the Quaternary units in Flat Lick Valley (for location see fig. 18). Letters to the left of columns are soil horizon designations.

basin northeast of the Waltersburg Quadrangle. During the Altonian and Woodfordian Subages of the Wisconsinan, the Ohio River carried glacial outwash and aggraded faster than tributary valleys south of the glacial border. High water levels and sediment dams formed at the mouth of the Saline River, impounding water within the drainage basin. Sediment carried by floodwaters from the Ohio River and sediment from the watershed accumulated in the lake. A similar sequence of events explains lacustrine deposits discovered in two borings in the Flat Lick Valley in the southwest corner of the Waltersburg Quadrangle.

The Equality Formation in the Waltersburg Quadrangle can be divided into two informal lithostratigraphic members (Oliver 1988), herein referred to as the upper and lower members (fig. 20). Both members have an unoxidized dark gray color. Textures range from silty clay loam to clay with clay content as high as 80%. The matrix contains primary carbonate minerals and shell fragments in all described sections. Illite was the dominant clay mineral in both members, although the percentage of expandable clays increased upward through the upper member (figs. 21a, b). The larger content of expandable clay could have originated from erosion of Roxana Silt from the surrounding uplands during deposition of the upper member. Organic carbon from the Farmdale Soil developed in the top of the lower member dated at 22,650 ±440 years BP (ISGS 1604). The Buncombe soil, an informal pedostratigraphic unit (Graham 1985) developed in the top of the upper member beneath its contact with the Cahokia Alluvium.

Heinrich (1982) divided the Equality Formation in the Saline River Valley into two informal units: the Altonian Subage Cottage member and the Woodfordian Subage Texas City member. He differentiated them on the basis of stratigraphic position and composition. Each member was further divided on the basis of color, presence or absence of carbonate minerals, clay mineralogy, and texture. The upper part of the Cottage member (Heinrich's unit b) is equivalent to the lower part of the Equality Formation. His entire Texas City member is equivalent to the upper part of the Equality. These suggested correla-

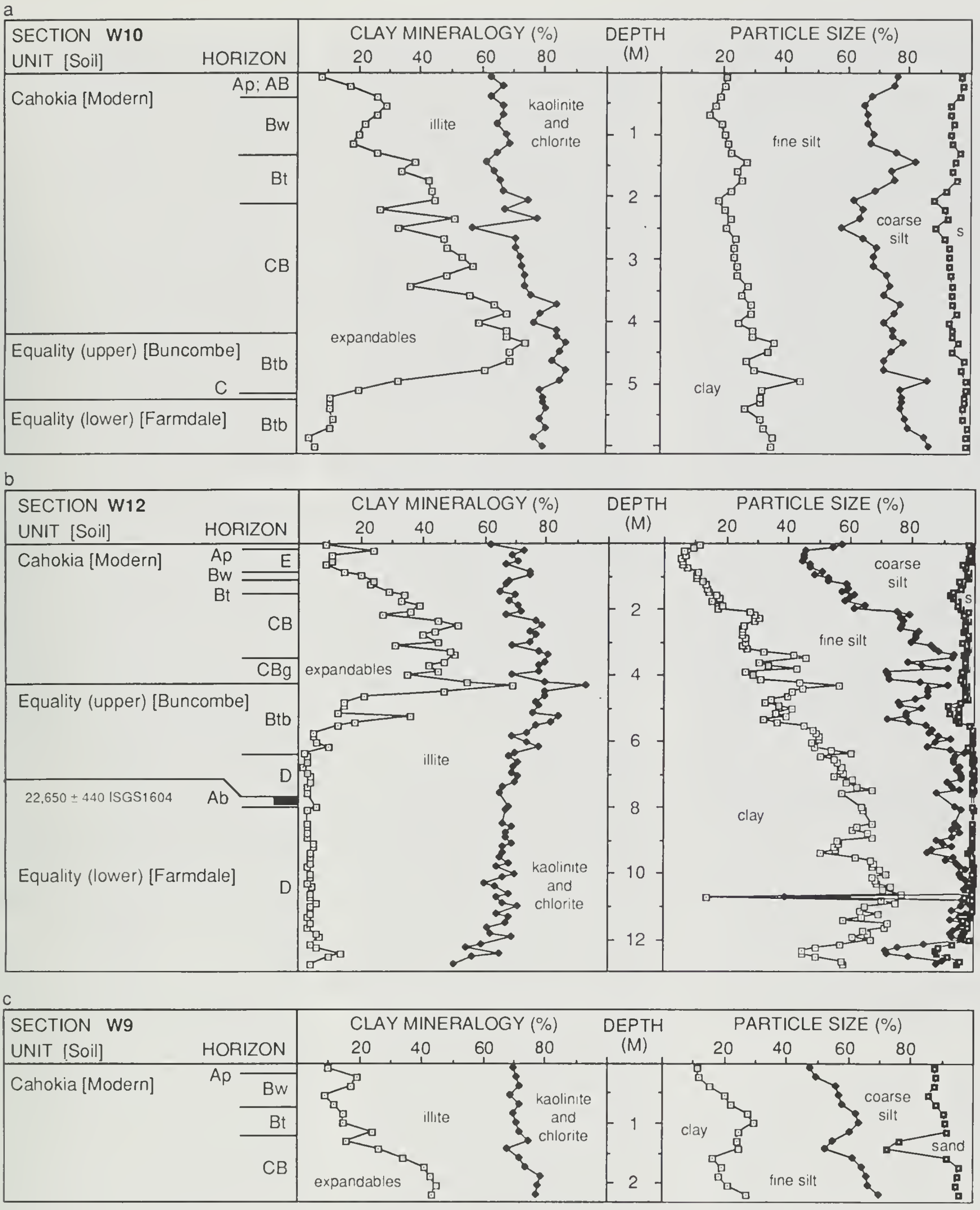



**Figure 21** Vertical distribution of clay minerals and particle sizes for borings (a) W10, (b) W12, and (c) W9 (for locations see fig. 18 and table 3).

tions are tentative, however, because the lacustrine sediments discussed by Heinrich and those in the Flat Lick Valley have distinct physical differences, particularly with regard to the presence or absence of carbonate minerals and oxidation state (color). These differences may be the result of different postdepositional weathering history of the deposits.

Willman and Frye (1970) divided the Equality Formation into the Carmi Member and the Dolton Member. By this classification, the deposits in the study area correlate with the Carmi Member, which includes the predominantly fine textured deposits that accumulated in low energy environments. The coarser end of the spectrum is assigned to the Dolton Member, which is typically sandy, represents higher energy environments such as beaches, and is not present in the study area.

**Cahokia Alluvium** Willman and Frye (1970) interpreted the Cahokia to consist of Holocene alluvial deposits. The unit is the surface deposit in all the valleys of the study area, excluding the narrow tributary valleys in which streams flow on rock. The texture of the Cahokia indicates that it originated from loess or redeposited loess. The unit overlies the Equality Formation in the Flat Lick Valley and ranges from 2.0 to 4.5 meters (6.6–14.8 ft) thick in the described sections. In other broad valleys within the Waltersburg Quadrangle, the Cahokia Alluvium may overlie bedrock or the Oak formation. The Cahokia generally is oxidized to yellowish brown with light brownish gray and gray beds and is leached of carbonate minerals. Elevated clay content typically characterizes the gray beds.

The alluvium in the valley bottoms may grade into the colluvium of the Peyton Formation near steep slopes along valley walls. The matrix of the Cahokia Alluvium is silty; its textures are similar to the source materials, the upland loess deposits, and residuum. Typical textures include silt loam, silty clay loam, and silty clay.

A change in clay mineralogy distinguishes the Cahokia Alluvium from the underlying Equality Formation in the Flat Lick Valley. The expandable clay content of the Cahokia generally increases with depth, whereas the expandable clay content of the upper member of the Equality formations generally decreases with depth (figs. 21a–c). The top of the Buncombe soil marks the contact between the two units.

### Pedostratigraphic Units

**Sangamon Soil** The Sangamon Soil developed in the Oak formation before deposition of the Roxana Silt on the uplands of the Waltersburg Quadrangle. The Sangamon Soil is distinguished from other pedologic units by its stratigraphic position and strength of development; in described sections, it has a pronounced Bt horizon and a moderate to strong blocky fabric that is commonly called soil structure.

**Farmdale Soil** The Farmdale Soil developed in the Roxana Silt on the uplands of the study area and is buried by the Peoria Silt. Where preserved in the valleys, the Farmdale Soil developed in the lower Equality Formation and is buried by the upper Equality Formation.

The Farmdale is recognized by its distinctive platy structure, although modern pedogenesis has obscured some of its primary features on the uplands of the study area. Common root traces may be primary features, but the presence of many clay films, manganese and iron oxide concretions, and stains along root channels probably reflects overprinting of the Farmdale Soil by modern pedogenesis. In one valley section (fig. 21b), the A horizon of the Farmdale soil was preserved.

**Buncombe soil** The Buncombe soil, an informal term, developed in the upper Equality Formation and is buried by the Cahokia Formation. Graham (1985) defined the soil using borehole sections observed along the upper Cache River valley. In the study area the Buncombe soil shows evidence of translocated clay, fine root traces, and manganese and iron oxide concretions, and stains.

## RESOURCES

In many areas, unconsolidated surficial deposits contain a variety of natural resources such as groundwater, gravel, sand and clay; however, no significant resources have been found in the thin surficial deposits of the study area. The unconsolidated units do not include any laterally extensive aquifers. The upland loess and residuum are generally unsaturated and the valleys contain fine textured sediments that seldom yield groundwater in economic quantities. Isolated sand lenses within the valley deposits may yield sufficient groundwater to supply a single-family dwelling, but these lenses are generally found by chance. The study area does not contain economic deposits of sand and gravel aggregate within the surficial materials. The weathered silt deposits that cover the upland have little commodity value except for construction fill or clay products such as brick.

## LAND USE

The value of surficial deposits of a region in terms of material and space for various land uses is becoming increasingly important; it is in these near-surface materials that roads, houses, and industrial facilities are built, sewers and pipelines are laid, crops are raised, and wastes are buried. The value of the land, particularly in developing regions, is often directly related to its suitability for such uses.

In the Waltersburg Quadrangle, important land use issues (beyond agricultural considerations) include the siting of waste disposal (landfill) operations and major construction projects. The characteristics and thickness of surficial deposits are critical to determining the suitability of a site for a particular type of land use. Although no large municipalities are now located in the study area, growth could occur in the region in future years. Once a general area is selected for any prospective construction or waste disposal use, a detailed site evaluation must be made of the surface deposits before the facility can be designed and constructed. This section summarizes the basic characteristics of surface materials in the quadrangle that can affect waste disposal, construction practices, and seismic risk considerations related to such projects.

### Waste Disposal

Municipal wastes includes household refuse and nonsalvageable commercial wastes such as metal and paper. This type of waste is commonly buried in sanitary landfills. The primary consideration in locating a sanitary landfill is minimizing the migration of leachate (a solution produced when infiltrating water reacts with the refuse) into groundwater and surface water. Guidelines of the Illinois Department of Public Health (1966) require that in selecting a sanitary (municipal) landfill site (1) no waste can be disposed in standing water, (2) no waste can be disposed in areas with a high water table unless preventative measures are taken to prevent leachate migration, (3) no surface runoff should flow into or through the operation or completed fill area, and (4) no disposal should take place "unless subsoil material affords reasonable assurance that leachate from the landfill will not contaminate ground or surface water."

In general, no site within the Waltersburg Quadrangle is suitable for a sanitary landfill unless measures are taken to prevent the migration of leachate. The upland loess units throughout the study area are less than 3 meters (9.8 ft) thick, too thin for disposal trenches or for use as a source for trench-cover material. Frequent flooding and high water tables (generally within 1 m of the surface) eliminates the valley areas for consideration as sanitary landfill sites. No major bedrock aquifers are located in the study area, but the upland units generally overlie sandstone that serves as a minor aquifer. If no other site is available within a reasonable distance of a community, a sanitary landfill could be located in the study area if the landfill is lined and leachate is collected and treated.

Even more stringent geologic conditions are required for the safe disposal of hazardous waste, including toxic chemical, biologic, radioactive, flammable, and explosive refuse. No suitable sites for hazardous waste disposal were found in the study area.

## General Construction

Most general construction projects such as subdivisions, small businesses, roads, drainage systems, and water and sewage lines can be sited, if properly designed and built, nearly everywhere in the study area. The exceptions are valleys prone to flooding or those with extremely steep slopes. Conditions on the uplands are most favorable. Loess, a silty deposit, typically has a low bearing capacity and is susceptible to frost action if saturated with water; however, the loess covering the uplands in the study area is unsaturated for most of the year and probably has a moderate bearing capacity.

Oliver (1988) estimated the soil cohesion by determining the unconfined compressive strength of the Peoria Silt and the Roxana Silt in the Waltersburg Quadrangle soil with a spring-loaded pocket penetrometer. The Peoria Silt had an average cohesion (3.06 psi), more than two times that of the Roxana Silt (1.35 psi). The cohesiveness of the Peoria Silt may be attributed to its higher percentage of clay-sized materials and its lower percentage of expandable clay minerals relative to the Roxana Silt.

Sandstone bedrock underlying the surficial material in many upland positions has a high bearing capacity and is generally found at depths less than 3.0 meters (9.8 ft). The shallow bedrock may be advantageous for projects requiring high bearing capacity, but it is a liability in excavating for sewer lines, water lines, or septic systems. The valley bottoms are generally not suitable for construction. These areas are characterized by a high water table (less than 1 m in places), poor surface drainage, and silty materials having low bearing capacity. Flash flooding is also a distinct possibility in the narrow valleys.

## Seismic Risk

The study area lies in a zone of high seismicity. Historical evidence indicates that earthquakes of large magnitude, associated with the New Madrid Fault Zone in eastern Missouri, could impact the area. In the winter of 1811–1812, a series of major earthquakes shook the region and intensities of IX or X on the modified Mercalli Intensity Scale were probably experienced in the area of the Waltersburg Quadrangle. Earthquakes of this intensity could cause total destruction of weak structures and major damage to well built structures (Nuttli 1973).

Structures built in the valley bottoms of the study area are most at risk; the thick, unconsolidated, and saturated deposits found in these areas generally amplify seismic waves and are prone to liquefaction, which causes a significant loss of bearing capacity. Structures having foundations in bedrock are at less risk. The foundations of critical structures, such as hospitals, schools, and emergency service centers should be constructed in the bedrock on gently sloping uplands.

# STRUCTURAL GEOLOGY

The Waltersburg Quadrangle is situated near the south margin of the Illinois Basin. Paleozoic strata regionally dip northward at an average rate of a few degrees toward the center of the basin. Only a few miles south of the quadrangle, Cretaceous and Tertiary sediments overlap Paleozoic rocks at the north edge of the Mississippi Embayment. The Waltersburg Quadrangle is dominated by northeast-trending fault zones (fig. 3), which are part of the Fluorspar Area Fault Complex. Three previously named fault zones—the Lusk Creek, Raum, and Hobbs Creek—cross the quadrangle. The newly named Flick Branch Fault is southeast of the Hobbs Creek Fault Zone.

The structural pattern mapped here differs from that shown by S. Weller and Krey (1939) primarily in detail, but several faults they mapped were not substantiated by this study. Minor discrepancies in fault mapping exist between the present map (Weibel et al. 1992) and the geologic map of the adjacent Shetlerville Quadrangle (Baxter et al. 1967). The discrepancies involve faults of small displacement in areas of poor exposure.

## Lusk Creek Fault Zone

The Lusk Creek Fault Zone (J. Weller et al. 1952) is the northwesternmost of three named fault zones in the study area, and it delimits the northwest margin of the Fluorspar Area Fault Complex. The Lusk Creek is exposed for about 28 miles, of which 7.5 miles lie within the study area. The Lusk Creek merges with the Shawneetown and Herod Fault Zones northeast of the Waltersburg Quadrangle, and it is buried by Cretaceous strata in the Mississippi Embayment southwest of the quadrangle (fig. 3). Kolata et al. (1981) mapped a subsurface continuation of the Lusk Creek Fault Zone in Paleozoic bedrock beneath the Embayment.

Within the study area, the Lusk Creek Fault Zone has an average trend of N45°E and varies in width from a few yards to about 1,400 feet. Numerous deep ravines cross the northern part of the fault zone and afford excellent exposures of its structure. Near the west edge of the quadrangle, the zone is not well exposed. Information from outcrops is supplemented by proprietary well data and seismic reflection data.

The net displacement of the Lusk Creek Fault Zone is 600 to 900 feet down to the southeast. Mississippian rocks northwest of the fault zone are juxtaposed with Pennsylvanian rocks southeast of the zone. The downdropped block southeast of the Lusk Creek is the Dixon Springs Graben (J. Weller 1939). The graben is bounded on the southeast by the Hobbs Creek Fault Zone and bisected by the Raum Fault Zone.

Pennsylvanian beds immediately southeast of the fault zone dip southeast away from the zone, at angles as steep as 70°. Dips rapidly diminish southeastward, toward the axis of a syncline, which lies 1/4 to 1/2 mile southeast of the Lusk Creek Fault Zone. Between the syncline and the Raum Fault Zone, bedding dips 4° to 12°NW. Two northwest-dipping, high-angle, normal faults of small displacement are near the synclinal axis close to the north edge of the quadrangle.

Northwest of the Lusk Creek Fault Zone, bedding distal to the zone dips northwest at an average of about 3°, but proximal to the zone, bedding generally dips 10° to 30°SE (toward the faults). In parts of Sections 29 and 30, T12S, R6E, strata near the northwest side of the fault zone dip northwest as steeply as 41°. Thus, bedding is upturned toward the fault zone on both sides, as shown in the cross section attached to the geologic map (Weibel et al. 1992).

The Lusk Creek Fault Zone is composed of high-angle faults, most of which dip southeast. Fault exposures are marked by outcrops and float of fractured, silicified sandstone and brecciated limestone. Fractures and crevices are filled with white calcite, and quartz, as well as minor amounts of fluorite and metallic sulfides. Numerous prospect pits and a few small abandoned mines occur along the faults. Angled borings in the fault zone in the northern part of the study area indicate that the major faults dip 60° to 70°SE (Robert Diffenbach, personal communication, 1985). Interpretation of a proprietary seismic profile and interpretations by Bertagne and Leising (1991) indicate that the Lusk Creek Fault Zone dips steeply to the southeast from the surface down to the Precambrian crystalline basement.

An unusual feature of the Lusk Creek Fault Zone is the presence of narrow slices of upthrown rock within the fault zone. Slices of rock older than that on either side of the zone occur at several places in the study area (fig. 22). The best example is at the Clay Diggings Mine, where a quarry highwall exposes the Ste. Genevieve Limestone and St. Louis(?) Limestone. Angled cores drilled through the fault zone also encountered these limestones at shallow depths in the fault zone (Diffenbach, personal communication, 1985). These formations are upthrown 800 to 1,500 feet relative to their positions on either side of the fault zone(fig. 22b). Upthrown slices containing the Vienna and Menard Limestones occur northeast of the Clay Diggings Mine along the northeast-trending ravine in the NW NE, Section 10, T12S, R6E. Outcrops and float of Ste. Genevieve(?) also occur along the fault zone between the mine and Copperous Branch.

Similar examples of upthrown slices in the Lusk Creek Fault Zone are documented both north of the study area in the Eddyville Quadrangle (Nelson et al. 1991) and west of the area in the Glendale Quadrangle (Devera 1991).

Downthrown fault slices are present in the form of narrow wedges of conglomeratic sandstone of the Caseyville Formation, faulted against Mississippian rocks on both sides (fig. 22). The downthrown Caseyville slices, in most cases, occur northwest of the upthrown slices of Mississippian rocks described above. A wedge of rock containing Caseyville and Tradewater strata is faulted between two slices of Mississippian rock at the midpoint of the boundary between Sections 20 and 21, T12S, R6E (fig. 22c).

The Lusk Creek Fault Zone contains both normal and reverse faults (fig. 22). The southeasternmost fault, a normal fault that borders the Dixon Springs Graben, exhibits the drag folding typical of a normal fault. Upthrown and downthrown slices within the fault zone are bounded by reverse and normal faults. In all cases, bedding within slices dips steeply southeast, commonly subparallel to the fault dips. Interpretation of the unusual structure of the Lusk Creek Fault Zone will be discussed at the end of this section.

## Raum Fault Zone

The Raum Fault Zone (Baxter et al. 1967) is a narrow zone of faults that lies southeast of, and forms a graben with, the Lusk Creek Fault Zone (fig. 3). The Raum Fault Zone extends southwestward from a complexly faulted area on the west flank of Hicks Dome in the Shetlerville Quadrangle (Baxter et al. 1967), crosses the Waltersburg Quadrangle, and continues beneath the Cretaceous overlap in the Mississippi Embayment (S. Weller and Krey 1939, Ross 1963, Gause 1966).

In the Waltersburg Quadrangle, the Raum Fault Zone is 7,500 to 12,000 feet southeast of the Lusk Creek Fault Zone. The Raum is mapped as a single fault or as a zone of faults generally less than 300 feet wide. At the surface, the Caseyville Formation and upper Pope Group are displaced with net throw down to the northwest. The net throw increases from less than 100 feet near the northeast corner of the quadrangle to 200 to 300 feet near the southwest corner.

Strata on both sides of the Raum Fault Zone generally dip less than 5°NW. The dips steepen up to 85°NW close to and within the fault zone. The dips are consistent with the displacement and are probably the result of drag. In some places,

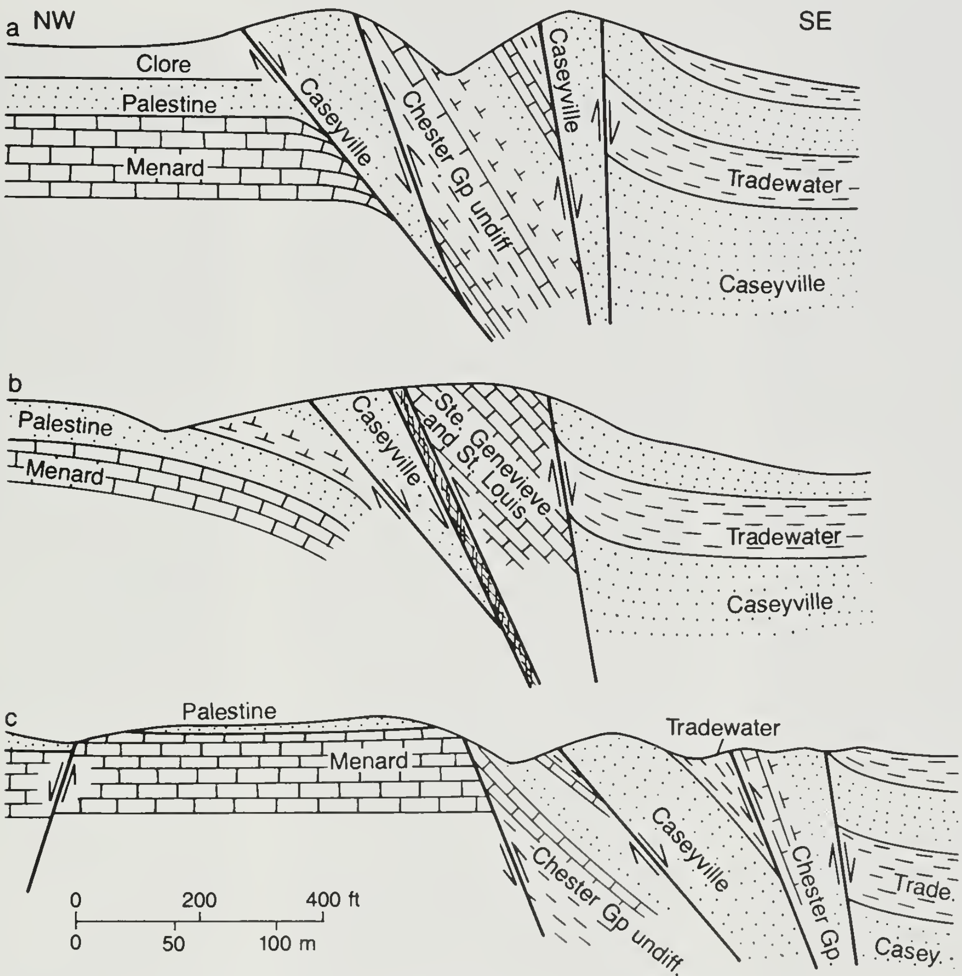



**Figure 22** Cross sections of Lusk Creek Fault Zone. (a) Ora Scott Mine, S1/2 SE NW, Section 10, T12S, R6E. The central upthrown slice of Chester Group strata is flanked by downthrown slices of Caseyville. (b) Clay Diggings Mine, SW NE SE, Section 16, T12S, R6E. The fault zone contains an upthrown slice of St. Louis(?) and Ste. Genevieve Limestones and a downthrown wedge of Caseyville. (c) SE NE, Section 20, T12S, R6E, and NW SW, Section 21, T12S, R6E. The downdropped block of Pennsylvanian strata is between two upthrown slices of Mississippian rock.

drag folding is absent, for example, near Sulphur Springs Church in Sections 20 and 27, T12S, R6E, and northwest of Rising Sun in Sections 5, 6, and 7, T13S, R6E.

Outcrops, well records, and a proprietary seismic profile indicate that the major faults dip steeply northwest. A major fault, exposed in a gully just northeast of the stream in the SW NW, Section 13, T12S, R6E, strikes N45°E and dips 60° to 80°NW. The fault is marked by a zone of fractured and brecciated rock. Angled core holes in the vicinity of Raum penetrated as many as four high-angle, northwest-dipping fault planes in the Raum Fault Zone (Diffenbach, personal communication, 1985). The seismic profile shows that the Raum is an antithetic branch of the Lusk Creek Fault Zone, intersecting the latter in Upper Cambrian or Lower Ordovician strata.

Similar to the Lusk Creek, the Raum Fault Zone contains slices of rock that are upthrown relative to both bordering blocks. A slice of Mississippian rock occurs between Pennsylvanian rocks near the east edge of the quadrangle in Sections 13 and 14, T12S, R6E (fig. 23a). The upthrown slice is bounded by a normal fault on the northwest and a reverse fault on the southeast. Rocks within and bordering the upthrown slice dip steeply northwest and are strongly sheared and fractured; however, little displacement has occurred across the fault zone.

Another upthrown slice in a cut bank of Lusk Creek in the N1/2 NE, Section 5, T13S, R6E (fig. 23b) exposes Degonia and Clore strata, faulted against Caseyville on the northwest and against Degonia on the southeast. Bedding of the upthrown slice dips 38° to 44°SE, contrary to the generally prevailing northwest dips in the Raum Fault Zone.

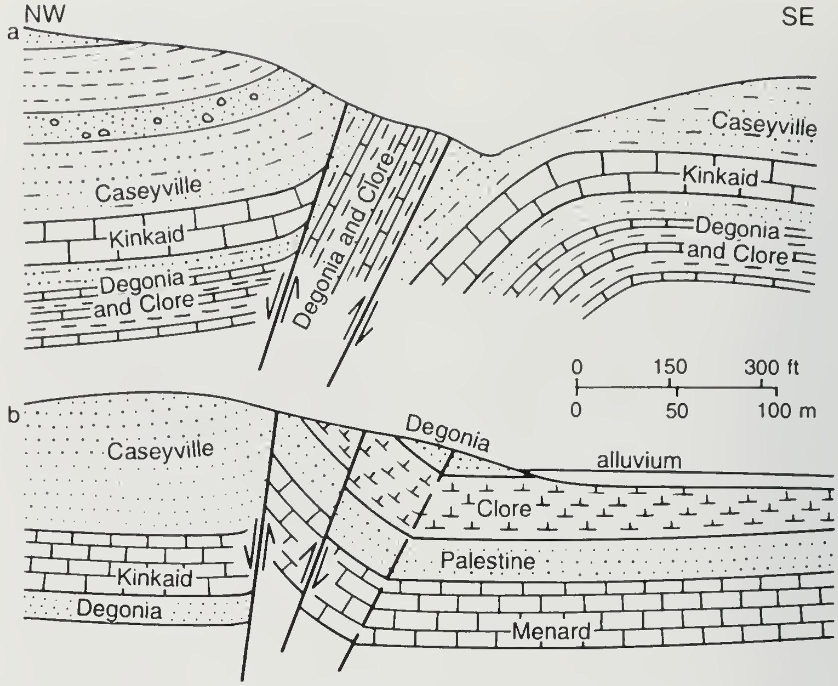



**Figure 23** Cross sections of Raum Fault Zone. (a) Center NW, Section 13, T12S, R6E. Displacement across fault zone is small, but the central slice of Chesterian rock is upthrown several hundred feet relative to Pennsylvanian rocks on both sides. (b) Bank of Lusk Creek, N1/2 NE, Section 5, T13S, R6E. Net displacement is down to northwest; slices of Chester Group strata are upthrown and tilted southeast.

## Hobbs Creek Fault Zone

The Hobbs Creek Fault Zone (Baxter et al. 1967), southeast of the Raum Fault Zone, extends from the west side of Hicks Dome to the edge of the Mississippi Embayment (fig. 3). It is a zone of normal faults having overall downward displacement to the northwest; the zone delimits the southeast margin of the Dixon Springs Graben.

Along most of its length in the Waltersburg Quadrangle, the Hobbs Creek Fault Zone is composed of the two faults that form a graben 800 to 4,000 feet wide. The southeastern fault is downthrown to the northwest and is the larger of the two. Vertical separation on this fault is more than 250 feet near Waltersburg, where the Caseyville Formation is juxtaposed against the Menard Limestone and Palestine Sandstone. The displacement decreases toward the northeast and is only about 20 feet near the east border of the quadrangle. The northwestern fault has a maximum throw of 70 feet, but along most of its length the displacement is less than 40 feet. This fault may die out to the northeast, where it lines up with a fault mapped in the Shetlerville Quadrangle by Baxter et al. (1967).

Faults of the Hobbs Creek Zone are high angle or nearly vertical. The best exposure of a fault plane is on an outcrop of the Caseyville Formation in the NE SE NE NE, Section 9, T13S, R6E, where the fault plane is juxtaposed with the Degonia Formation. A surface that is parallel to the fault trace and contains vertical (dip-slip) slickensides occurs on the southeast side of the sandstone outcrop. The straight trends of the faults across rugged topography indicate steep dips. In the Shetlerville Quadrangle, the Shelby Fault (part of the Hobbs Creek Fault Zone) is a normal fault that dips 60° (J. Weller et al. 1952). The general absence of drag structures and wide, fractured and brecciated zones is also suggestive of normal faulting. Strata adjacent to and within the Hobbs Creek Fault Zone generally dip northwest a few degrees, in contrast to the steep dips along the Lusk Creek and Raum Fault Zones.

A triangular fault slice, obliquely crossing the Hobbs Creek Fault Zone, occurs near the common corner of Sections 3, 4, 9, and 10, T13S, R6E. The slice contains Kinkaid Limestone and is upthrown relative to adjacent rocks within the fault zone. It is in an intermediate structural position relative to the lower rocks southeast of the fault zone and the higher rocks northwest of the zone. Thus, this slice differs from slices in the Raum and Lusk Creek Fault Zones, in which slices are structurally above the adjacent strata. The slice in the Hobbs Creek Zone is a small horst, bounded by normal faults, within a graben. The large northwest-dipping fault, on

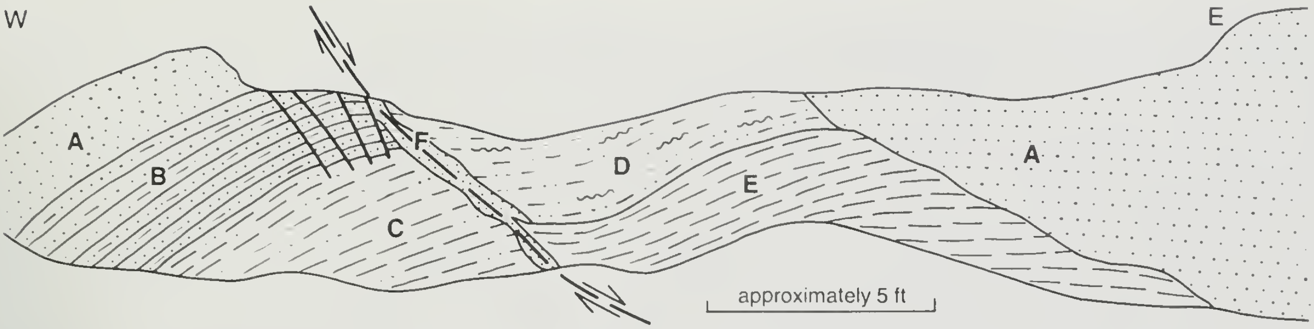



**Figure 24** Field sketch of deformed Tradewater strata exposed in stream bank, NW SW NW, Section 14, T12S, R6E (see fig. 25). Folding, low-angle faulting, and a sandstone dike are visible. A—White, fine grained, massive, quartz sandstone; B—brown gray, very fine grained, micaceous, argillaceous, thin bedded sandstone; C—dark gray, silty, carbonaceous shale; D—dark gray, bioturbated, carbonaceous siltstone; E—black, fissile, carbonaceous shale; and F—sandstone dike associated with listric fault.

the southwest side of the Hobbs Creek Fault Zone, is the master fault of the system; other faults probably intersect it at depth (see cross section on geologic map (Weibel et al. 1992)).

## Flick Branch Fault

The Flick Branch Fault is southeast of the Hobbs Creek Fault Zone and extends N55°E from Waltersburg to the east edge of the quadrangle, where it connects with a fault mapped by Baxter et al. (1967) in the Shetlerville Quadrangle. The fault passes near the mouth of Flick Branch and takes its name from that stream. The Flick Branch probably is a high-angle normal fault. The northwest side is downthrown about 65 feet at the east border of the quadrangle, and about 100 feet in the vicinity of Waltersburg. Mississippian formations from the Clore to the Tar Springs are displaced. Strata on both sides of the Flick Branch Fault dip northwest at an average of about 5°. Dips as steep as 35°NW occur close to the fault plane and are attributed to drag. Along part of its length, the Flick Branch Fault splits into two faults that outline a graben.

## Other Faults

A fault having a trend of N20°E is interpreted to be in Sections 9 and 16, T13S, R6E. This fault diagonally links the Flick Branch Fault with the Hobbs Creek Fault Zone. The fault is indicated by juxtaposition of Clore Limestone against Menard and Palestine Formations. It has a downward displacement of 50 to 100 feet to the east.

A fault striking N45°E in Section 12, T13S, R6E, was extrapolated into this quadrangle from the Shetlerville Quadrangle, where it is more clearly exposed. In the roadbed just north of the southwest corner of Section 12, the Tar Springs Sandstone dips about 20°SE (James Baxter, personal communication, 1990). The fault probably is a normal fault having downward displacement of 10 to 20 feet to the southeast.

## History And Origin of Faulting

The Illinois–Kentucky Fluorspar District is among the most complexly deformed areas of the North American midcontinent, and it has a long history of faulting. Previous workers who have discussed regional relationships and timing of events include Rhoades and Mistler (1941), J. Weller (1943a, 1944), S. Weller and Sutton (1951), Heyl and Brock (1961), Heyl et al. (1965), Hook (1974), Trace (1974), Trace and Amos (1984), and Nelson and Lumm (1987). These workers outlined a variety of scenarios, but all recognized recurrent events of faulting, doming, igneous intrusion, and mineralization, extending from late Paleozoic into Cenozoic time.

Evidence within the Waltersburg Quadrangle supports at least three, and possibly four, episodes of faulting, which in some cases involved reversals in the direction of slip along the same fracture surfaces.

A proprietary seismic profile supports Bretagne and Leising's (1991) interpretation that Cambrian strata are thicker on the southeastern, downthrown side of the Lusk Creek Fault Zone than they are on the northwestern, upthrown side. This thickness pattern is the result of normal movement of the fault zone during Cambrian sedimentation.

Thickness patterns and paleoslump features indicate that the Lusk Creek Fault Zone may have been active during deposition of the Pennsylvanian Caseyville and Tradewater Formations. The basal "Wayside" member of the Caseyville thickens abruptly from about 20 feet northwest of the fault zone to 140 feet or more southeast of the zone. Paleo- slump structures, such as the one illustrated in figure 10, are common in the "Wayside" southeast of the fault zone. These slumps may have been triggered by seismic activity during deposition of the "Wayside." Coarse conglomerates containing large clasts of sedimentary rocks are interbedded with fine grained strata of the "Wayside" within the Dixon Springs Graben. The clasts may have been derived from nearby bordering fault scarps.

Deformed bedding in the Tradewater Formation (fig. 24) is common along the axis of the syncline that lies just southeast of the Lusk Creek Fault Zone. In one area, deformed lower Tradewater and upper Caseyville strata (Pounds Sandstone) contain large rotational slump blocks that are outlined by listric normal faults (fig. 25). The beds are folded and penetrated by sandstone dikes. These structures indicate extensive failure of sediments prior to lithification, perhaps in response to tectonic activity. This activity is consistent with the downward movement of the Dixon Springs Graben during the Morrowan and Atokan Epochs. In addition, the middle sandstone unit of the Tradewater thins and grades laterally into shale southeast of the syncline in the SW, Section 15, T12S, R6E. This facies change possibly indicates the influence of local structural movement during deposition.

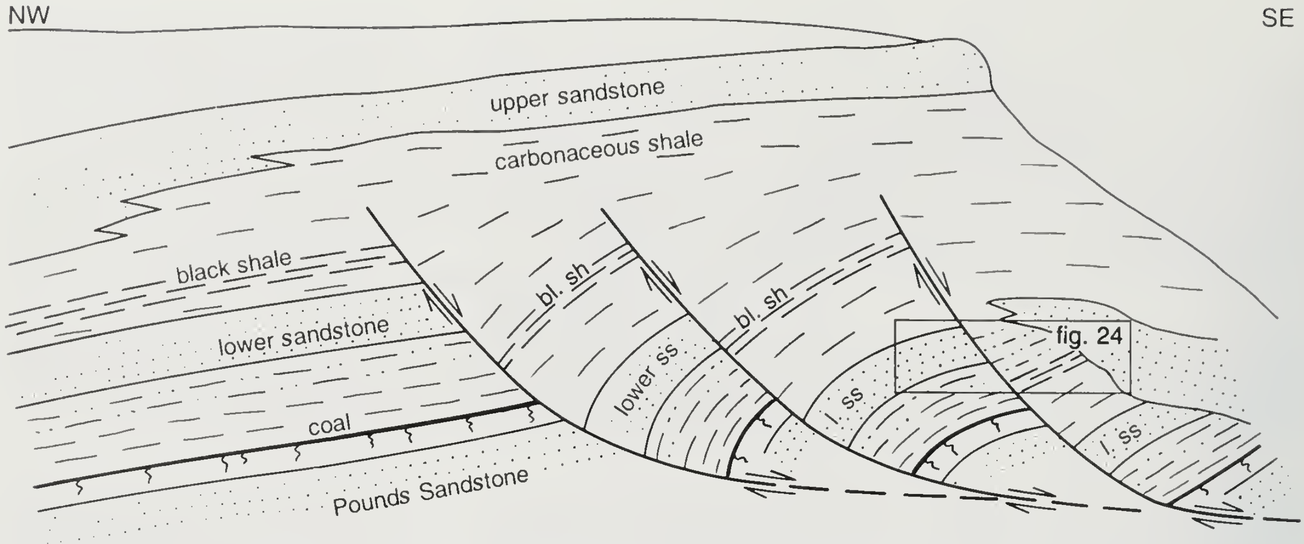



**Figure 25** Interpretive sketch (not to scale) of deformed Pounds Sandstone and Tradewater strata discontinuously exposed along a large ravine in the SW NW, Section 14, T12S, R6E and SE NE, Section 15, T12S, R6E. Listric normal faulting (rotational slumping) occurred during deposition of carbonaceous shale. Slumping may have been triggered by tectonic movements along the Lusk Creek Fault Zone, about 1 mile northwest of this site.

The Lusk Creek Fault Zone displaces the Tradewater Formation, indicating that most faulting is post-Atokan. Other faults in the study area are parallel to the Lusk Creek and exhibit similar geometry, indicating a similar history of movement. Most of the faults in the quadrangle are high-angle normal faults, indicating a stress field with northwest-southeast extension.

Reverse faults and upthrown fault slices in the Lusk Creek and Raum Fault Zone cannot be explained by extension. An episode of compression is required to induce reverse faulting. Bedding attitudes in and near the Raum and Lusk Creek Zones indicate that the last major displacements in both zones were normal. Bedding along both fault zones dips predominantly toward the downthrown block (footwall). Hence, reverse movements must have occurred earlier than the normal movements. Drag from the later normal movement may have obliterated drag structures that had formed during the earlier reverse faulting. Possible remnants of the reverse drag occur in a few places. Along the Lusk Creek Fault Zone, in the line of the cross section on the geologic map (Weibel et al. 1992), beds dip away from the fault on both sides. The southeast-dipping fault slices of the Raum Fault Zone (fig. 23b), and upthrown slices also may be remnants of reverse drag. The upthrown slices are fragments of the hanging wall and were uplifted during reverse faulting. In some places, the earlier reverse faulting and later normal faulting occurred along different fault planes (figs. 23, 24), and slices of rock between the two faults were left behind when the hanging wall subsided during normal faulting (fig. 26).

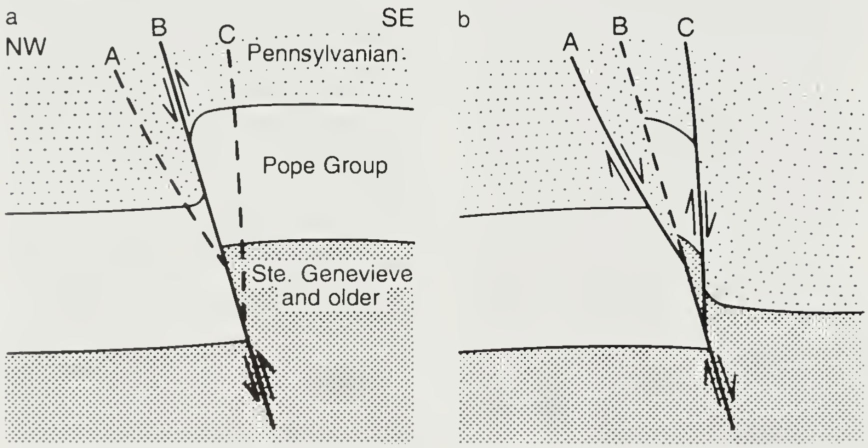



**Figure 26** Origin of upthrown and downthrown slices in Lusk Creek Fault Zone. (a) Reverse faulting occurs along fault B, southeast black uplifted. Faults A and C are incipient. (b) Later normal faulting occurs, southeast block downdropped. Most displacement occurs along faults A and C. An "upthrown" wedge of rock is caught between faults B and C, whereas a slice of rock is downdropped between faults A and B.

Downthrown slices in the Lusk Creek Fault Zone probably formed during the later phase of normal faulting. These slices are wedge-shaped fragments of the footwall that were rotated and dragged downward (fig. 26).

Although several studies have indicated strike-slip movement on northeast-trending faults in the fluorspar district (Heyl and Brock 1961, Hook 1974, Trace and Amos 1984), no evidence for horizontal movement was found in this study. The nearly vertical plunge of slickensides, parallelism of faults and drag folds, and absence of en echelon or pinnate structures point to predominantly dip-slip movement.

In summary, the following sequence of structural events is proposed (fig. 27).

(1) Rifting occurred during the Cambrian Period; the Lusk Creek Fault Zone developed as a normal fault (southeast side down).

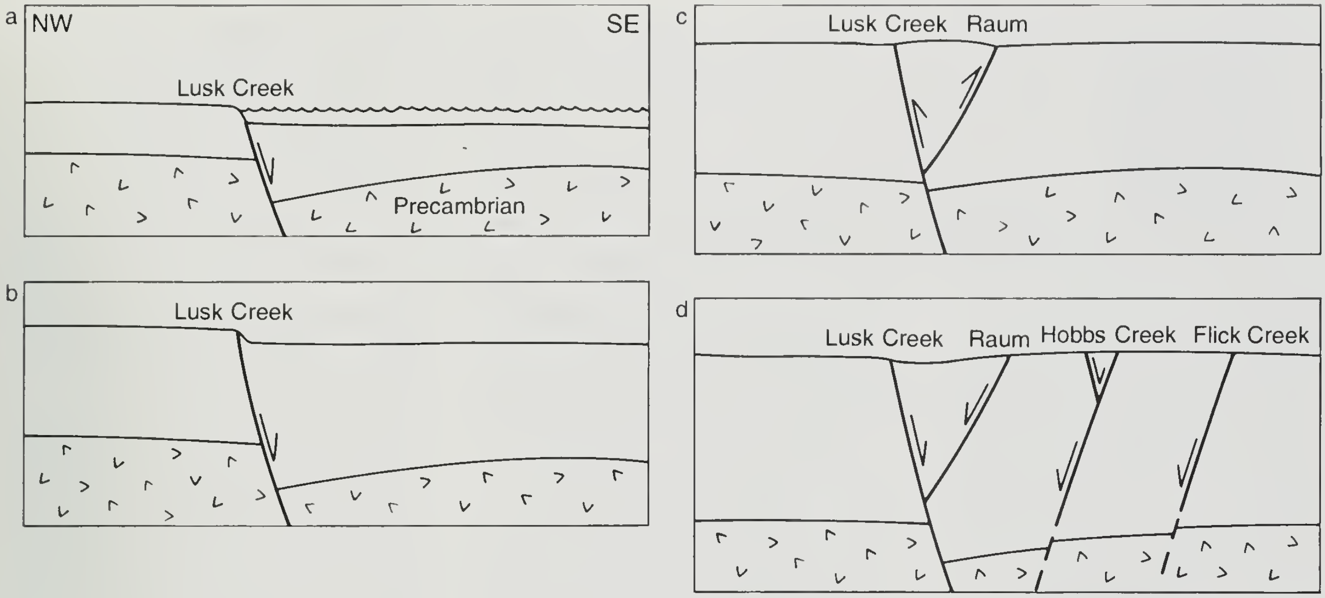



**Figure 27** Interpretive structural history of the Waltersburg Quadrangle. (a) Cambrian rifting. (b) Possible Morrowan–Atokan normal faulting. (c) Post-Pennsylvanian reverse faulting. (d) Final episode of normal faulting.

(2) Additional normal faulting on the Lusk Creek Fault Zone may have occurred during the Morrowan and Atokan Epochs, influencing thickness and facies patterns and inducing slumping of Caseyville and Tradewater sediments prior to lithification.

(3) Post-Atokan reverse faulting along the Lusk Creek and Raum Fault Zones (which merge at depth) uplifted the intervening block.

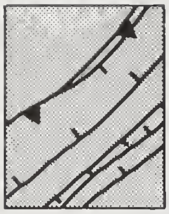
(4) The final episode of faulting was extensional and induced normal displacements on faults in the study area.

This sequence of events is similar to that inferred for the Rough Creek–Shawneetown Fault System (Nelson and Lumm 1987, Bretagne and Leising 1991, Kolata and Nelson 1991).

The Lusk Creek Fault Zone is nearly aligned with faults in southeastern Missouri and northeastern Arkansas, where seismic profiles indicate more than 10,000 feet of Cambrian normal displacement (Howe and Thompson 1984). These faults define the northwest margin of the Reelfoot Rift (Ervin and McGinnis 1975), a failed intracratonic rift. At its northeast end, the Lusk Creek Fault Zone merges with the Rough Creek–Shawneetown Fault System (fig. 3), which is the north boundary of the east-trending Rough Creek Graben (Soderberg and Keller 1981, Bretagne and Leising 1991). Seismic profiles across the Rough Creek–Shawneetown Fault System indicate normal displacement (down to the south) occurred during the Cambrian Period (Bretagne and Leising 1991). Thus, during the Cambrian and perhaps later, in the Rough Creek–Shawneetown, Lusk Creek, and the Reelfoot Rift northwest-bounding faults in southeastern Missouri and northeastern Arkansas were an interconnected rift-boundary fault system.

The presence of the McCormick and New Burnside Anticlines (fig. 3) northwest of the Lusk Creek Fault Zone indicates that the northwest boundary of the reactivated Reelfoot Rift may have shifted northwestward during the late Paleozoic. Seismic data indicate that the faults associated with these anticlines do not extend to the basement. These faults are probably listric faults that parallel bedding planes and probably merge with the Lusk Creek Fault Zone at depth. The anticlines are the product of post-Pennsylvanian compressional reactivation of the rift faults.

A recent study by Hildenbrand et al. (1992) suggests that correlative magnetic and gravity anomalies about 80 kilometers (50 mi) northwest of the Lusk Creek Fault Zone (Johnson County) may be indicative of a mafic intrusion along the northwest boundary of the rift structure. The age of this pluton is not known.



# ECONOMIC GEOLOGY

The principal geologic resources in the Waltersburg Quadrangle are limestone for construction and agricultural purposes, and sandstone for construction purposes. Fluorspar and base metals have been mined along fault zones in the past; additional resources may exist in the subsurface. Resources of coal are small; coal beds are too thin and discontinuous to be exploited economically. Few exploration wells for petroleum have been drilled, and much of the quadrangle has yet to be tested. The resource potential (e.g., groundwater, sand and gravel) of the surficial geologic materials of the quadrangle have been previously assessed in the section on surficial stratigraphy.

## Fluorspar

Fluorspar and associated minerals have been produced from vein deposits in the quadrangle, which lies on the west margin of the Illinois–Kentucky Fluorspar District. Several abandoned fluorspar mines and prospect pits occur along the Lusk Creek Fault Zone. The Clay Diggings Mine, also known as the Pittsburg Mine, consisted of at least five shafts between 70 and 85 feet deep. The shafts followed narrow veins and breccia containing fluorite, galena, and sphalerite (Bain 1905, J. Weller 1944, J. Weller et al. 1952). Very little is known about the early production history of this mine; it produced fluorspar from 1939 to 1941 and possibly in 1942.

The Ora Scott Mine, in the S 1/2 SE NW, Section 10, T12S, R6E, produced a small amount of fluorspar from small veins within brecciated limestone and quartz sandstone (J. Weller et al. 1952). According to J. Weller (1943a), mining was initiated around 1900, and in the following 40 or 50 years, a total of more than 1,000 tons of fluorspar was extracted on an intermittent basis from several adits and shafts. The last known year of production was 1952. Of the two mines described by Bain (1905), either the McClellan Mine or the Luella Mine is probably the same as the Ora Scott Mine, but absence of precise locations precludes accurate identification.

Prospect pits and waste piles near the head of a small ravine about 1,000 feet north of the Ora Scott Mine indicate possible previous exploration or small scale mining. J. Weller's (1943a) map indicates an abandoned shaft surrounded by several prospect pits in this area.

Other small abandoned mines and prospect pits occur along the fault zone, but they are not shown on the geologic map (Weibel et al. 1992). J. Weller (1943b) reported that although this area had characteristics similar to both the Ora Scott and Clay Diggings Mines, mineralization had not been reported. The Ozark-Mahoning Company drilled angled core holes for prospects along the Raum Fault Zone (Robert Diffenbach, personal communication, 1985).

The mineral deposits in the Illinois–Kentucky Fluorspar District occur as vein deposits in breccia zones and fissures along faults, bedded replacement deposits in the wall rocks of the faults, and residual deposits (J. Weller et al. 1952). In the Waltersburg Quadrangle, known mineral deposits occur only as vein deposits. The chief minerals in vein deposits in the district are fluorite and calcite, but sphalerite, galena, and barite are locally abundant (Baxter and Bradbury 1989). Most economic vein deposits of fluorspar have occurred along faults of moderate displacement (J. Weller et al. 1952). These ore bodies are associated with faults of 25 to 500 feet displacement. These faults apparently provided the optimum avenues and open fissures for fluid circulation and mineral deposition (Baxter and Bradbury 1989).

Vein deposits in the Illinois–Kentucky Fluorspar District are concentrated in the interval from the St. Louis Formation up to the Cypress Sandstone (Grogan and Bradbury 1968). Throughout the quadrangle, these formations occur at depth, and in most cases, below the level of past mining and prospecting. In the Lusk Creek Fault Zone, the wallrock for ore is mainly the uppermost Mississippian and the lower Pennsylvanian. The Clay Diggings Mine is the only place in the quadrangle where mineralization occurs at the surface. Thus, the potential for shallow resources is low. Unknown deeper resources may be present, particularly in the interval from the St. Louis to the Cypress, along the Lusk Creek Fault Zone and other faults in the Waltersburg Quadrangle. The ongoing Conterminous U.S. Mineral Assessment Program (CUSMAP) is attempting to determine the likelihood of finding additional mineral resources in the area.

## Limestone

The Kinkaid and Menard Limestones offer the best prospects for small or moderate quarry operations in the Waltersburg Quadrangle. Limestone resources of southernmost Illinois, including the Waltersburg Quadrangle, were evaluated in a regional study by Lamar (1959). His report is the primary source for the following evaluations. The Kinkaid Limestone has the thickest limestone beds and the best potential in the quadrangle for limestone production for Portland cement, agricultural limestone, and crushed rock; however, the Kinkaid, locally contains shale beds and chert nodules that are deleterious to commercial production. The Goreville Limestone Member of the Kinkaid was quarried about 1 mile south-southeast of Eddyville (SE NE SE, Section 17, T12S, R6E). J. Weller et al. (1952) also reported that the Kinkaid Limestone was quarried during the 1930s by the Civilian Conservation Corp at the Clay Diggings Mine, along Lusk Creek in the SE, Section 16, T12S, R6E. Examination of the site indicates that the Ste. Genevieve

Limestone and possibly other limestones were quarried. The Glen Dean and Cora Limestones generally contain shale beds and are too thin to be quarried. The Menard Limestone contains shale beds and chert nodules, but may have limestone beds thick enough in some places to be used for agricultural limestone and crushed rock. The Vienna Limestone is thin and contains abundant chert nodules, precluding it as a limestone resource.

### Sandstone

Thin bedded sandstone in the "Wayside" Member of the Caseyville Formation is quarried in the NE corner, Section 27, T12S, R6E for use as flagstone and facing stone (The geologic map of Weibel et al. [1992] does not have a quarry symbol.) Similar rock crops out along the Beatty Branch and in Flick Branch valley.

### Clay

Clay was mined from a shaft at the Clay Diggings Mine from about 1866 to 1907 (Lamar 1942). The clay deposit, about 15 feet wide, was located along the major fault of the Lusk Creek Fault Zone (Engelmann 1866b, Purdy and DeWolf 1907) and on the northwest side of the narrow Ste. Genevieve fault block. Lamar (1942) analyzed samples of the clay from waste piles and identified the clay as halloysite. The quantity of clay is unknown.

### Petroleum

Three unsuccessful oil and gas exploration wells have been drilled in the quadrangle. The wells were ranked as wildcats because they are more than 1.5 miles from established commercial operations. The quadrangle lies about 10 miles south of the Mitchellsville Oil Field, the southernmost oil field in Illinois (located in T10S, R6E). The Minton-Baker No. 1 Well was drilled in the horst between the Raum and Hobbs Creek Fault Zones to the Mississippian Haney Limestone Member of the Golconda Formation at a depth of 610 feet. The Austin Roberts No. 1 Well was drilled between the Hobbs Creek Fault Zone and the Flick Branch Fault to the Devonian Lingle Limestone at a depth of 3,802 feet. The Rodger, Barger et al. No. 1 Well was drilled in the graben within the Hobbs Creek Fault Zone to the Mississippian Ste. Genevieve Limestone at a depth of 1,000 feet. The wells presumably were drilled for oil in fault-bounded structural traps. No oil shows were reported in any of the wells.

The predominant source rocks for oil produced in the Illinois Basin are organic-rich shales of the Devonian–Mississippian New Albany Group (Barrows and Cluff 1984). In the Waltersburg area, studies of source rocks indicate the New Albany is an excellent source rock and is within the oil maturation window (Barrows and Cluff 1984). Older and deeper Ordovician and Cambrian source rocks may be present in the area, but the distribution and quality of these sediments is not established. The presence of Early Cambrian (pre-Mt. Simon Sandstone) rift-fill shale sediments within the Reelfoot Rift/Rough Creek Graben has been suggested by Hester (1983) and Kolata and Nelson (1991). Verification of these sediments in this region and their analysis for a potential source rock await the drilling of a well through the Paleozoic sediments to the Precambrian basement.

Complex regional faulting, sparseness of drill hole data, and lack of seismic data further limit the evaluation of possible hydrocarbon traps. Structural closures may exist along faults in the quadrangle, but it is not known whether faults in this area are barriers to hydrocarbon migration. Most of the quadrangle, including areas adjacent to faults, has not been tested. Upper Mississippian and Pennsylvanian rocks, which are the most prolific and widely distributed reservoirs in Illinois, are exposed at the surface (or eroded) and flushed of hydrocarbons. Reservoir characteristics of buried, pre-upper Mississippian strata are unknown within the quadrangle, although the potential for the occurrence of hydrocarbon accumulations associated with Silurian pinnacle reefs in the area has been postulated by Whitaker (1988). The inferred reversals of displacement along the Lusk Creek and Raum Fault Zones could diminish the potential for petroleum occurrences because hydrocarbons may have been flushed prior to this last major episode of deformation.

### Coal

For local use, local supplies of coal have been mined in the Caseyville and Tradewater Formations at several sites in the quadrangle, particularly from the lower Tradewater. The mines consisted of shallow drift and small strip mines; all are now abandoned. The remaining coals occur in thin or lenticular beds that have poor potential for commercial exploitation.

Coals in the Caseyville Formation consist only of small, isolated pods. Near the center, S1/2 NE SE, Section 8, T13S, R6E, about 1.3 feet of shaley coal crops out in a small ravine in which a small amount of coal was mined, apparently for local use. Palynological and biostratigraphic analyses (Peppers, personal communication, 1987) indicate the coal is in the lower Caseyville Formation. H. R. Wanless (unpublished ISGS field notes, 1934) reported 2.2 feet of "shaley" coal cropping out near an abandoned mine drift in the ravine (near center SW, Section 5, T13S, R6E) north of Rising Sun. Wanless referred to the coal as the "Wayside" coal, but this designation was made on the basis of stratigraphic relationships and without the aid of palynology. Neither the outcrop nor the drift opening could be located during this study. This coal is probably younger than the lower Caseyville coal described above, although it is possible that the coals are the same age. A small, lenticular coal bed in the Pounds Sandstone crops out along Lusk Creek in the SW SW SE, Section 32, T12S, R6E. The bed is less than 0.5 feet thick, and the lower part is argillaceous. Several prospect pits surround the exposure, but it appears that very little coal was mined.

The Tunnel Hill(?) Coal Bed in the lower shale and sandstone member of the Tradewater Formation cropped out south of the Mount Zion Church in the center S 1/2 S 1/2, Section 12, T13S, R5E. It was intermittently mined by several companies from the 1930s to the late 1970s. Production figures are not available, but the mine reportedly produced 5,955 tons in 1970. The coal contained several clay partings and varied in thickness from about 2.5 to 3.5 feet, but thinned laterally to the north and northeast. The mine was abandoned because of the clay partings, the difficulty of removing overlying sandstone, and the depletion of coal.

Table 4 Chemical analyses of channel sample of Tunnel Hill (?) Coal.

| | Basis | |
|---|---|---|
| | As received | Moisture and ash-free |
| Moisture | 12.1% | — |
| Volatile matter | 29.6% | 39.6% |
| Fixed carbon | 45.1% | 60.4% |
| Ash | 13.2% | — |
| Total sulfur | 0.45% | 0.57% |
| Heating value (Btu/lb) | 10,055 | 13,468 |

The mine site has recently been reclaimed. The chemical analysis in table 4 is taken from a channel sample of the coal, excluding shale partings. The sulfur content of this sample is relatively low for coal from the Illinois Basin, but the ash content is high.

The most widespread coal in the quadrangle is in the Tradewater Formation. It crops out intermittently near the crest of the ridge between the Raum Fault Zone and Lusk Creek. Palynological and biostratigraphic analyses of the coal (Peppers, personal communication, 1989) indicate the coal approximately correlates to the Smith coal bed in the lower Tradewater Formation of western Kentucky. The coal is discontinuous, has a maximum thickness ranging from 2 to more than 3 feet, and locally has a clay parting of 0.1 to 0.3 foot. The Western Mining Corporation (also known as the Shawnee Mining Company) mine, the last operating mine in the quadrangle, extracted this coal in the W1/2, SE, SE, SE, Section 29, T12S, R6E. The operation was abandoned in 1974. R. B. Nance and G. J. Allgaier (unpublished ISGS field notes, 1975) measured a lower 0.6 foot coal and an upper 1.0 foot coal which contained a pyritic layer. The coals were separated by 0.10 foot of argillaceous coal. The coal crops out in a stream bed just south of the mine site; it is about 2 feet thick, overlies a rooted underclay, and grades up to black carbonaceous shale. Northeast of the strip mine, about 1.3 feet of the coal crops out in a small ravine just east of the Eddyville–Golconda road (NW SE, Section 22, T12S, R6E). The same coal was mined prior to 1934 from several pits in the SW NW, Section 14, T12S, R6E. H. B. Stonehouse (unpublished ISGS field notes, 1954) measured 1.2 to 2 feet of coal on the north side of this ravine.

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