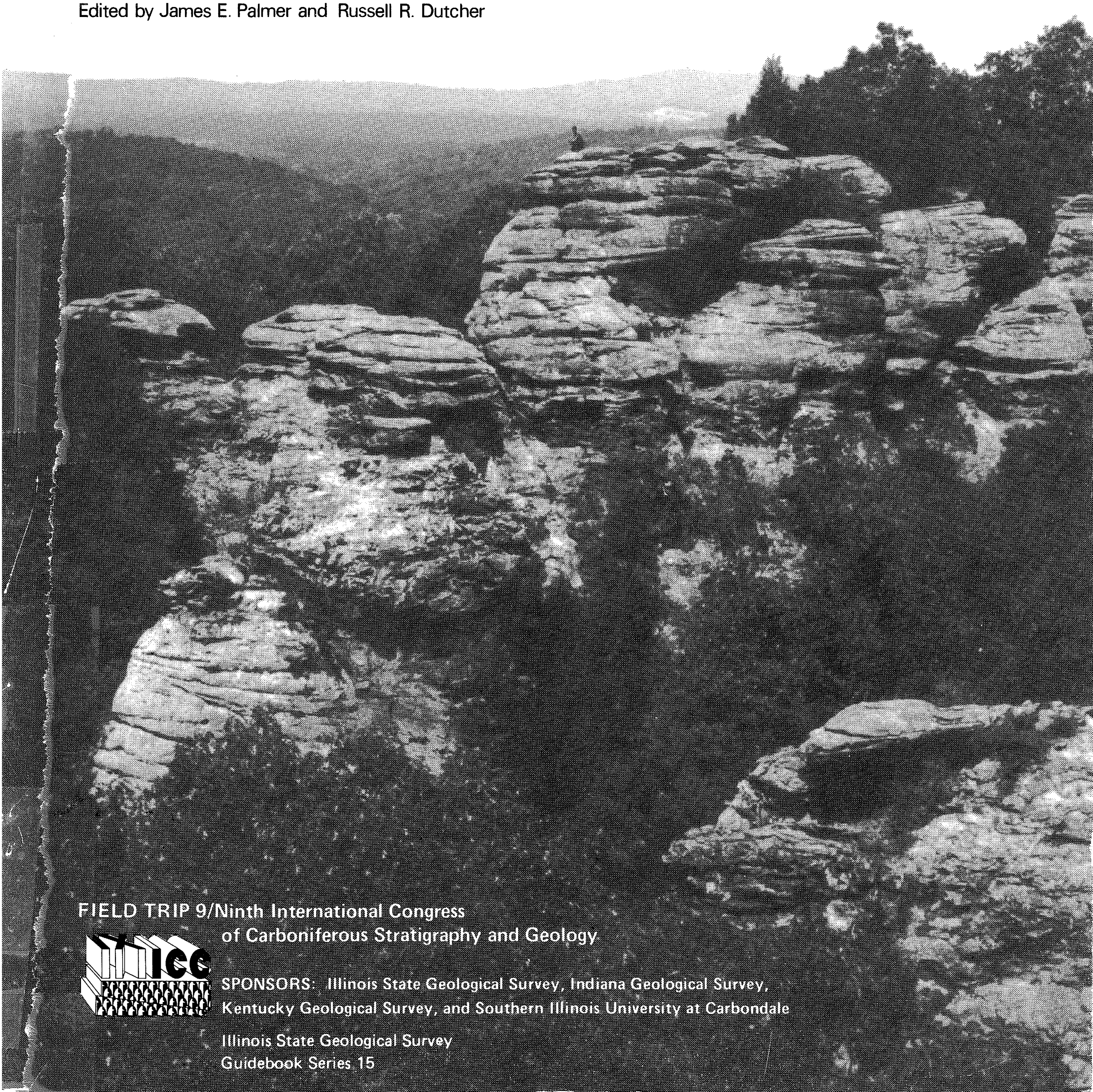
Depositional and structural history of the Pennsylvanian System of the Illinois Basin

Part 1: Road log and descriptions of stops

Edited by James E. Palmer and Russell R. Dutcher



FIELD TRIP 9/Ninth International Congress of Carboniferous Stratigraphy and Geology

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Illinois State Geological Survey
Guidebook Series 15

COVER PHOTOS

Front: Camel Rock (*far left*) and associated sandstone pinnacles, Garden of the Gods Recreation Area, Shawnee National Forest, Saline County, Illinois. Sandstone is of fluvial origin. Cut-and-fill structures, extensive cross-bedding, and steeply dipping joints are conspicuous. (Pounds Sandstone Member, Caseyville Formation)

Back: Circular, suboval, and irregular Liesegang banding. These iron-oxide-rich bands are believed to be the result of repeated uniform precipitation from colloidal suspension in porous and permeable sandstone. About one-third actual size. (Pounds Sandstone Member, Caseyville Formation)

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Depositional and structural history of the Pennsylvanian System of the Illinois Basin

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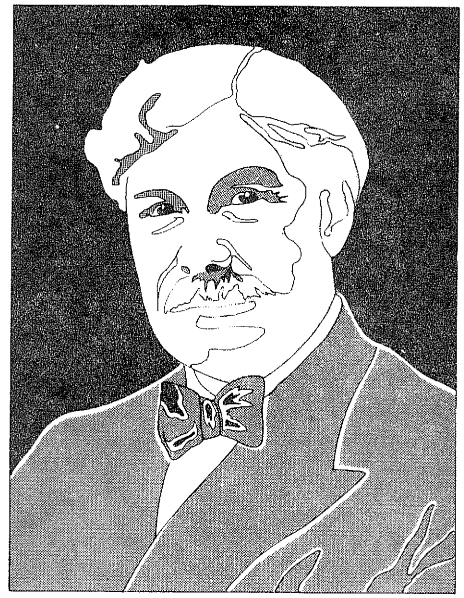
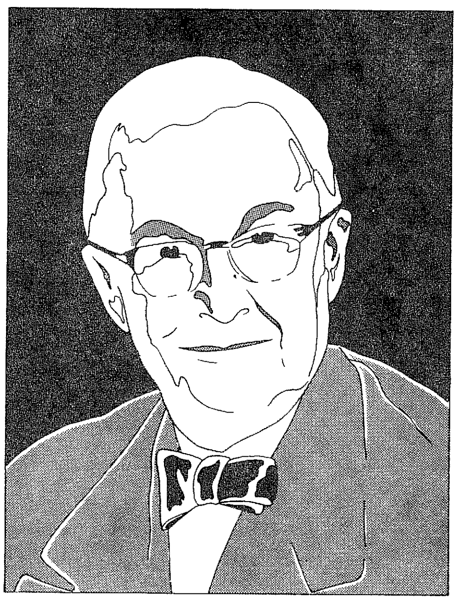
DEDICATION

This volume in Pennsylvanian geology of the Illinois Basin is dedicated to the memory of four individuals who have made monumental contributions to the geology of the region but whose contributions and influence extended far beyond this area.

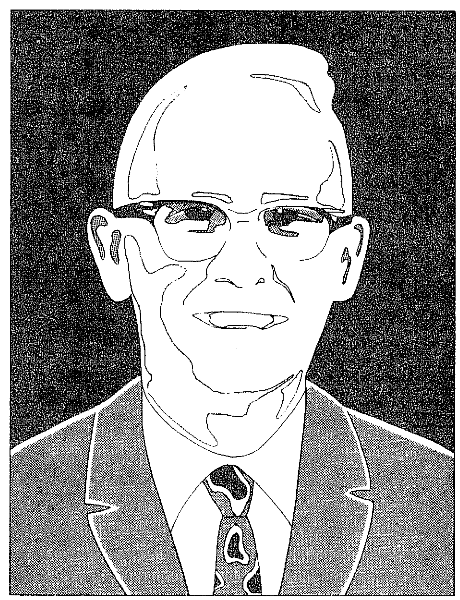
David Dale Owen
1807-1860



George Hall Ashley
1856-1951



Gilbert H. Cady
1882-1970



Harold R. Wanless
1892-1970

LIST OF AUTHORS

Please note that the individuals listed as trip leaders in this Guidebook are not necessarily the authors of the information for particular days. The following individuals authored the designated portions of the field trip.

Indiana

Day 1. Walter A. Hasenmueller, Henry H. Gray, and Donald D. Carr, Indiana Geological Survey.

Day 2. Walter A. Hasenmueller, Henry H. Gray, and Donald D. Carr, Indiana Geological Survey.

Kentucky

Day 2. Allen D. Williamson and Preston McGrain, Kentucky Geological Survey; Wayne A. Pryor and Paul E. Potter, University of Cincinnati.

Day 3. Allen D. Williamson, Preston McGrain, and Howard R. Schwalb, Kentucky Geological Survey; H.-F. Krausse and W. John Nelson, Illinois State Geological Survey.

Day 4. Robert D. Trace and Preston McGrain, Kentucky Geological Survey.

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Day 4. James E. Palmer and C. Brian Trask, Illinois State Geological Survey, with contributions by James W. Baxter and Richard D. Harvey, Illinois State Geological Survey.

Day 5. John T. Popp, Illinois State Geological Survey, with contributions by George H. Fraunfelter, John E. Utgaard, and Charles F. Mansfield, Southern Illinois University.

Day 6. Russell J. Jacobson, Illinois State Geological Survey, with contributions by Stanley E. Harris, Jr., John E. Utgaard, and Marc Deshowitz, Southern Illinois University, Carbondale.

ACKNOWLEDGMENTS

The field trip was planned and organized by geologists of the Illinois, Indiana, and Kentucky Geological Surveys, and members of the Geology Department faculty, Southern Illinois University, Carbondale. Most planning activities and field trip arrangements were completed by the Field Trip Policy Committee, which consists of the following members: Donald D. Carr, Indiana Geological Survey; Russell R. Dutcher, Southern Illinois University, Carbondale; Preston McGrain, Kentucky Geological Survey; James E. Palmer, Illinois State Geological Survey; and Allen D. Williamson, Kentucky Geological Survey.

Many other details of the field trip were managed by field trip and stop leaders, as identified within the text of the guidebook. Their help is gratefully acknowledged.

The invited papers of Part 2 were contributed upon relatively brief notice by various researchers who possess special knowledge of aspects of Illinois Basin geology. The scientific quality and significance of the guidebook has been greatly enhanced by the contributions of these authors.

Financial and technical support for the field trip was provided by the Illinois State Geological Survey, the Indiana Geological Survey, the Kentucky Geological Survey, and Southern Illinois University, Carbondale.

Special appreciation is extended to the Publications Staff of the Illinois State Geological Survey.

INTRODUCTION

The Illinois Basin Coal Field has been studied by geologists for more than 150 years. Due to long-term and continuing studies of surface exposures and a large amount of widely distributed subsurface data, the character of strata of the Pennsylvanian System throughout most of the area of the Illinois Basin is probably as well known as any comparable area in the world.

This field excursion will be devoted to examining natural and man-made exposures which provide information on the depositional and structural history of the Illinois Basin.

Geologic features emphasized on field trip

The following aspects of geology will be given special consideration:

General characteristics of fluvial and deltaic sedimentation. Major segments of about 1,200 feet (366 m) of rock strata, extending from the base of the Pennsylvanian System (Westphalian A) to the base of the Modesto Formation (upper Westphalian D) will be examined. Numerous sedimentary features and processes that give evidence of fluvial and deltaic sedimentation will be identified.

Occurrence and extent of channel-fill sandstones. Sandstones are generally recognized to be "the most variable and the most disruptive units within otherwise relatively regular stratigraphic sequences" in the Pennsylvanian of the Illinois Basin (Simon and Hopkins, 1966). The relationship of channel-fill and other sandstones to adjacent strata will be inspected at several field trip stops.

General characteristic of Pennsylvanian cyclic sedimentation. Wanless and Weller (1932) proposed the term "cyclothem" to designate "a series of beds deposited during a single sedimentary cycle of the type that prevailed during the Pennsylvanian Period." Opportunities will be provided during the trip to inspect nearly complete cyclothems in the middle Pennsylvanian as described by Wanless and Weller, and the more rudimentary cyclic deposition of units of the lower Pennsylvanian. Their characteristics and origin will be considered.

Depositional environments of black carbonaceous shales of the Pennsylvanian System. Both very shallow water deposition (Zangerl and Richardson, 1963) and deep water deposition (Heckel, 1977) have been proposed to explain the origin of these shales. The black shale will be accessible for close exmination at several outcrops, and various sedimentary features will be identified.

Demonstration of broad lateral continuity of some coals and other rock units in the Illinois Basin. Some coals, underclays, and limestones, although relatively thin, are the most persistent lateral units of the Pennsylvanian System. Several coal and limestone beds have been traced more or less continuously over a distance of about 350 miles (510 km). Opportunities will be presented on the field trip to compare individual units and stratigraphic successions at widely separated exposures.

Origin of the "blue-band" claystone parting in the Illinois Herrin (No. 6) Coal Member (western Kentucky No. 11). This prominent parting is normally 1 to 3 inches thick and is present almost everywhere in the lower portion of the No. 6 Coal in the Illinois Basin. Its origin has been the subject of debate for many years. The "blue band" will be observed at four widely separated localities on the field trip.

Occurrence and extent of marine limestones in close association with coals of the Illinois Basin. During middle Pennsylvanian (Desmoinesian) time, more marine transgressions occurred in the Illinois Basin than in the Appalachians, and more nonmarine strata were deposited here than in areas to the west (Wanless, 1975, Part 1, p. 85). The occurrence of these marine limestones, which will be observed at several localities, further demonstrates the close association of coals in the Illinois Basin with marine environment and remarkably uniform regional cycles in which nearly identical depositional environments extended without interruption for thousands of square miles.

Characteristics, extent, and origin of the major unconformity separating the Pennsylvanian System from the underlying Mississippian System. This unconformity and strata directly overlying it will be observed at several stops on the field trip. Howard (this Guidebook, part 2, p. 34-43) suggests that the morphology of the sub-Pennsylvanian surface is the product of alternating erosional and aggradational episodes, which may have been caused by alternating humid and arid climates.

Origin and local occurrence of bimodally sorted clastics (medium- to coarse-grained sandstone containing white quartz pebbles) in Pennsylvanian strata. At some localities in western Kentucky and southern Indiana, basal Pennsylvanian strata consist almost entirely of white quartz pebbles in a ferruginous fine-grained sandstone matrix. The abundance of white quartz pebbles within basal Pennsylvanian sandstone will be observed at several localities in the basin. The depositional history of the sandstone and its similarity to the Millstone Grit of England will be considered.

The gradual increase in argillaceous matrix and mica flakes with decreasing age of clastic rocks. This increase suggests a gradual change in provenance of sediments in middle and late Pennsylvanian time. Evidences of such a change will be considered at several field trip stops.

Occurrence of coal balls (fossil peat) in the Illinois Basin Coal Field and derived paleobotanical data. Coal balls occur in 17 coals at more than 50 locations in the Illinois Basin Coal Field. An opportunity will be afforded at one or more stops on the field trip to obtain coal ball samples.

General characteristics of Pennsylvanian stratigraphy

Pennsylvanian rocks have a maximum thickness of more than 3,500 feet (1,066 m) in Union County, western Kentucky, where the thickest section occurs in a graben block downthrown more than 1,000 feet (304 m). Douglass (this Guidebook, part 2) has identified Permian (Wolfcampian) strata in the uppermost part of the graben block. Elsewhere in the Illinois Basin, the maximum thickness of the Pennsylvanian System is slightly more than 2,500 feet (762 m). The formations are generally thickest in southeastern Illinois and western Kentucky. Some lower strata are present only in the southern part of the basin and are overlapped by younger formations in the north.

About 90 to 95 percent of the Pennsylvanian System in the Illinois Basin consists of clastic rocks (figure 2, Peppers and Popp, this Guidebook, part 2). Siltstone, shale, and underclay constitute about 40 percent of the lower part of the system and 65 to 70 percent of the middle and upper parts. Sandstones are particularly well developed in the lower part, where they constitute about 60 percent of strata; in the middle and upper parts, they constitute only about 25 percent of the strata. Limestone is rare, but in some areas constitutes as much as 5 to 10 percent of the upper two-thirds of the system. Limestone is especially common in the Bond Formation of Illinois, where limestone members as much as 50 feet thick have been recognized. Coal, one of the least abundant lithic units of the Pennsylvanian System, constitutes no more than two percent of rock strata in most areas.

More than 500 units of sandstone, siltstone, shale, limestone, coal, and clay are distinguishable in the Pennsylvanian strata of the Illinois Basin. The abruptness and great number of vertical changes in lithology indicate that changes in depositional environment were rapid. Because of the relatively large number of lithic units, a somewhat complex stratigraphic nomenclature has developed (figs. 1 and 2). Although some commonality in nomenclatures exists between Illinois, Indiana, and Kentucky, many different names have also been adopted in each state. Much has been done to establish equivalance of stratigraphic nomenclature in each state.

Structural framework of the Illinois Basin Coal Field

Strata of the Pennsylvanian System in the Illinois Basin were deposited in a subsiding trough open at its southern margin and bounded by structural arches or uplifts to the north, east, and west (fig. 3). However, at times, bordering structural features were at or below depositional base level, and some lithic units were deposited without substantial interruption in an area extending from Pennsylvania to Kansas (Wanless, 1975, Part I, p. 72). The Illinois Basin was structurally closed during Mesozoic time by uplift of the Pascola Arch by more than 10,000 feet (3,048 m).

Many major structural features of the Illinois Basin originated or experienced important growth and development during the Pennsylvanian Period. The La Salle Anticlinal Belt (fig. 3), which extends from La Salle County in northern Illinois to Lawrence County in southeastern Illinois, a distance of more than 200 miles (320 km), was substantially uplifted prior to deposition of Pennsylvanian rocks. Much of the area of the La Salle Anticlinal Belt must have been a peninsula or archipelago during early Pennsylvanian time, because no Caseyville strata were deposited, and the Abbott and Spoon Formations are much thinner there than elsewhere. Clegg (1965) reported that progressive movement took place throughout Pennsylvanian time, and intensive uplift of all Pennsylvanian strata occurred in very late Pennsylvanian or post-Pennsylvanian time.

The Du Quoin Monocline and associated Salem and Louden Anticlines (fig. 3) extend along the western margin of the Fairfield Basin for nearly 100 miles (160 km). The monocline forms a hinge line separating gently dipping strata to the west from more steeply dipping rocks at the margin of the Fairfield Basin. The monocline has local structural relief of about 500 feet (152 m) at the Herrin (No. 6) Coal and more than

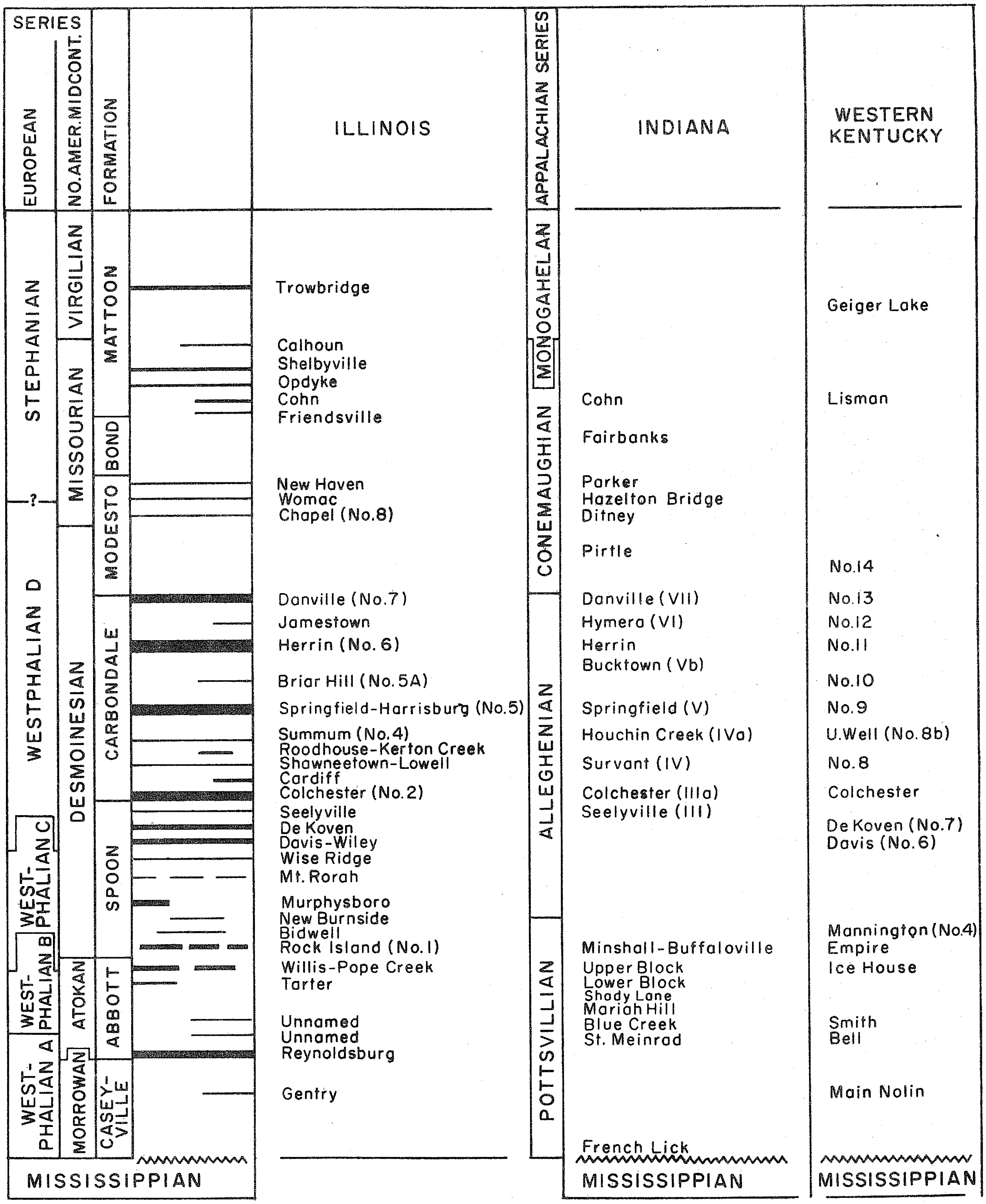


Figure 1. Generalized section of the Pennsylvanian in Illinois showing approximate vertical relations of the principal coals (after Willman et al., 1975) and approximate correlation of coals in Indiana (after Shaver et al., 1970) and in western Kentucky (Peppers and Williamson, personal communication) (from Harvey et al., 1979.)

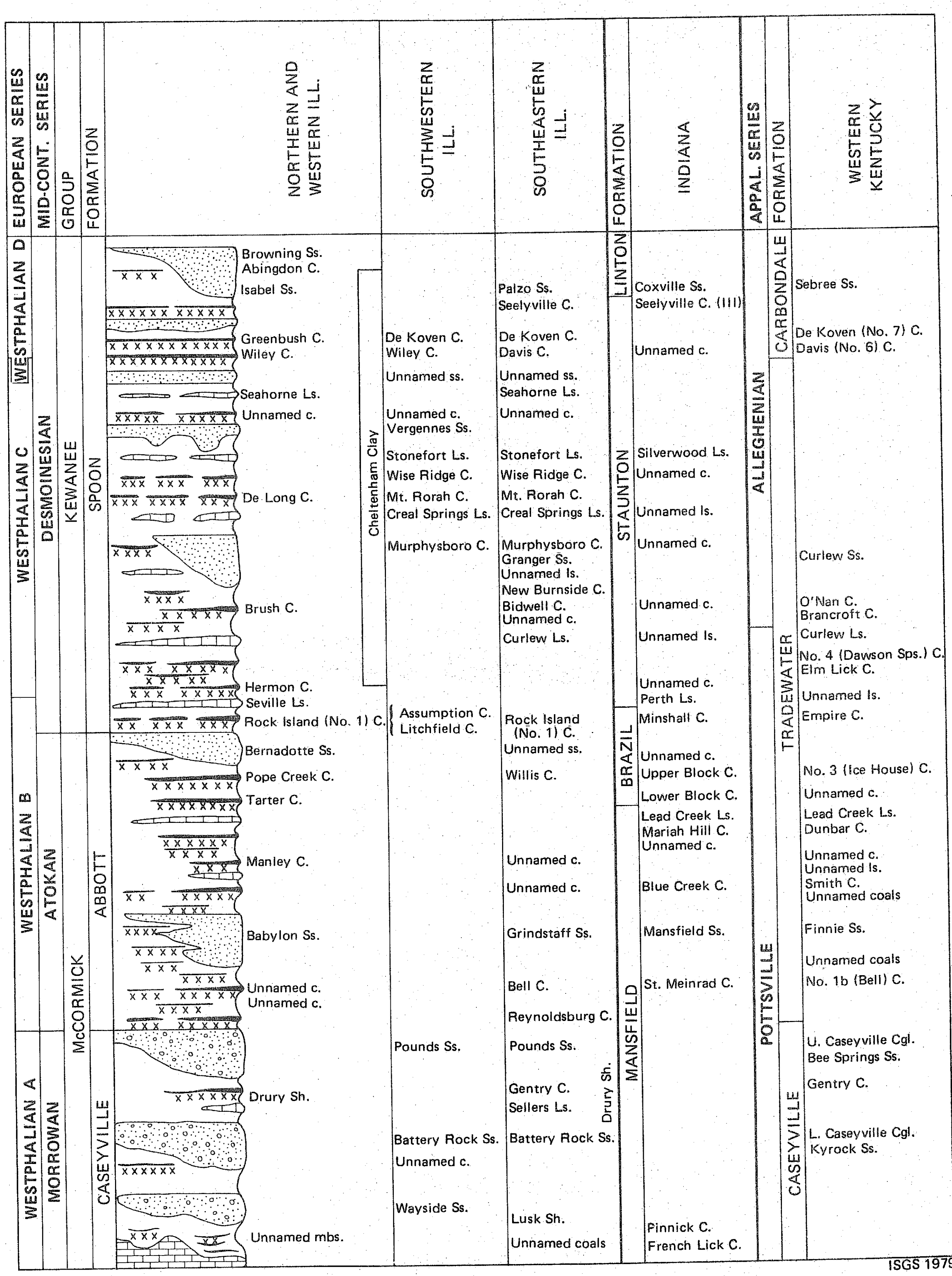


Figure 2. Correlation of formations and major stratigraphic members and beds in the lower part of the Pennsylvanian in the Illinois Basin Coal Field. (From Peppers and Popp, 1979. Adapted from Kosanke et al., 1960, and Willman et al., 1975. p. 163-201.)

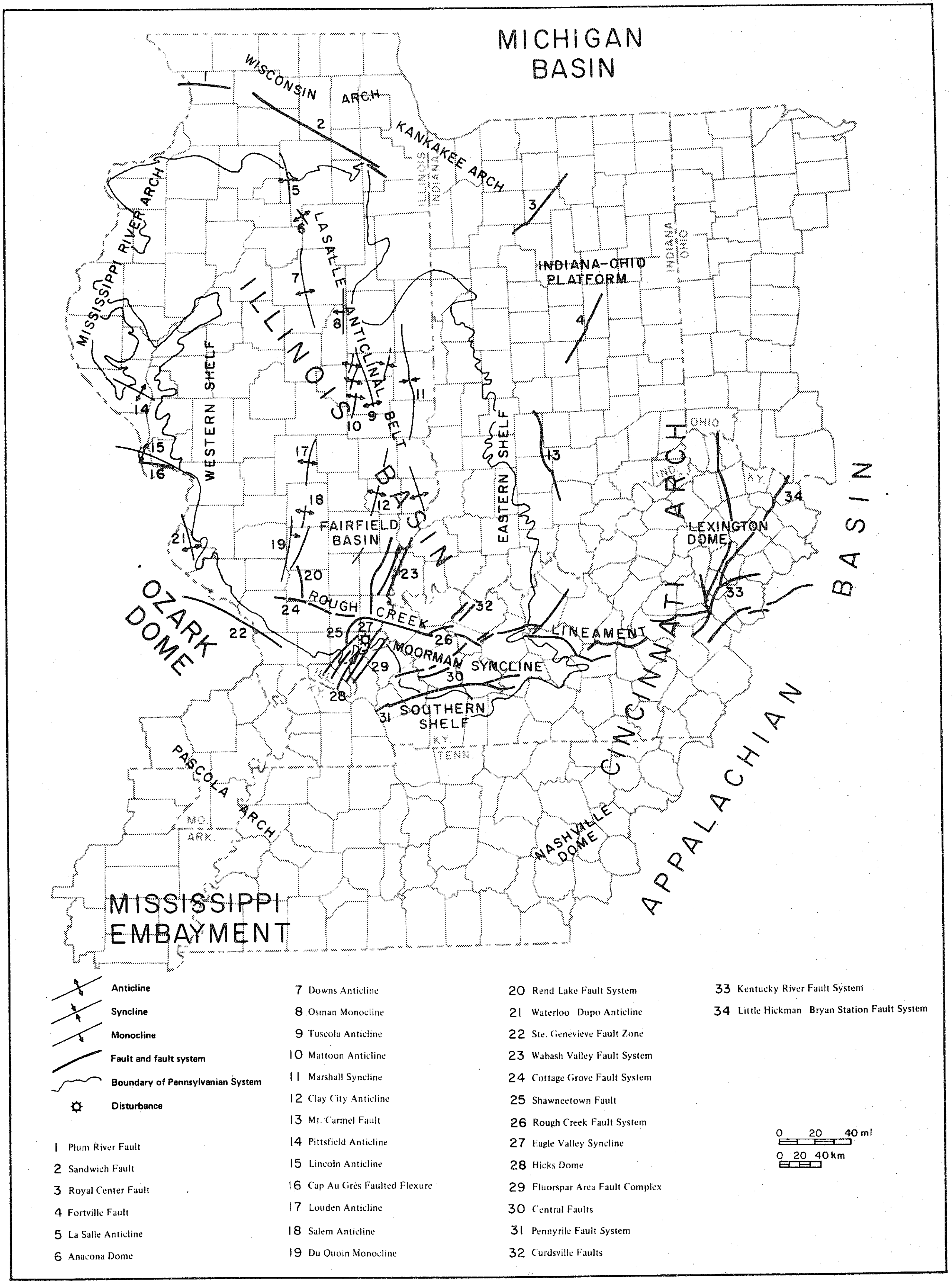


Figure 3. Structural features of the Illinois Basin (from this Guidebook, part 2, p. 106).

1,000 feet (304 m) in rocks of Chesterian (late Mississippian) age. The Du Quoin Monocline did not develop until after deposition of youngest Mississippian strata; maximum growth appears to have occurred during early and middle Pennsylvanian time.

The Rough Creek Fault System (fig. 3) is an east-trending belt of normal and reverse faults located near the southeastern margin of the Illinois Basin. Regionally, the fault zone, together with the Cottage Grove Fault System of southern Illinois, divides the Illinois Basin into two lobes: a northern basinal area, the Fairfield Basin, and a southern basinal area, the Moorman Syncline. The southern basinal area is disrupted near its western end by the strongly faulted and mineralized area of Hicks Dome and the Fluorspar Area Fault Complex (fig. 3). Faults of the Rough Creek Fault System are all post-Pennsylvanian. The Moorman Syncline to the south appears to have formed contemporaneously with faults of the Rough Creek System. Additional data concerning structural history of the Illinois Basin are provided by Bushbach and Atherton (this Guidebook, part 2, p. 112-115). Details of structural features of the southern part of the Illinois Basin are presented by Krausse and Treworgy (this Guidebook, part 2, p. 115-120).

Occurrence and mining of coal in the Illinois Basin Coal Field

The first discovery of coal in the United States reportedly was by "Joliet and Father Marquette in their voyage of exploration in 1673 by way of the Illinois Valley and Chicago River . . . some place between the present cities of Utica and Ottawa" (Bement, 1929). The first substantial mining operation in the Illinois Basin Coal Field began in Illinois before 1810 near Murphysboro in the Murphysboro Coal Member of the Spoon Formation. Early commercial mining began in western Kentucky in 1820 on the Green River in Muhlenberg County. The first coal company to officially begin operations in Indiana was the American Cannel Coal Company, which opened its first mine in 1837.

The Illinois Basin Coal Field includes a total land area of about 45,000 square miles (116,500 km^2). It is about 400 miles (643 km) long, measured in a northwesterly direction, and about 250 miles (402 km) wide.

At least 80 coals have been identified in the Pennsylvanian System of the Illinois Basin Coal Field. Most of the coals are less than six feet thick and many are considerably thinner. Most mining is from the Harrisburg (No. 5) Coal Member of Illinois, (Indiana Springfield Coal Member (V), west Kentucky No. 9) and the Herrin (No. 6) Coal of Illinois (western Kentucky No. 11 Coal), which are commonly 4 to 6 feet (1.2 to 1.8 m) thick.

Resource estimates have been completed for about 30 coals that are considered to be of minable thickness (more than 28 inches or 71 cm); at least 20 of the coals have been mined commercially. Total resources for the coal field including hypothetical and speculative coal in beds greater than 14 inches (35 cm) thick is 365 x 10^9 short tons (Averitt, 1975). Total identified resources (measured, indicated, and inferred) of the coal field are about 236 x 10^9 tons. The identified reserve base including beds greater than 28 inches thick at depths of less than 1,000 feet (305 m) is 90 x 10^9 tons, which is 21 percent of the total reserve base of the United States. Coal in the Illinois Basin is classified as high volatile A, B, and C bituminous. The sulfur content is commonly high, 3 to 6 percent on a dry ash free basis, and a systematic decrease in rank occurs from the southeastern to the northwestern part of the basin. An estimated 6 x 10^9 tons of relatively low sulfur coal reserves remain (U.S. Bureau of Mines, 1974; Smith and Stall, 1975). In 1979 there are about 360 active mines in Illinois Basin Coal Field that produce 135 million tons of coal, about 20 percent of total United States production. About 60 percent of the coal is surface mined, and the remainder is from deep mines at depths of less than 1,000 feet (304 m).

The largest surface mine now in the Illinois Basin Coal Field is the Lynnville Mine, Peabody Coal Company, near Lynnville, Indiana, which produced about 3.3 million tons in 1977. The largest underground mine is the Pawnee No. 10 Mine, Peabody Coal Company, located near Springfield, Illinois, which produced 2.8 million tons of coal in 1977. Most coal mines in Illinois produce in excess of 1 million tons per year, and mines are more numerous and generally smaller in Indiana and Kentucky.

Saturday, May 26, 1979

Organizational day. New Harmony, Indiana (overnight stop).

STOP 1. New Harmony, Indiana.

Sunday, May 27, 1979

DAY 1. New Harmony, Indiana, to French Lick, Indiana.

STOP 2. Peabody Coal Company, Lynnville Mine, Eby Pit.

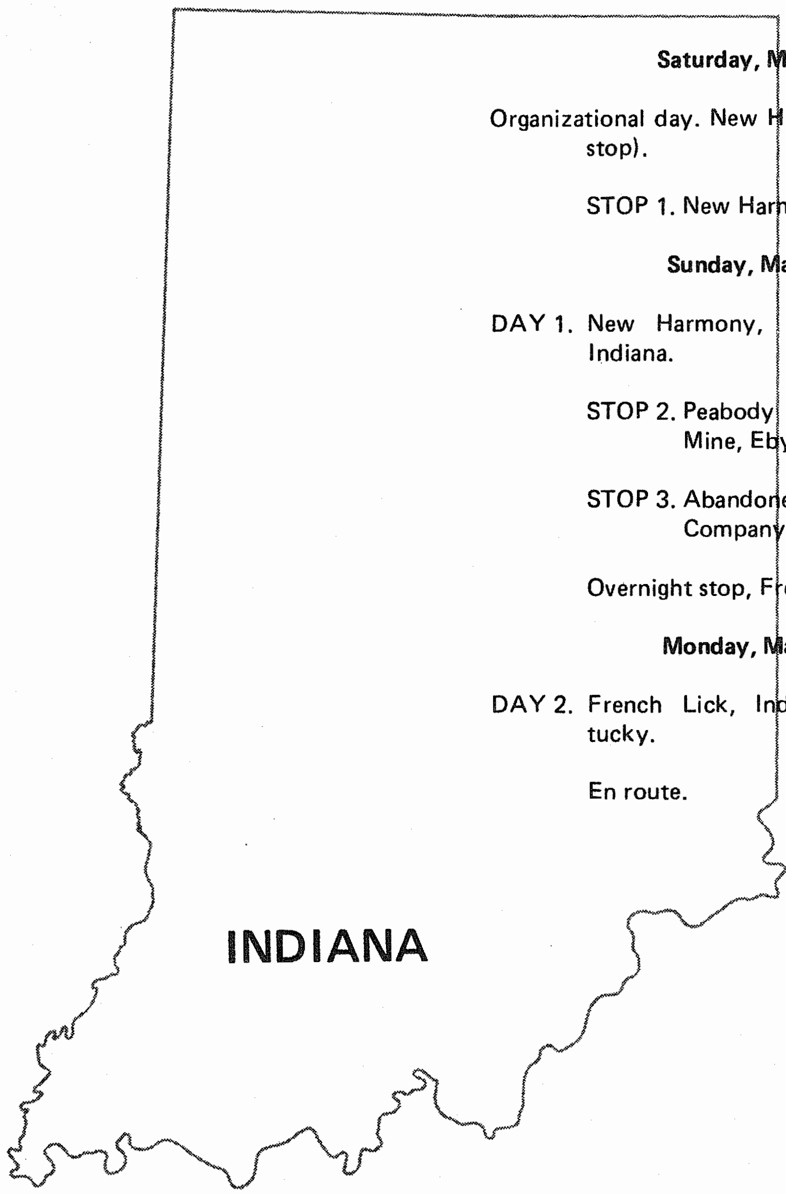
STOP 3. Abandoned General Refractories Company Conglomerate Quarry.

Overnight stop, French Lick-Sheraton Hotel.

Monday, May 28, 1979

DAY 2. French Lick, Indiana, to Hawesville, Kentucky.

En route.



ORGANIZATIONAL DAY New Harmony, Indiana (overnight stop).

Trip leaders: Walter A. Hasenmueller, Henry H. Gray, and Donald D. Carr, Indiana Geological Survey.

Saturday, May 26, 1979

STOP 1. New Harmony, Indiana.

Mileage

0.0 Enter New Harmony, Indiana. Proceed to Entry House of the New Harmony Inn; end of route log for first half day of trip.

STOP 1 New Harmony, Indiana.

Leaders: John and Josephine Elliott, New Harmony, Indiana; and John B. Patton, Indiana Geological Survey.

Harmonie was founded in 1818 by Father George Rapp and his flock of about 700 members of the Harmony Society, a group of Lutheran dissenters from Württemberg, Germany, via Pennsylvania. They believed that the second coming of Christ would occur during their lifetimes and based their social and religious activities, including celibacy and communal living, on the theory that they should subjugate all personal desires to the good of their community. The tangible results of their self-denial and industriousness at Harmonie included 200 acres under cultivation; large vineyards and orchards; a portable greenhouse for raising oranges and lemons; four multi-storied brick dormitories; a massive brick church; a large fort-granary; 126 brick, frame, or log homes; two distilleries; a brewery; woolen, cotton, hemp, and sawmills; a mechanics' shop; a tanyard; and a shoe factory.

In 1825, Rapp, in order to complete a divine plan, moved the members of the Society back to Pennsylvania and sold the town to Robert Owen, a Welsh-born industrialist, who renamed the town "New Harmony." Owen in partnership with William Maclure, a geologist and Scottish philanthropist, assembled a group of renowned teachers and scientists from Europe and America to help establish a communal society in New Harmony based on education as the key to a new and better way of life. Included in this distinguished group of scholars were Gerard Troost, a Dutch geologist; Charles-Alexandre Lesueur, an artist-naturalist; Thomas Say, entomologist and conchologist; Samuel Chase, entomologist; and Marie-Duclos Fretageot, educator. Although this experiment in a utopian society failed, New Harmony contributed many "firsts" to American culture: the first kindergarten; first infant school; first trade school; first free library; first civic dramatic club; first organized women's club; seat of the first two geological surveys of scientific significance conducted by the United States government; and first headquarters for geological surveys of Indiana.

DAY 1 New Harmony, Indiana, to French Lick, Indiana.

Trip leaders: Walter A. Hasenmueller, Henry H. Gray, and Donald D. Carr, Indiana Geological Survey.

Sunday, May 27, 1979

STOP 2. Peabody Coal Company, Lynnville Mine, Eby Pit.

STOP 3. Abandoned General Refractories Company Conglomerate Quarry.

Overnight stop, French Lick-Sheraton Hotel.

0.0 Board buses in front of the Entry House of the New Harmony Inn and proceed west on North Street. See figure IN-1 for a map of today's route.

0.1 Intersection of North Main St. and North St.; turn left (south) on North Main St.

0.2 Intersection of Indiana Route 66 and 69 in center of New Harmony, Indiana; turn left (east) on Indiana 66.

1.2 The road at this point is built on the nearly level surface of a low terrace of Wisconsinan-age valley train sediments. This terrace is slightly higher than the alluvial sediments of the modern Wabash River floodplain located about .25 mile (.4 km) north of this point. Commercial sand and gravel deposits are found in Wisconsinan valley train deposits similar to these, but ground water and farming are the principal economic uses associated with these deposits.

1.9 Junction of Indiana Routes 66 and 68; turn

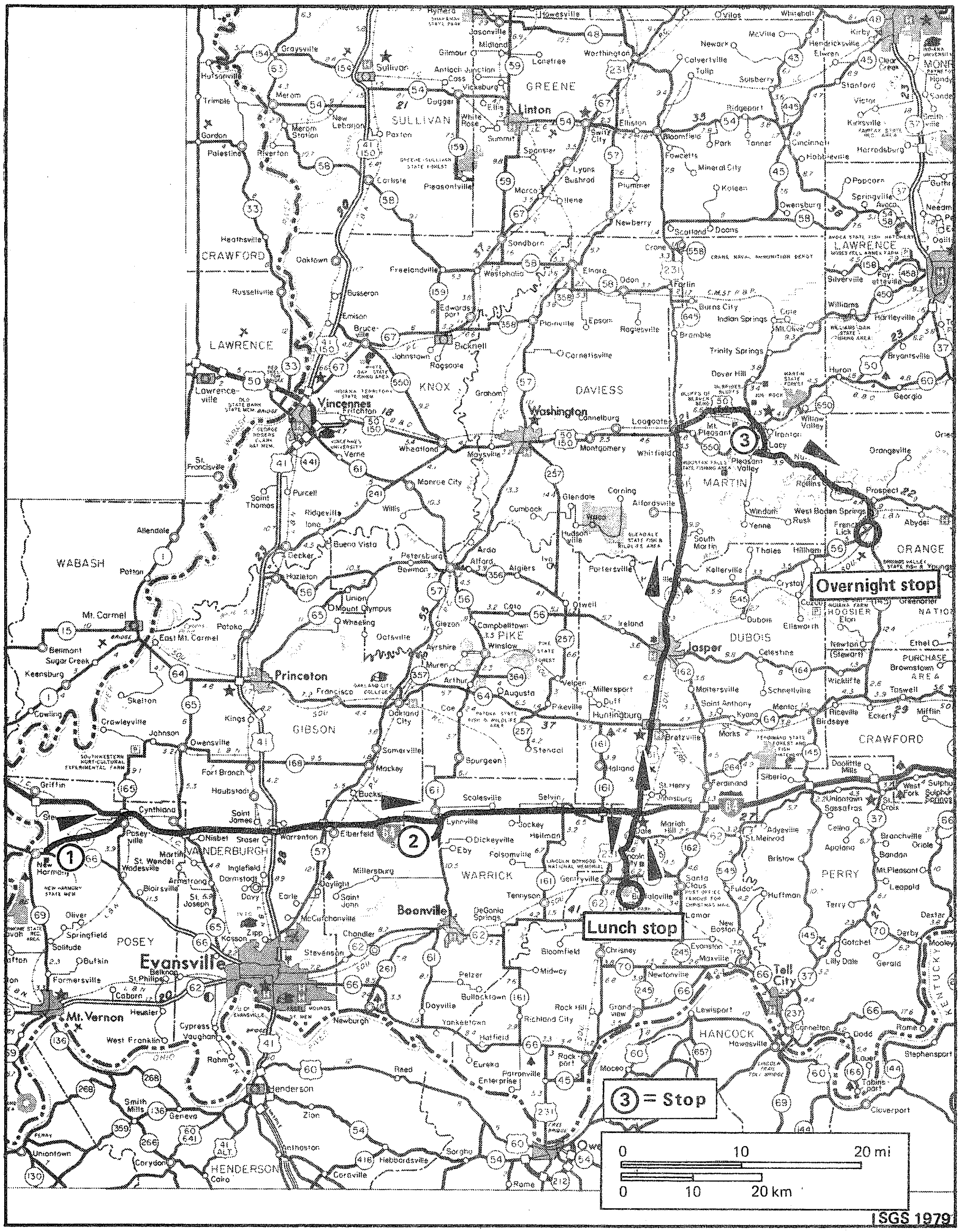


Figure IN-1. Field trip route for Indiana, Day 1, from New Harmony, Indiana to French Lick, Indiana.

left (northeast) on Indiana 68.

2.2 Oil well on right (south) side of road is a part of the Black River Consolidated Field discovered in 1950. Oil production is from sandstones of Pennsylvanian and Mississippian ages. Other wells of the Black River Consolidated Field are visible on both sides of the road for the next mile.

3.9 Good exposure of Wisconsinan-age loess in the roadcut on the right (south) side of the road as we leave the Wabash River valley. During the morning, our route will cross the Wabash Lowland, a physiographic unit described by Malott (1922). The low, rolling, bedrock-cored hills are mantled by loess and Illinoian till, and are interspersed with broad, deeply filled valleys.

4.6 Oil well to left (north) is part of the Roger East Field discovered in 1943. Oil production is from a sandstone of late Chesterian age at a depth of 2,200 feet (671 m).

7.0 Crops of the Shoal Creek Limestone Member, basal member of the Bond Formation (fig. IN-2), are located approximately at bend in road.

7.7 The low hills which the road is following at this point are blanketed by Wisconsinan loess, but the broad, nearly flat area to the right (south and southeast) is one of the numerous sites in southwestern Indiana that was occupied by glacial-age lakes. The silts, clays, and sands which comprise the sediments deposited in these lakes typically have poor bearing capacity; slumping of cut banks in these deposits is common, making them difficult materials to handle in the surface mining of coals.

8.4 Cemetery on right (south) side of road.

9.2 Intersection of Indiana Routes 68 and 165 on the southwest edge of Poseyville, Indiana; turn left (north) on Indiana 68-165.

9.3 Crossing railroad tracks and entering Poseyville, Indiana. The town was laid out in 1840 and was called Palestine until 1852, when the name was changed to Poseyville after the county in which it is situated. Posey County was organized in 1814 and named after General Thomas Posey, an officer in the American Revolution and governor of Indiana Territory (1813-1816).

10.2 Junction of Indiana Routes 165 and 68; continue north on Indiana 165.

11.0 Indiana Route 165 interchange with Interstate 64; turn right (east) on I-64.

11.7 Oil well to the left (north) is part of the Poseyville Field discovered in 1954. Oil production is from sandstones and limestone of Chesterian and Valmeyeran ages at depths of 2,680 to 2,765 feet (817 to 843 m).

13.9 Cleveland Road crosses over I-64.

16.7 Indiana Route 65 interchange with I-64; continue east on I-64. Entering Vanderburgh County. The county was organized in 1818 and named for Judge Henry Vanderburgh, officer in the American Revolution and Judge of the first court in Indiana.

17.1 Crossing approximate location of the crop of the West Franklin Limestone Member, uppermost member of the Shelburn Formation.

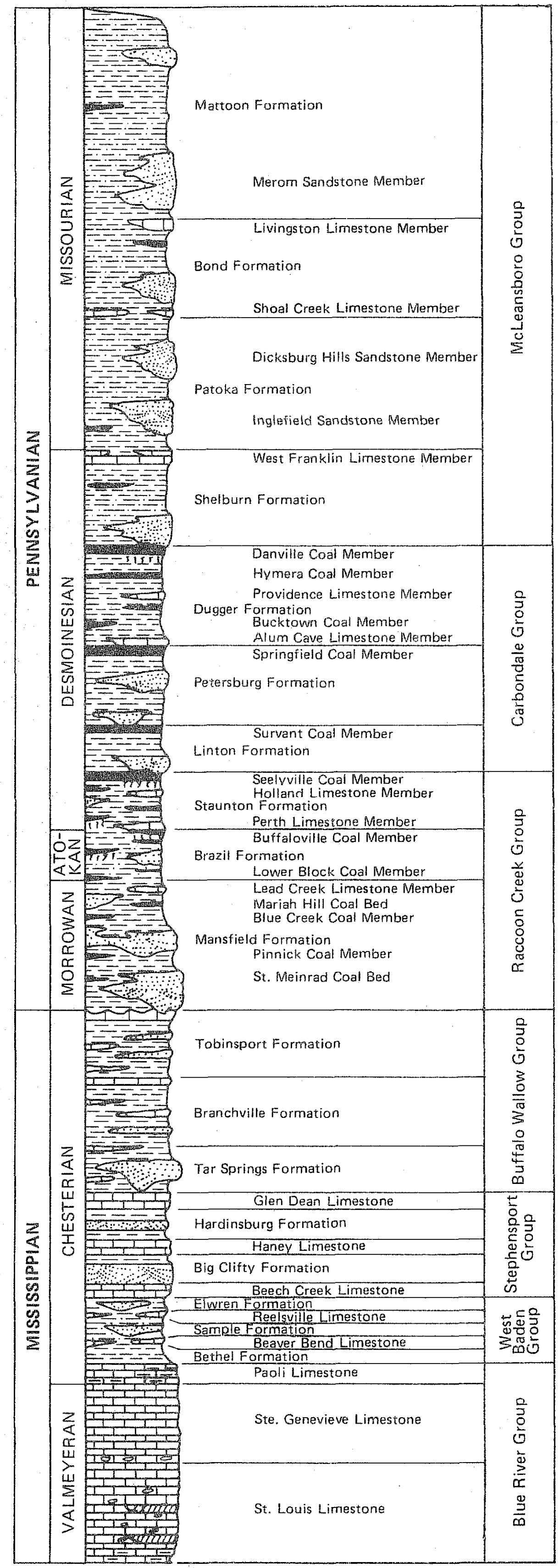


Figure IN-2. Generalized columnar section of southwestern Indiana. (Modified from Gray, 1979.)

22.9 Entering Gibson County, which was organized in 1813 and named for General John Gibson, Secretary of Indiana Territory from 1801 to 1816.

24.0 U.S. Route 41 interchange with I-64; continue east on I-64.

26.3 The Warrenton East Oil Field is located to the left (north). This field was discovered in 1950, and production is obtained from sandstones and limestones of Chesterian and Valmeyeran ages.

28.5 Indiana Route 57 interchange with I-64; continue east on I-64.

29.0 Entering Warrick County, organized in 1813 and named for Captain Jacob Warrick, who was killed at the Battle of Tippecanoe in the War of 1812.

31.8 Crossing the trace of the Wabash and Erie Canal: part of a statewide network of canals that were main arteries of transportation in the 1840s before railroads were extensively developed in the State. These canals were expensive to build and difficult to maintain. The Southern Division of the Wabash and Erie Canal was particularly troubled by maintenance problems, leading to its early closing in 1861.

33.9 The area to the right (southeast) was surface mined in the mid and late 1960s as a part of Peabody Coal Company's Lynnville Mine. The Danville Coal Member (VII) and the Hymera Coal Member (VI), of the Dugger Formation (fig. IN-2), were bench mined at this location.

35.8 The spoil banks visible on the left (northeast) mark an area where the Danville and Hymera Coal Members were mined in the early 1960s by the Lynnville Mine. The Lynnville Mine is currently mining these and the Springfield Coal Member (V) in four separate pits. The largest pit of the Lynnville Mine is located about three miles south of here and has a highwall about 3 miles (4.8 km) in length.

36.6 Area on both sides of the highway was mined in the early 1960s as a part of the Lynnville Mine. The Danville and Hymera Coal Members were mined at this site.

38.0 Area to the right (south) was mined in the late 1950s by the Sunlight Coal Corporation. The Danville and Hymera Coal Members were both mined here.

38.6 Indiana Route 61 interchange with I-64; exit I-64 and proceed right (south) on Indiana 61. The town of Lynnville is located about 0.25 mile (.4 km) north. Lynnville was platted in 1839 by John Lynn and named for him.

40.0 Entrance road to the Peabody Coal Company's Lynnville Mine; turn left (west) and follow the mine entrance road to the mine office.

42.4 Mine office of Lynnville Mine on right (north) side of road; turn into the mine-office parking lot. We will have a brief stop here to meet Peabody Coal Company personnel who will lead us to Stop 2, the Eby Pit of the Lynnville Mine, where the Springfield Coal Member (V) of the Petersburg Formation and the lower half of the Dugger Formation are exposed in the highwall.

STOP 2 Peabody Coal Company, Lynnville Mine, Eby Pit.

Leaders: Walter Hasenmueller and Henry H. Gray, Indiana Geological Survey; and Leonard Hughes, Peabody Coal Company.

Lynnville Mine is a good example of a large, modern surface-mining operation in the Illinois Basin. Almost 3.4 million tons (3.1×10^6 MT) of washed coal were produced from four separate pits in 1977. More than 53 million cubic yards (40.5×10^6 m^3) of overburden have been removed, and 484 acres (196 hectares) have been affected since the mine began production. Nearly 64 million tons of coal have been produced and approximately 9,400 acres have been affected since the mine began production.

Lynnville Coal Corporation began operation of Lynnville Mine in 1955 and sold the mine to Peabody Coal Company in December 1957. Peabody increased production of the mine to a peak of 4,173,500 tons (3.8×10^6 MT) in 1972. The mine is projected to continue production through the year 2007, at which time most of the surface-minable reserves will be depleted. Four hundred and fifty hourly workers and eighty-seven salaried management and support people are employed in the simultaneous operation of the four pits.

Two Marion 1150-B draglines with 30-cubic-yard (22.9 m^3) buckets operate respectively in the two westernmost pits, the No. 2 Pit and the Dragline Pit, removing up to 80 feet (24 m) of overburden from the Danville and Hymera Coal Members (which locally are called the Upper and Lower Millersburg Coals), as well as the parting material between the two seams. These coals are also produced from the Shovel Pit (the central pit), where a 5900 Marion shovel with a 105-cubic-yard (80 m^3) bucket uncovers coal to a maximum depth of 100 feet (30 m). The parting between the two seams is removed by smaller loading shovels in this pit. Raw coal from these three pits is hauled by 100-ton trucks to two separate preparation plants. The fourth, and easternmost, pit is the Eby Pit. This is the pit you will be observing during your visit at Lynnville Mine. Here a 5761 Marion shovel with a 65-cubic-yard (50 m^3) bucket uncovers the Springfield Coal Member (V) at a maximum depth of 80 feet (24 m). The raw coal is hauled by truck and rail to the central preparation plant.

Land at Lynnville Mine is reclaimed using twelve dozers, four graders, and sixteen pan scrapers. The pan scrapers are used primarily for removal and replacement of topsoil. Revegetation practices have changed over the years, with areas mined early in the life of the mine being reclaimed primarily to forest vegetation. In more recent years, vegetation has been primarily mixtures of grasses and legumes for hay and pasture use.

Most of the finished product at Lynnville Mine is shipped by rail to two electric-generating plants owned and operated by Indianapolis Power and Light and Southern Indiana Gas and Electric Co. A small portion of the coal is hauled by truck to the Louisville Cement Co. plant at Speed, Indiana.

The Springfield Coal Member of the Petersburg Formation (fig. IN-2) averages 4 to 5 feet (1.2 to 1.5 m) in thickness in this pit, which is about average for the Springfield Coal in Indiana (Coal Group, 1979). The overburden in the Eby Pit consists of the lower Dugger Formation overlain by a few feet of Illinoian till. The Dugger Formation ranges in thickness from 85 to 160 feet (26 to 49 m) in Warrick County; hence, about one-half to two-thirds of the Dugger can be seen in the Eby Pit where the highwall stands at its maximum.

The Eby Pit lies about 1 to 1.5 miles (1.6 to 2.4 km) north of a 1- to 2-mile wide belt where sediments of a distributary channel system mapped and interpreted by Don Eggert (in preparation) partially or completely replace the Springfield coal. Hence, although a more or less typical sequence of lower Dugger rocks is present in the Eby Pit area, anomalous gray shale, gray sandy shale, and sandstone are present in the lowest part of the Dugger, often at the expense of the black fissile shale which normally forms the basal unit of the Dugger and the Alum Cave Limestone Member. Numerous shale partings in the Springfield coal in the Eby Pit area and just to the south of it also evidence the proximity of the contemporaneous distributary system.

Drilling records in the Eby Pit area and close to it show an average of 0.5 foot (.15 m) of black fissile shale directly overlying the Springfield Coal Member. To the south and east of the pit area, however, gray shale is commonly present between the coal and the black fissile shale.

The occurrence of the Alum Cave Limestone Member (fig. IN-2) is irregular in the Eby Pit area. Where present, the Alum Cave directly overlies the black fissile shale or is separated from it by a few feet of gray shale. The Alum Cave is finely crystalline, argillaceous and silty, fossiliferous limestone in sections near the Eby Pit.

Drilling logs show that the Bucktown Coal Member (Vb) is present to the north and east of the Eby Pit. A black fissile shale a few feet above the Alum Cave Limestone Member may represent the Bucktown Coal Member.

42.4 Reboard bus at the main office of the Lynnville Mine and proceed east on the mine entrance road.

44.8 Intersection of mine entrance road and Indiana Route 61; turn left (north) on Indiana 61.

45.9 Indiana Route 61 interchange with Interstate 64; turn right (east) on I-64.

46.4 Good cross-sectional view of spoil banks left after area mining of the Danville and Hymera Coal Members to the right (south). This area was mined in the late 1940s and early 1950s.

46.6 Final-cut highwall where the Danville and Hymera Coal Members were mined to the right (south). Interbedded siltstones and shales of the lower Shelburn Formation are exposed in this highwall.

47.8 Crossing north end of the abandoned Sunlight Coal Corporation's Sunlight No. 14 Mine. Rocks of the basal Shelburn Formation in this pit are similar to those seen at mileage 46.6. The Danville and Hymera Coal Members were area-mined to their crop line at this point.

The Providence Limestone Member of the Dugger Formation (fig. IN-2) was quarried at a site about 1.2 miles (1.9 km) south-southwest of here. A section at this quarry measured by Harold L. Deane records 5.2 feet (1.6 m) of medium-gray, finely crystalline, massive limestone interbedded with dark-gray, clastic, argillaceous, very cherty limestone. Spiriferoid brachiopods, *Tetradium*, and bryozoans were found.

48.9 Abandoned highwall of Old Ben Coal Company's No. 1 Mine, Log Creek Field, to the left (north). About 90 feet (27 m) of the Dugger Formation was removed here to mine the Springfield Coal Member. The area to the left (north) for the next 2 miles (3.2 km) has been surface mined by Old Ben Coal Company. Most of the mined area visible from I-64 has been reclaimed as range land, but Old Ben Coal Company is also reclaiming parts of the Log Creek Field for pasture and hay fields, forest land, and row crops.

49.6 A resistant massive sandstone of the Dugger Formation can be seen in the exposed portion of the final-cut highwall to the right (south); the black fissile shale, calcareous shale (Alum Cave Limestone Member), and siltstone which underlie the exposed massive sandstone are below the present water level in the pit. The Springfield Coal Member was mined here in the late 1940s by the Tecumseh Coal Corporation.

51.2 The sandstone exposed in the final-cut highwall of the abandoned Tecumseh Coal Corporation's No. 13 Pit to the right (south) lies about 35 feet (10.7 m) above the base of the Dugger Formation, according to a section measured near this site by Harold L. Deane when this mine was active. The Bucktown Coal Member (Vb) lies about 20 feet (6.1 m) below the base of the sandstone and is underlain by 10 feet (3 m) of interbedded sandstone, siltstone, and shale, 1 to 1.5 feet (.3 to .5 m) of calcareous shale and dark gray argillaceous limestone comprising the Alum Cave Limestone Member, 2 feet (.6 m) of gray shale, and 1 foot (.3 m) of black fissile shale. The Springfield Coal Member of the Petersburg Formation is 3 feet (.9 m) thick and is at the base of this section.

52.0 The sequence of units of the lower Dugger Formation exposed in the final-cut highwall of the abandoned Tecumseh Coal Corporation's North Pit No. 17 on the right (south) is similar to that exposed in highwall of the No. 13 Pit at mileage 51.2, but here the Bucktown Coal Member is clearly visible about 15 feet (4.6 m) above road level (fig. IN-3). The top of the Alum Cave Limestone Member is exposed at the base of this highwall about 25 yards (23 m) south of the road.

53.2 Road 400E crosses over I-64.

53.6 The crop line of the Survant Coal Member (IV), uppermost member of the Linton Formation, is located in the hill north of I-64 at this point.

57.2 Crossing the approximate position of the crop of the Seelyville Coal Member (III), uppermost member in the Staunton Formation and the Raccoon Creek Group.

57.3 Road 800E crosses over I-64.

57.9 Indiana Route 68 crosses over I-64.

60.0 Indiana Route 161 interchange with I-64; continue east on I-64.

61.4 Entering Spencer County; organized in 1818 and named for Captain Spier Spencer, who was killed at the Battle of Tippecanoe.

63.1 U.S. Route 231 interchange with I-64; exit I-64 to right and proceed south on U.S. 231.

64.7 Entering Dale, Indiana; laid out in 1843 and originally named Elizabeth, but since there were already two towns with that name in the state, the name was changed to Dale in honor of Robert Dale Owen of New Harmony, who was congressman at the time of the name change.

65.4 Intersection of Indiana Route 62 and U.S. Route 231 in the center of Dale; continue south on U.S. 231.

66.5 Junction of Indiana Route 345 and U.S. 231; turn left (south) on Indiana 345.

67.6 Cross Little Pigeon Creek, which is flowing across a glacial-age lake bed at this point.

68.8 Enter Lincoln City.

68.9 Cross railroad tracks.

69.0 Junction of Indiana Routes 162 and 345; turn right (south) on Indiana 345-162.

69.1 Lincoln Boyhood Home National Memorial on the left (east).

69.6 Junction of Indiana Routes 162 and 345; cross Indiana 162 and continue south on the entrance road to Lincoln State Park.

69.7 Entrance to Lincoln State Park.

Abraham Lincoln, sixteenth president of the United States, was born in Kentucky in 1809 but moved with his family to Indiana when he was seven. Two years later his mother, Nancy Hanks, died; her grave can be seen from the trail to the site of the Lincoln cabin. A year later his father, Thomas, returned to Kentucky and married Sarah Bush Johnson, a widow with three children, who raised the two Lincoln children along with her own and who is credited with having a strong influence on Abraham's life. His penchant for education is remarkable considering that both parents were illiterate and formal schooling was scarcely available. His skills as a mimic and story teller, his shrewd native intelligence and pioneer spirit, and his physical attributes—tall and lanky but powerful body—attracted many friends and carried him through short-lived careers as a rail splitter, flatboatman, store keeper, postmaster, surveyor, and blacksmith. At twenty-one, he moved with his family to Illinois where he later passed the Illinois bar exam through self study, practiced law, entered politics, and in 1861 became president. His rise through self determination from humble beginnings to greatness became a legend, which grew to almost mythical proportions after his death by an assassin's bullet in 1865 during the second term of his presidency.

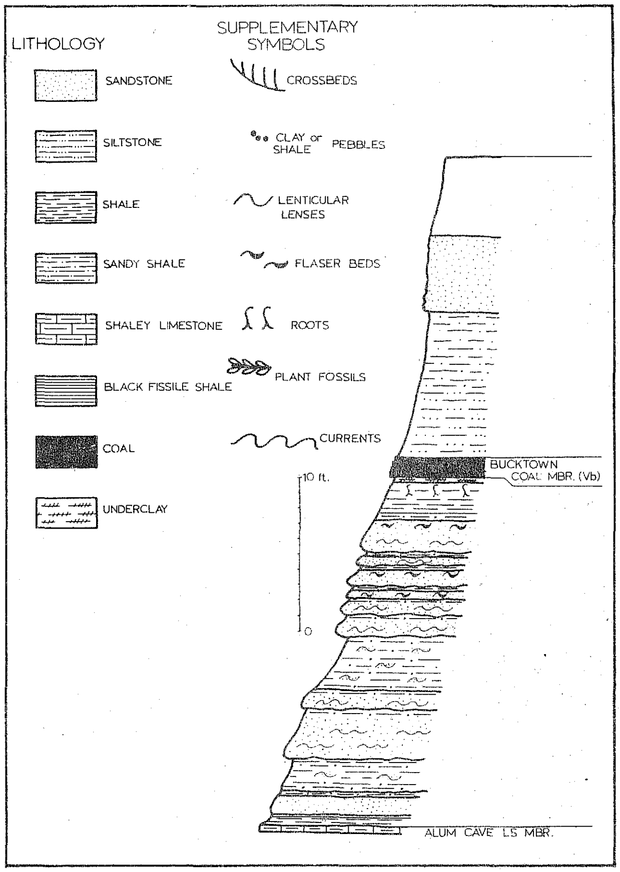


Figure IN-3. Exposure of part of the Dugger Formation at Day 1, mileage 52.0.

69.8 Entrance to Oak Grove Shelter on left (east); turn into parking area for Lunch Stop.

69.8 Reboard buses at the Oak Grove Shelter in Lincoln State Park and proceed north on park road.

69.9 Entrance to Lincoln State Park.

70.0 Junction of Indiana Routes 162 and 345; cross Indiana 162 and proceed north on Indiana 345. Route for the next 20 miles (32 km) is along the eastern edge of the Wabash Lowland.

70.7 Junction of Indiana Routes 162 and 345; turn left (west) on Indiana 345.

72.1 Buffaloville Coal Member of the Brazil Formation (fig. IN-2) crops about half way up the low hills ahead. The Buffaloville and unnamed coals near the base of the Brazil have been extensively mined southeast of Dale in the past few years. The Buffaloville is the uppermost member of the Brazil Formation (Hutchison, 1976, p. 18) and is correlated with the Minshall Coal Member of west central Indiana (Hutchison, 1959).

73.1 Junction of U.S. Route 231 and Indiana Route 345; turn right (northeast) on U.S. 231.

74.2 Intersection of Indiana Route 62 and U.S. 231 in the center of Dale; continue north on U.S. 231.

76.0 I-64 interchange with U.S. 231; continue north on U.S. 231.

76.8 Entering Dubois County; organized in 1818 and named for Toussaint Dubois, a French soldier who fought with General William Henry Harrison at the Battle of Tippecanoe.

77.3 U.S. 231 crosses the approximate location of the Buffaloville Coal Member crop at this point; the ridge ahead and ridges for the next 5 miles (8 km) (to Huntingburg) are capped with rocks of the Staunton Formation.

77.4 The stone obelisk on the right marks the location where the Indian Treaty Line, surveyed by Thomas Freeman in 1802 and ratified as the Treaty of Vincennes in 1804 under President Thomas Jefferson, crosses the road. The Treaty of Vincennes was signed by nine Indian tribes and gave the United States title to disputed lands along the Wabash River.

78.9 Road to Holland, Indiana, on left; continue north on U.S. 231. Holland was laid out in 1859 by Henry Kunz, who named the town after his native land. Today Holland is noted for its dairy products.

The section that is considered the type section of the Holland Limestone Member of the Staunton Formation (fig. IN-2) is located about 4 miles (6.4 km) west of this intersection. The chert, shale with limestone pebbles, and dense limestone which comprise the Holland contain fusulinids and ostracods, which indicate a middle Pennsylvanian age.

80.5 The broad flat area ahead and to the left (west) is Illinoian and Wisconsinan lake sediments.

81.3 Sandstones of the basal Brazil or uppermost Mansfield Formation crop out in the roadcut to the right (east).

81.4 U.S. 231 lies at or slightly above the crop of the Buffaloville Coal Member of the Brazil Formation for the next 0.4 miles (.6 km).

82.1 Entering Huntingburg, Indiana; founded in 1839 by Joseph Geiger who named the town Huntingdon, allegedly because he came here to hunt before he had purchased the land. The name was confused with Huntington in northern Indiana and was therefore changed to Huntingburg.

83.5 Center of Huntingburg; note the many old brick buildings in the downtown area. Clay and shale in the upper Brazil Formation have long been used for bricks and pottery manufacture in the Huntingburg area. Clays are so abundant and accessible that many of the older houses and stores in the town were built using bricks made and fired on the site.

83.7 Intersection of Indiana Route 64 and U.S. 231 in Huntingburg; continue north on U.S. 231.

83.8 Abandoned beehive kilns of the Huntingburg Brick Co. on the left.

86.5 Crossing onto floodplain of the Patoka River.

87.6 Bridge over the Patoka River.

88.8 Entering Jasper, Indiana; laid out in 1830 by surveyor Hosea Smith. The name Jasper was chosen by Mrs. Elandor Enlow, wife of a donor of the land, who selected the name Jasper from the Books of Apocalypse, Chapter 21, Verse 19. Jasper has long been a center of commerce in this area. The Enlow Mill, located on the Patoka River, was established in 1820 and used by early settlers from as far as the Ohio River, including the Lincoln family. The abundance of hardwoods in Dubois County and woodworking skills of the predominantly German settlers have been the basis of the furniture-manufacturing industry in Jasper since the early 1800s.

90.4 Junction Indiana Route 56 and U.S. Route 231; bear right (east) on U.S. 231-Indiana 56.

90.8 Junction Indiana Route 162 and U.S. 231 near the center of Jasper; turn left (north) on U.S. 231.

91.1 St. Joseph's Church on the left. The church was constructed with sandstone from the Mansfield Formation quarried east of Jasper, and native timbers. Construction began in 1867, and the church was consecrated in 1888. The style of the church is Romanesque; the steeple, which was added later, is patterned after the Big Ben tower in London, complete with clocks and bells.

From Jasper northward for the next 20 miles (32 km), the route closely follows the boundary between the Crawford Upland (on the east) and the Wabash Lowland (on the west). The Crawford Upland is a physiographic unit of rugged hills, narrow valleys, sandstone cliffs, and many bedrock exposures (Malott, 1922).

92.4 Crossing the approximate location of the contact between the Mansfield and Brazil Formations. The contact has been placed at the base of the coal which lies in about the same stratigraphic position as the Lower Block Coal Member, the lowest member of the Brazil in its type area near Brazil, Indiana, but the correlation with the Lower Block coal is tentative. Exposures along U.S. 231 for the next 19 miles (31 km) (to Loogootee) are the rocks in the upper Mansfield.

92.5 The Jasper Corporation to the right (east) is a division of Kimball International, Inc., which manufactures furniture, pianos, and electronic organs.

94.3 U.S. 231 is on a terrace of Illinoian proglacial lake sediments for the next 1.5 miles (2.4 km). Dissection of this terrace can be seen to the left (west and northwest).

96.1 The yellowish-gray to moderately yellowish-brown sandstone that crops out in the roadcut to the right (east) lies close to the top of the Mansfield Formation. This sandstone, like many of the sandstones in the Mansfield, is quite micaceous.

96.6 Buckingham's Base Line is noted on the roadside historic marker on the right (east). This primary east-west survey line was established by Surveyor-General Jared Mansfield and run by Surveyor Ebenezer Buckingham, Jr., in 1804. It intersects the Second Principal Meridian in Orange County at the "Pivot Point."

97.2 U.S. 231 follows the approximate route of the "Buffalo Trace" for the next 0.5 mile (0.8 km). The Buffalo Trace was a path 10 to 20 feet (3 to 6 m) wide created by buffalo herds that migrated from Illinois to Kentucky where they wintered over and returned to Illinois along the same route in the spring. Early settlers took advantage of the well-worn trail, using it for travel and commerce.

97.7 Junction of Indiana Route 56 and U.S. 231 on south edge of Haysville, Indiana; continue north on U.S. 231.

98.0 Intersection in center of Haysville.

98.5 Crossing the approximate position of the Mariah Hill Coal Bed (Mansfield Formation) at the bend in the road.

98.6 Exposures of the rocks of the Mansfield Formation that lie between the Blue Creek Coal Member and the Mariah Hill Coal Bed in the roadcuts on both sides (fig. IN-4). The top of the Blue Creek Coal Member is exposed in the ditch beside the driveway on the left (west) side of the cut just before the bridge over the East Fork White River. The Blue Creek coal is highly variable in thickness and quality; hence, mining is limited to small-scale operations where thickness and quality are suitable. The Mariah Hill Coal Bed is not exposed in this roadcut, but its stratigraphic position lies at the top of the river bluff.

98.7 Cross East Fork of White River and enter Martin County. Martin County was organized in 1820 and named for Major John P. Martin of Newport, Kentucky.

99.7 Scattered exposures of fine-grained, ripple-marked sandstones of the upper Mansfield Formation can be seen in roadcuts for the next 0.6 miles (0.2 km).

101.5 Exposure of Mansfield Formation sandstone on left (west).

102.7 Excellent exposure of the Blue Creek Coal Member and associated strata in the roadcut to the right (east). The micaceous, wavy-bedded sandstones and shales that dominate this exposure (fig. IN-5) are the typical lithologies of the upper Mansfield. Resistant, ledge-forming sandstones, such as the one seen near the top of this exposure, are often the more prominent lithologies of the upper Mansfield.

103.3 Exposure of the micaceous, wavy-bedded sandy shales and ripple-marked sandstones of the upper Mansfield Formation that overlie the Blue Creek Coal Member. A thin, organic-rich bed about 12 feet (3.7 m) above road

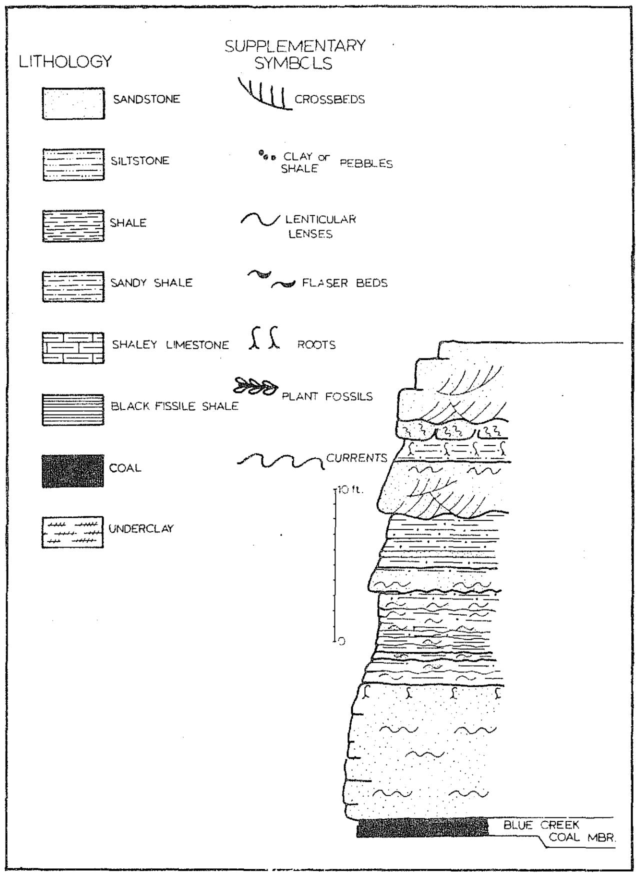


Figure IN-4. Exposure of part of the Mansfield Formation at Day 1, mileage 98.6.

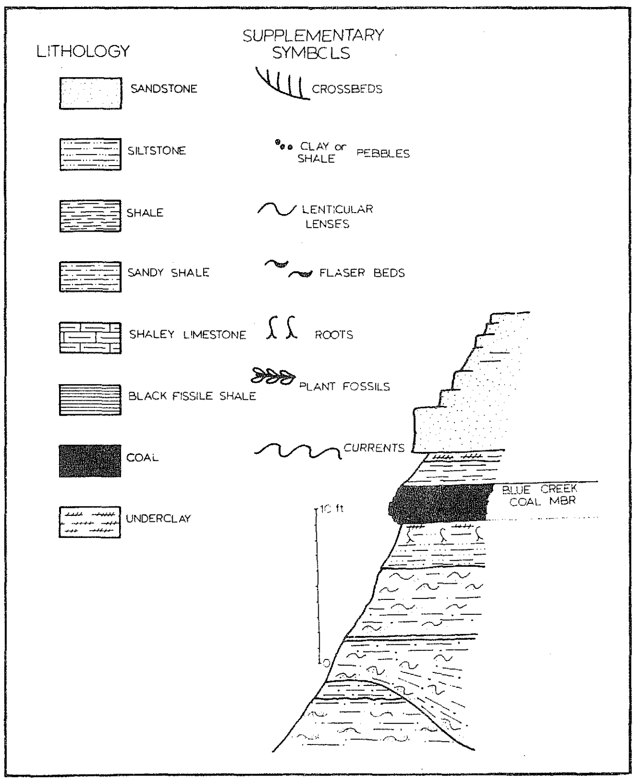


Figure IN-5. Exposure of part of the Mansfield Formation at Day 1, mileage 102.7.

level probably marks the position of an unnamed Mansfield coal which has a thickness of 1 foot (0.3 m) in an abandoned mine about 1500 feet (457 m) southeast of here.

103.6 Mine waste to the left probably marks the position of an unnamed Mansfield coal below the Blue Creek Coal Member.

103.8 The Blue Creek Coal Member and unnamed coal in the Mansfield below the Blue Creek have been surface mined recently to the left (west).

104.0 Wavy-bedded sandstones and shales of the Mansfield Formation above the Blue Creek Coal Member exposed to the right (east).

105.1 Passing the East Fork Water Tank on the right (east).

106.5 Exposures of thin, wavy-bedded sandstones and shales of the upper Mansfield Formation in the roadcut on the right (east).

106.6 Massive Mansfield Formation sandstone exposed in the roadcut on the right (east) at the base of the hill.

107.5 Enter the small settlement of Whitfield, Indiana. At about this point, the route subtly reenters the glaciated part of the Wabash Lowland. The till, which is Illinoian in age, is thin and has little physiographic expression.

108.9 Outcroppings of upper Mansfield Formation sandstones in roadcuts on both sides.

111.2 Junction of U.S. Routes 50 and 231 on the south edge of Loogootee; turn right (north) on U.S. 50-U.S. 231.

111.7 Junction U.S. 231 and U.S. 50 at traffic light; continue straight (east) on U.S. 50.

112.0 Junction of U.S. 50 and Indiana Route 550 at the east edge of Loogootee; continue straight (east) on U.S. 50.

For the remainder of the trip in Indiana, the route will be deep in the rugged terrain of the Crawford Upland. Local relief in this region in most places is on the order of 300 feet (91 m). Hillslopes are steep, and there are many cliffs and outcrops of sandstone and limestone. Upland tracts are rather broad, and commonly are upheld by sandstone rimrock. Valleys are narrow, but are rather deeply filled, nevertheless, by Pleistocene and Holocene alluvium, outwash, and lake deposits.

The northern part of the Crawford Upland has been glaciated, but here the Illinoian glacial boundary, which is about one mile ahead, nearly coincides with the boundary between the physiographic divisions.

112.4 Mansfield Formation sandstone from the quarry to the left (north) was used as a glass sand.

112.6 Cross the approximate location of the thalweg of a valley in the pre-Pennsylvanian erosional surface.

112.7 Upper Mansfield Formation sandstone, shale, underclay, and weathered coal are exposed in the roadcut on the left (north). The coal lies in the approximate position of the Mariah Hill Coal Bed.

113.4 Conglomeratic, planar cross-bedded, medium-to-coarse sandstone of the Mansfield exposed in cuts on both sides of the road. Rounded, milky quartz pebbles and granules occur in the cross-bed laminae and between cross-bed sets. Stratigraphically-lower sandstones exposed south of the bridge just ahead do not contain quartz pebbles.

113.8 Abandoned gravel pit to the left (north) exposes Illinoian outwash.

114.4 Wavy-bedded sandstones and sandy shales form recessed units or slopes and thicker, ripple-marked sandstones form projecting beds in the roadcut exposure of the Mansfield Formation to the right (south). Sandstones in this exposure are fine to medium grained and micaceous. Shale clasts are locally abundant in the thicker sandstone units, especially where cut and fill has occurred.

115.1 Dark greenish-gray, micaceous, silty shale with siderite nodules overlain by cross-bedded sandstone, all of the Mansfield Formation, are exposed in cuts on both sides of the road. The base of this exposure lies about 20 feet (6 m) above an unnamed coal and 200 feet (61 m) above the base of the Mansfield.

115.4 Wavy-bedded, micaceous sandstones and sandy, carbonaceous shales interbedded with irregular, cross-bedded sandstones comprise the bulk of the exposure to the left (north). An intraformational conglomerate about 30 feet (9 m) above the base of this exposure includes rounded shale clasts and siderite nodules (fig. IN-6). The base of this section lies an estimated 5 feet (1.5 m) above the top of the section depicted in figure IN-7 and about 110 feet above the base of the Mansfield.

115.5 Sandstone exposures on the left (north) are the uppermost unit of the stratigraphic section depicted in figure IN-7. Lower units of this section are exposed on the left (north) for the next 0.1 miles (0.16 km). The base of this section lies about 60 feet (18 m) above the base of the Mansfield.

115.8 Wavy-bedded and lenticular-bedded sandstones and shales form a prominent unit at the base of the exposure of Mansfield Formation on the left (north). A thick sandstone with numerous cuts and fills, cross-bedded sandstones, and an intraformational conglomerate overlie the wavy-bedded unit, and they, in turn are overlain by a dark shale and cross-bedded sandstone. The base of this exposure lies about 50 feet (15 m) above the base of the Mansfield.

115.9 Several exposures of sandstones of the basal Mansfield Formation can be seen in the bluffs to the left (north) for the next 0.2 miles (0.3 km).

116.3 A 1-to-2-foot (.3-to-6-m), organic-rich, sandy shale with sparse vitrain bands overlies the cross-bedded sandstone at the base of the Mansfield Formation exposure to the left (north). The cross-bedded sandstone units at the top of this exposure locally cut out the organic shale and the gray sandy shale that overlies it. The base of this exposure is approximately 20 feet (9 m) above the base of the Mansfield.

116.9 Cross-bedded sandstone of the Mansfield

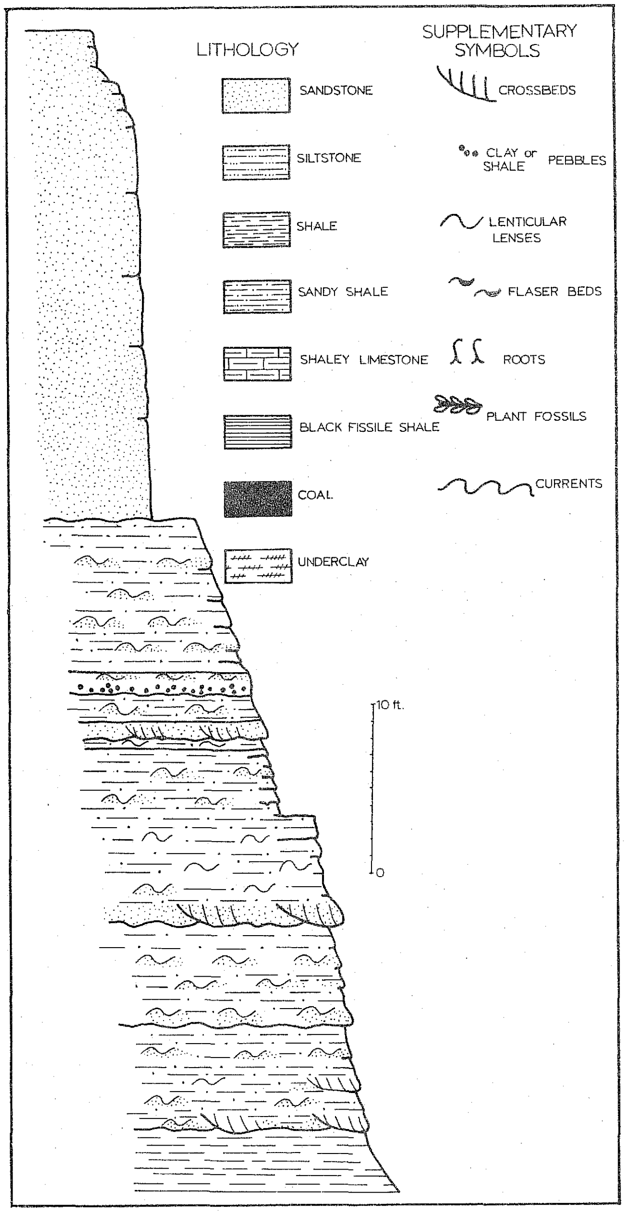


Figure IN-6. Exposure of part of the Mansfield Formation at Day 1, mileage 115.4.

Formation exposed to the left (north) lies about 20 feet (6 m) above the base of the Mansfield.

117.1 Entering "Peek Cut"; exposures of Mansfield Formation are on both sides of road for next 0.4 miles (0.6 km) (fig. IN-8). The road crosses the approximate position of the Pinnick Coal Member (fig. IN-2) just before entering the cut.

118.0 Junction of U.S. Routes 50-150 and Indiana Route 450; continue straight (southeast) on U.S. 50-150.

118.2 Cross the approximate position of thalweg of a valley in the Mississippian-Pennsylvanian unconformity.

118.4 Entering city limits of Shoals, Indiana, named for the shoals in the East Fork White River located about 100 yards (91 m) south of the U.S. 50-150 bridge.

118.6 Jug Rock on the left (north), almost hidden by trees, is a weathered remnant of Mansfield Formation sandstone.

118.7 Deep roadcut through planar cross-bedded, medium-to-coarse Mansfield Formation sandstone. Very sparse milky quartz granules are present in the upper units exposed here.

119.2 Cross the East Fork White River.

119.3 Center of Shoals, Indiana; turn right (south) on 4th Street.

119.6 Junction of 4th Street and River Road at south edge of Shoals; turn left (southwest) on the River Road.

120.5 Bridge over Beaver Creek. The Beech Creek Limestone is exposed in the river bank about a quarter of a mile to the right (northwest).

120.6 Spout Spring on the right (west) issues from the base of the cross-bedded and differentially weathered Mansfield Formation sandstone exposed in the bluff to the right (west). A few small quartz pebbles and granules are found in this exposure.

120.8 Abandoned General Refractories preparation plant to the left (east). See discussion below at mileage 122.8.

121.4 Meander core hill and abandoned course of Beaver Creek on the left (east).

121.9 Intersection of River Road and Indiana Route 550; turn right (west) on Indiana 550.

122.1 Exposure of cross-bedded Mansfield Formation sandstone in the bank to the right (north). Numerous exposures of Mansfield sandstone can be seen in the roadcut and

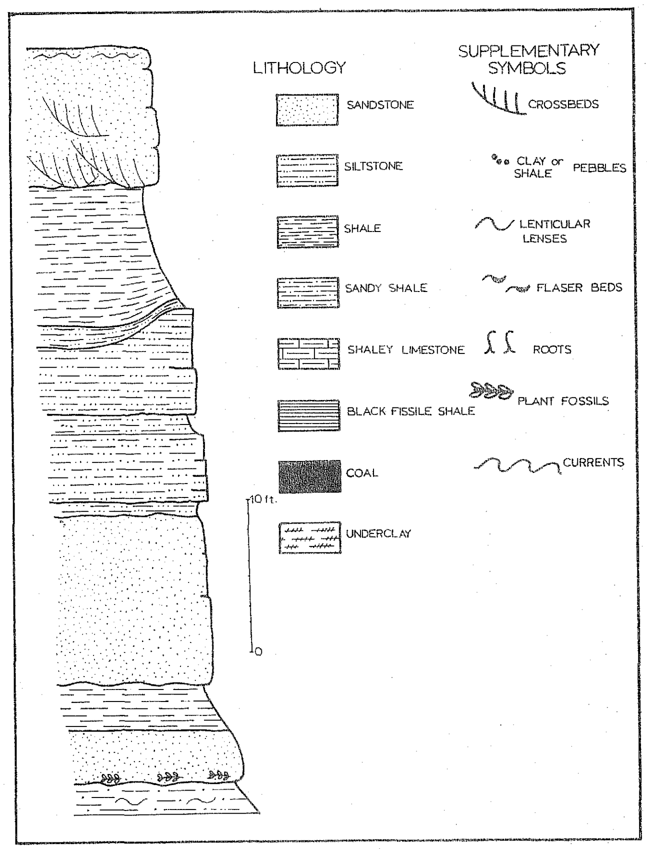


Figure IN-7. Exposure of part of the Mansfield Formation at Day 1, mileage 115.5.

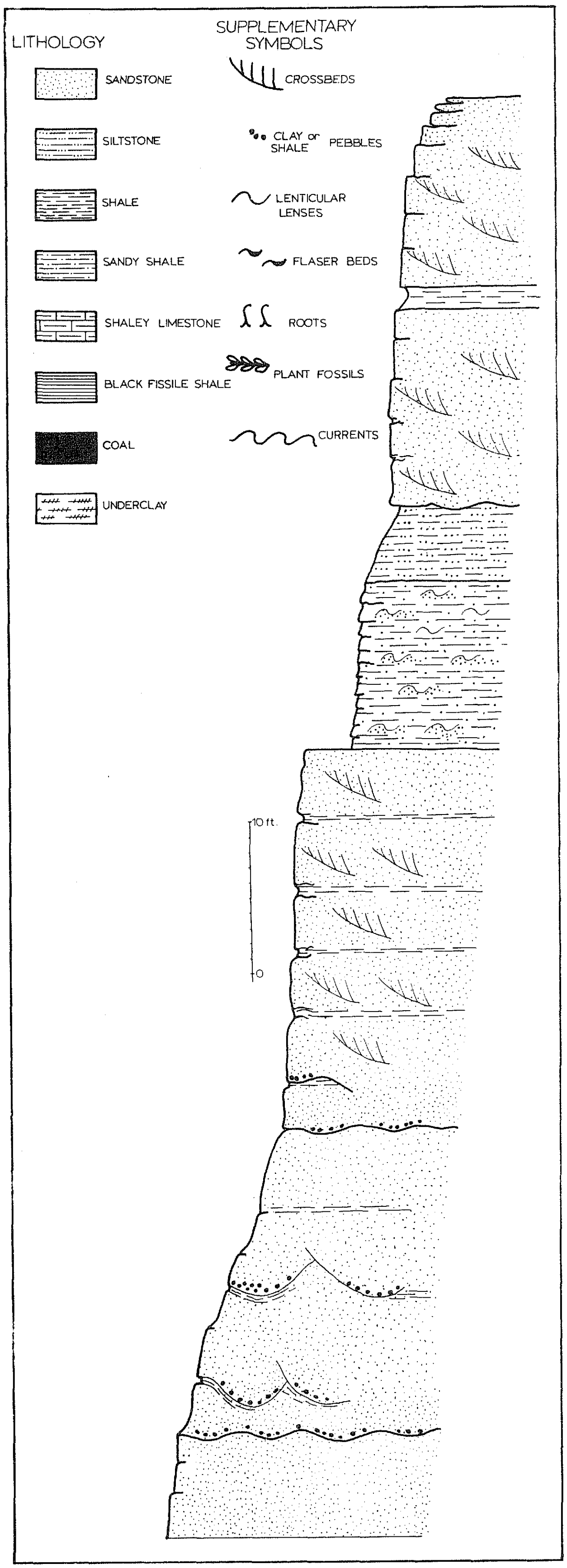


Figure IN-8. Exposure of part of the Mansfield Formation at Day 1, mileage 117.1. (Adapted from Gray et al., 1957, p. 17-18.)

bluffs on both sides of the road for the next 0.7 miles (1.1 km).

122.8 Pull into the driveway on the right (north) side of Indiana Route 550. After disembarking from the buses, we will follow the haulage road into the pit.

STOP 3 Abandoned General Refractories Company conglomerate quarry.

Leaders: Walter A. Hasenmueller, Henry H. Gray, and Donald D. Carr, Indiana Geological Survey.

The General Refractories Company quarried quartz pebble conglomerate from the Mansfield Formation here from 1955 to 1967 as a source of high silica refractory materials. Although quartz pebbles are widely distributed in basal Pennsylvanian beds, true conglomerate like that exposed here is rare.

Exposures of pebbly sandstone in the Mansfield Formation form a line trending north-northeast toward Indian Springs where Malott (1931) mapped a deep valley in the Mississippian-Pennsylvanian unconformity surface. Malott traced these exposures southward as far as Shoals and later (1946, 1951), located additional exposures in western Lawrence County and as far east as Buddha, about 20 miles (32 km) east-northeast of here. He concluded that quartz pebbles in the Mansfield were characteristic of unconformity valley fills and were wanting over the upland areas of the unconformity surface. Later work (Siever, 1951; Potter and Siever, 1956; Siever and Potter, 1956), has shown that the quartz pebble phase of the basal Pennsylvanian is not confined to unconformity valleys. This exposure substantiates these observations. The base of the quarry is about 40 feet (12 m) above the unconformity surface and lies above an upland on this surface (fig. IN-9); hence, sedimentation here took place after the unconformity valleys had been filled.

A channel sample from this quarry examined by D. D. Carr and L. F. Rooney contained 96.4 percent silica, which is in accord with the regional orthoquartzitic composition of the basal Pennsylvanian sediments observed by Siever and Potter (1956). Potter and Siever (1956b, p. 328) postulated a north and northeast source area of largely pre-existing sediments for the Mansfield. Detailed measurements of cross-bed orientations in the Mansfield just southeast of this site confirm a southwestward transport direction, and the low variance in the measure indicates a fluvial origin (Sedimentation Seminar, 1966).

122.8 Leave Stop 3. Proceed eastward on Indiana Route 550. Outcrops for the next few miles are mostly cliff-forming sandstones belonging to the Mansfield Formation.

126.4 Junction of U.S. Route 150 and Indiana Route 550; bear right (east) and follow U.S.

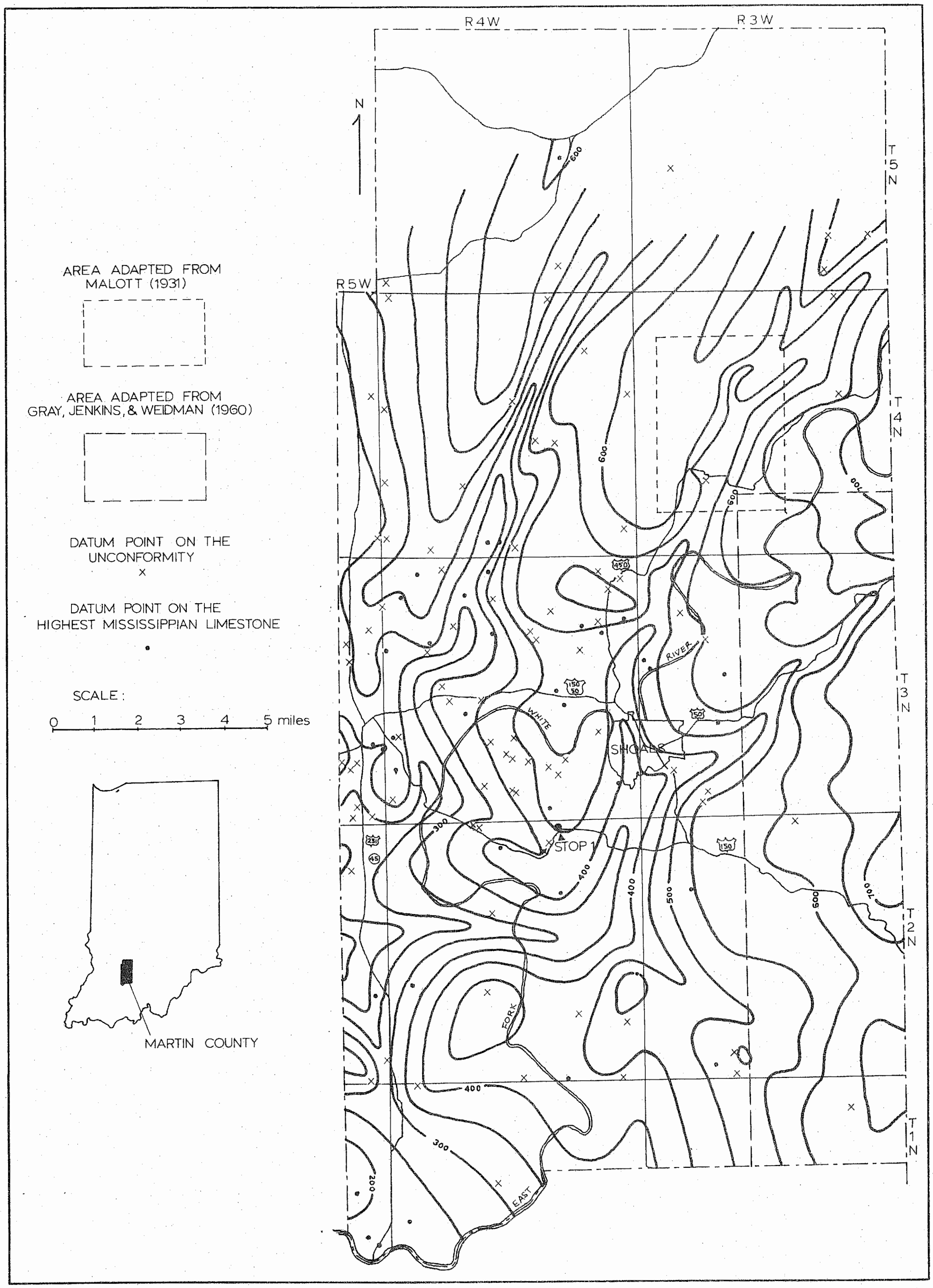


Figure IN-9. Generalized contour map of the Mississippian-Pennsylvanian unconformity surface in Martin County, Indiana.

150. Hills on both sides of route are underlain by Mariah Hill and Blue Creek Coal Members and an unnamed coal somewhat lower in the Mansfield Formation. These coals were mined in this vicinity for many years, primarily in small drift mines, but also in small surface operations. Because their sulfur content is relatively low (Hutchison, 1967), there has been considerable recent interest in them. New surface mines have been opened in areas to the south of the field trip route.

127.7 Highway begins descent into a valley underlain by rocks of the Chesterian Series, Mississippian System.

131.1 Highway begins descent into the valley of Sams Creek. Hilltop is capped by about 80 feet (24 m) of sandstone in the basal part of the Mansfield Formation, which here rests unconformably on the Glen Dean Limestone (fig. IN-2) in exposures to right (west) of the road (Gray, Jenkins, and Weidman, 1960, p. 69-70). Regionally, this disconformity truncates the entire Mississippian System from south to north in Indiana; thus, youngest Mississippian rocks are known only from southern parts of the state, whereas 150 miles (241 km) north of this point, the Mansfield Formation rests on the New Albany Shale, most of which is Devonian in age (Gray, 1979).

131.8 Exposures to right (south) are, in descending order, 30 feet (9 m) of fine-grained sandstone of the Big Clifty Formation, 15 feet (4.6 m) of Beech Creek Limestone, and 15 feet (4.6 m) of red-brown and green-gray mudstone of the Elwren Formation (Gray et al., 1957, p. 21).

132.2 Exposed on the right (south) is a 20-foot (6-m) ledge of sandstone belonging to the Sample Formation. Just downstream from highway bridge is a small spring and outcrop of the Beaver Bend Limestone (Gray, Jenkins, and Weidman, 1960, p. 68-69).

133.9 Cross Lost River. Exposures on the hill ahead include, on the left (north), 35 feet (11 m) of sandstone of the Sample Formation overlain by 6 feet (1.8 m) of calcarenite of the Reelsville Limestone and 22 feet (6.7 m) of sandstone of the Elwren Formation (Gray, Jenkins, and Weidman, 1960, p. 68). On opposite side of hill about a mile ahead, the Reelsville is represented by a fossiliferous calcareous sandstone (Gray and Perry, 1956).

134.4 Exposures here and in cuts just ahead show 15 feet (4.6 m) of Beech Creek Limestone overlain by 24 feet (7.3 m) of sandstone of the Big Clifty Formation (Gray and others, 1957, p. 22).

135.3 Exposure on left at foot of hill is Paoli Limestone (fig. IN-2), lowest formation in the Chesterian Series of Indiana (Gray, Jenkins, and Weidman, 1960, p. 68).

135.8 Again, cross Lost River. This is the lower, open-channel route of a famous karst stream that heads some 25 miles (40 km) east of this point. After flowing for 12 to 15 miles (19 to 24 km) in a surface channel over a rather thickly soil-covered part of the limestone plateau known as the Mitchell Plain, Lost River sinks at several points along its open channel into a subterranean channel system. More sink capacity is needed at high water than at low; thus at high water the surface flow extends several miles downstream from the first or low-water sinks. Below the lowest active sink is an abandoned dry-bed nearly 15 miles (24 km) long that connects the surface segments.

The subterranean channels, which principally are in the Ste. Genevieve Limestone of Valmeyeran age, carry the Lost River beneath the Chester Escarpment into the Crawford Upland. Straight-line distance from the last sink to the rise is about 4 miles (6.4 km). Another prominent rise a short distance upstream at Orangeville, some 5 miles (8 km) northeast of the field trip route at this point, forms the head of the lower open-channel segment of the stream but actually represents tributary subterranean drainage from a considerable area. From Orangeville to its confluence with the East Fork of White River below Hindostan Falls, Lost River flows in a surface channel.

Much of the underground drainage route has been explored, mainly by C. A. Malott (1932, 1949, 1952), whose studies of this drainage system have become classics of the karst literature. One point of access to the underground system is a large karst window known as Wesley Chapel Gulf.

137.0 Highway Junction at the village of Prospect; turn right (south) on Indiana Route 56.

137.4 Again, cross Lost River and enter West Baden-French Lick area.

French Lick, the oldest and most famous of the mineral springs in Indiana, derived its name because some French settlers near Vincennes in the late 18th century tried to develop a salt deposit here near an animal lick. The enterprise was thwarted, however, by Indian inhabitants of the region, mainly Miamis and Piankeshaws, who considered the salty bitter spring a source of healing water. The healing aspect of the water is open to question, but its major sodium chloride and calcium sulfate and minor sodium and magnesium sulfates and calcium carbonate produce a purgative that is unquestioned. The water is derived from solution of evaporite beds, mainly gypsum, in the lower St. Louis Limestone (fig. IN-2) about 250 feet (76.2 m) below the surface and is fed to the surface through solution-enlarged joints in St. Louis, Ste. Genevieve, and Paoli limestones.

The first commercial hotel was built near "Pluto Springs" in 1836; the water soon became known for its medicinal value and attracted the infirm from throughout the Midwest. A sister resort was developed at Mile Lick, named that because it was 1 mile (1.6 km) north of French Lick, but the name of the town was soon changed to West Baden for the famous spa in Germany. During the heyday of the spas, from about 1890 to 1910, as many as twelve passenger trains a day pulled into French Lick and West Baden from connections in Chicago, Cincinnati, Indianapolis, Louisville, and St. Louis. Both hotels, each with more than 700 rooms, were considered the ultimate in luxury, but the hotel at West Baden, constructed in 1901 to replace a previous structure destroyed by fire, was heralded as the "eighth wonder of the world" because its central structure is a steel and glass dome, 200 feet (61 m) in diameter, unsupported except along its perimeter. About 1915, with the advent of the automobile and modern roads, improved medical care, and change in people's recreational interests, the popularity of the spas declined. In 1934 the hotel at West Baden was given to Jesuits, who removed much of the ornamentation and operated a college until 1967. The building was then acquired by Northwood Institute, a two-year private school now specializing in hotel and restaurant management.

The French Lick Hotel was acquired in 1957 by the Sheraton organization. The company has undertaken extensive remodeling and modernization, but during your stay you will see glimpses of former grandeur and learn about former customs. In the past, guests would visit Pluto Spring each morning, drink a cup of hot Pluto Water before breakfast, and take a brisk constitutional along one of the many sawdust paths. That option, without the sawdust, is still available to you today, but remember, there is truth in the words: "If nature won't, Pluto will."

139.0 French Lick-Sheraton Hotel on right; end of route log for second day's trip.

DAY 2 French Lick, Indiana, to Hawesville, Kentucky.

Trip Leaders: Henry H. Gray, Walter A. Hasenmueller, and Donald D. Carr, Indiana Geological Survey.

Monday, May 28, 1979

En route.

0.0 Leave French Lick-Sheraton Hotel; turn left (north) onto Indiana Route 56. See figure IN-10 for a map of today's route.

0.1 Turn right (east) onto Indiana Route 145.

2.9 Exposures on left (east) side of road and in next roadcut ahead are Beaver Bend limestone and shale of the underlying Bethel Formation (fig. IN-2). Solution-enlarged joints are prominent in the limestone.

5.2 Exposures on left (east) side of road and in stream and roadcuts ahead are sandstone of the Big Clifty Formation and underlying Beech Creek Limestone.

6.4 Upland surface here is developed on Glen Dean Limestone; higher hilltops to the right and left are capped by the Mansfield Formation.

8.6 Cross Painter Creek arm of Patoka Reservoir. Structure to left is boat launching ramp. Animals elsewhere known as cougars, pumas, or mountain lions (*Felis concolor*) are called "painters" (panthers) in this area. Whether any actually inhabit the area today is questionable, but sightings are occasionally reported.

9.3 Tillery Hill is capped by 60 feet (18 m) of fossiliferous gray shale that in its upper part is thinly interlaminated with ripple-stratified fine-grained sandstone. These rocks belong to the Tar Springs Formation of late Chesterian age (Gray, 1979).

10.2 Exposure on left (east) side of road is Haney Limestone and overlying shale and sandstone of Hardinsburg Formation.

10.6 Exposures in roadcuts are of Haney Limestone; shale interbeds are abundant in lower part of formation.

11.3 Cross Patoka Reservoir, newly completed by the U.S. Army Corps of Engineers to control flooding and to maintain low flows on the Patoka River. Recent salvage archaeological excavations of nine sites within the area of the reservoir, carried out by the Glenn Black Laboratories of Indiana University with funds provided by the Corps of Engineers, have revealed an occupational history of the area extending from 8000 B.C. to A.D. 1400. The time of most intensive occupation extends from 2800 B.C. to 1460 B.C. and is classified as Late Archaic; at that time the peoples of this area were hunters and gatherers and most of the sites were occupied seasonally, primarily for nut gathering. Among the identified sources of flint artifacts found here is the Holland Limestone Member (p.14, mileage 78.9).

11.7 Exposures to left (east) of road and in cut ahead are shale and sandstone of Hardinsburg Formation.

12.7 Exposures in cuts on both sides of road near top of hill are shaly ripple-stratified sandstone of Tar Springs Formation.

13.1 Exposure high in cut to left (east) of road is Glen Dean Limestone.

14.4 To left (east) is a large limestone quarry operated by Mulzer Crushed Stone Co. The quarry began operation as an open pit in 24 feet (7.3 m) of Glen Dean Limestone (a measured section here is given in Gray and others, 1957,

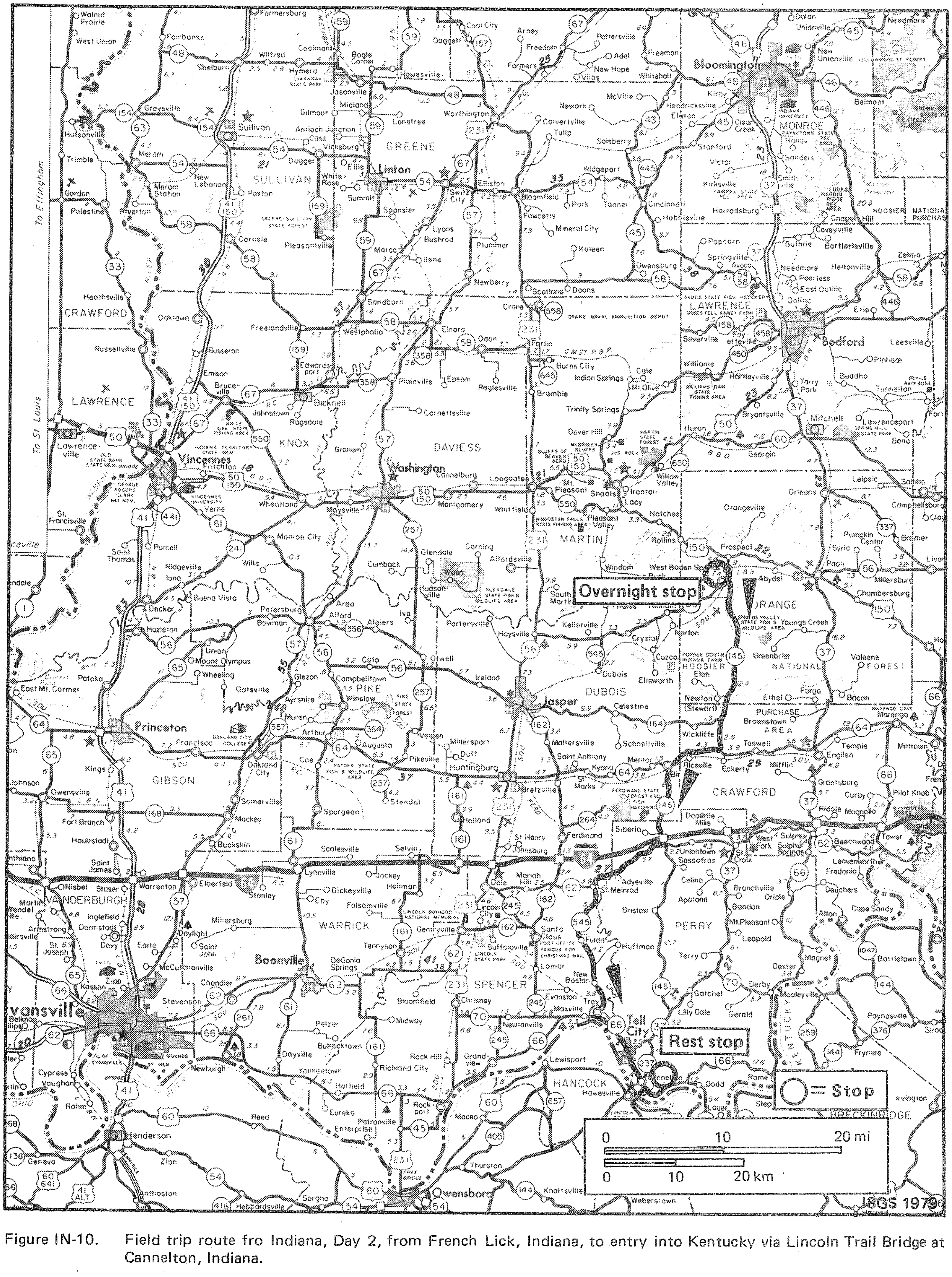


Figure IN-10. Field trip route fro Indiana, Day 2, from French Lick, Indiana, to entry into Kentucky via Lincoln Trail Bridge at Cannelton, Indiana.

p. 26-28). Quarrying was then extended underground to the east; finally, a tunnel was completed through the hill, and open pit operations were begun on the other side. Quarrying at present is by both surface and underground methods, and in both the Glen Dean and Haney Limestones of the Chesterian Series. Crushed stone is shipped mainly westward into parts of Indiana that have insufficient limestone resources.

Exposures of Glen Dean Limestone may be seen low on valley walls for the next mile along field trip route.

15.2 Roadcut at right (west) exposes 46 feet (14 m) of sandstone and shale of the Mansfield Formation (Gray and others, 1957, p. 28-29).

16.3 Junction with Indiana Route 64; turn right (west) and follow Indiana 145. Scattered exposures along field trip route for next 4 miles (6.4 km) are mainly sandstones of the Mansfield Formation.

20.3 Enter village of Birdseye. Legend says that the town was named about 1880 when Rev. Bird Johnson, a postmaster at a nearby town, chose a location for a new post office here. He supposedly said that the designated site looked good to Bird's eye, whereupon the city fathers, realizing that a clever name could bring fame followed by industrial and urban growth, coined the name.

20.6 At intersection turn left (south) following Indiana Route 145.

21.3 Leave Birdseye. Good view ahead—a Birdseye view, perhaps?—of typical topography of Crawford Upland.

21.7 Near bottom of hill, route passes onto sandstones and shales of Buffalo Wallow Group (fig. IN-2); exposures for next 6 miles (9.7 km) are of these rocks.

27.6 Borrow pit for highway fill on hill at left (east) exposes shales and thin limestones of Buffalo Wallow Group.

27.8 Cross Interstate 64.

28.0 At intersection turn right (west) on Indiana Route 62. Exposures for next few miles are mainly sandstones and shales of Buffalo Wallow Group.

32.5 Low ridge to right (north) is capped by sandstone of Mansfield Formation.

35.6 Exposures to right (west) of road here and in roadcut ahead are sandstone and shale in lowermost part of Mansfield Formation.

36.3 Enter village of St. Meinrad.

36.6 Turn left (south) on Indiana Route 545. Ahead and to the right (west) are buildings of St. Meinrad Archabbey and Seminary, a Benedictine establishment founded in 1854 by Swiss emigrants. There are about 170 monks, including both priests and brothers, and 400 students, most of whom enter the priesthood.

The abbey church at the north end of the main building complex was commenced in 1898 (fig. IN-11). Like most of the other buildings, it is constructed of native sandstone from the Mansfield Formation. For many

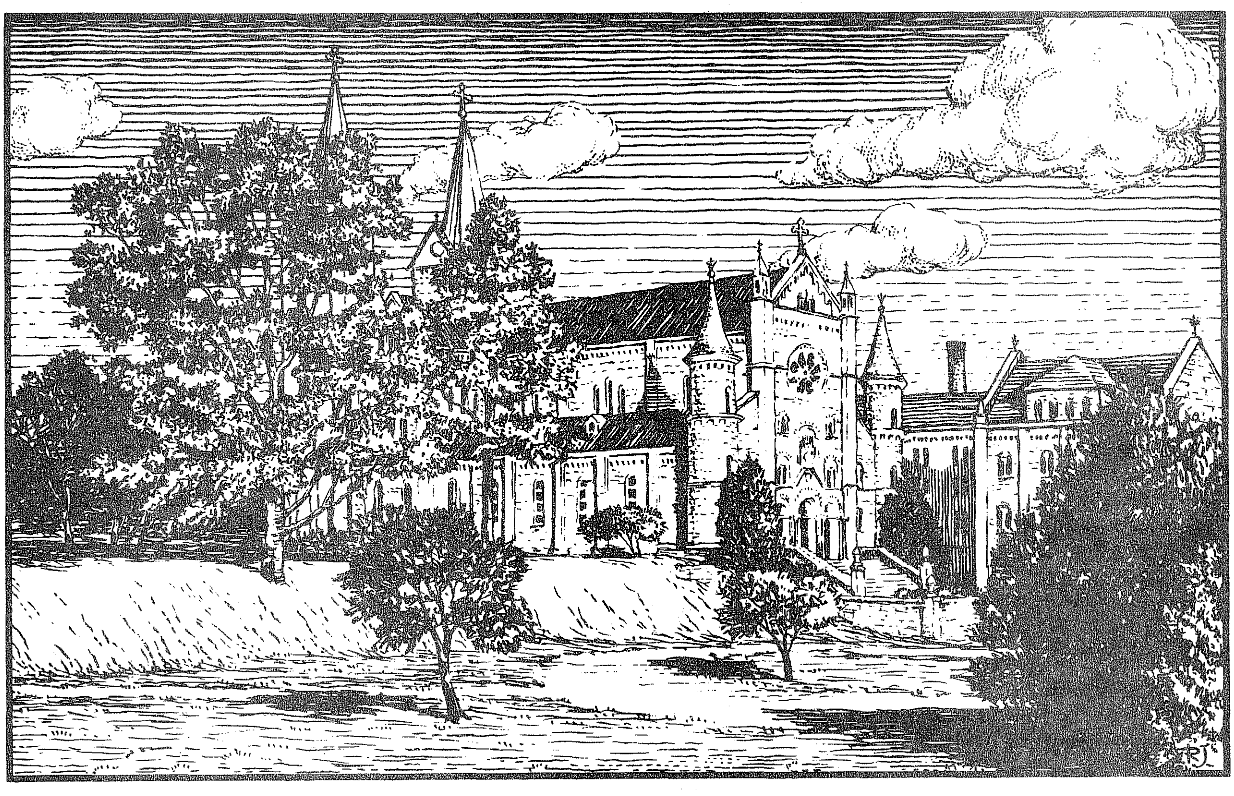


Figure IN-11. St. Meinrad Archabbey Church built from Mansfield sandstones between 1898 and 1907. (From Carr and Hatfield, 1975.)

years the abbey operated its own stone quarry and mill, and St. Meinrad sandstone was shipped as far as Chicago and Cleveland. Major uses were for residential ashlar facing and for dimension stone in church buildings and related structures. For many years the abbey also operated its own coal mine.

38.1 Abandoned drift mine workings behind barn on right (west) are in St. Meinrad Coal Member (Hutchison, 1959). Route southward passes through low hills of western part of Crawford Upland. Scattered exposures for the remainder of the route in Indiana are mainly sandstones and shales of the Mansfield Formation.

41.4 Village of Fulda, named for the cathedral town in Germany. Many areas in southwestern Indiana were settled by Germans and Swiss.

43.0 At crest of hill, now mostly covered at left (east) of road is upper bed of the Lead Creek Limestone Member of Mansfield Formation (fig. IN-2). Ostracod fauna of this member indicates a late Morrowan age (Shaver and Smith, 1974).

49.1 Cross Anderson River. Terraces are underlain by lake beds (mostly calcareous silt) as much as 150 feet (46 m) thick and probably entirely Woodfordian (late Wisconsinan, latest Pleistocene) in age.

50.1 Enter village of Troy. One of the earliest river towns on this part of the Ohio River, Troy was the seat of government in Perry County from 1815 to 1818. An early mineral industry at this place was a pottery that produced stoneware from local clay. According to Owen (1859, p. 49) forty English workmen were brought from Staffordshire to man this enterprise, but it was not successful and was soon abandoned.

50.5 Turn left (east) onto Indiana Route 66.

50.6 Ohio River is to right (south). To left of road are exposed lenticular sandstones and shales of the Mansfield Formation aggregating 122 feet (37 m) in thickness and including two thin and discontinuous coal members, the Blue Creek (in two beds with a 1-foot [0.3 m] shale parting, near road level at crest of grade) and Mariah Hill (about 50 feet [15 m] higher). At top of exposure is a 19-foot (5.8-m) bed of fossiliferous sandy iron ore that apparently represents the Lead Creek Limestone Member.

51.8 To left (north), roadcut exposes more than 50 feet (15 m) of mostly ripple-stratified interlaminated sandstone and shale of the Mansfield Formation.

52.4 Cuts on both sides of road expose about 75 feet (23 m) of sandstone, mudstone, and gray carbonaceous shale of the Mansfield Formation. The coal member most extensively mined in this area is the St. Meinrad Coal Member, which lies about at the level of the valley floor some 20 feet (6 m) below the base of these exposures (Hutchison, 1971).

53.3 Enter town of Tell City; follow Indiana Route 66 through town.

53.5 Turn left at traffic light.

53.8 Turn right at traffic light. Founded by the Swiss Colonization Society in 1856, Tell City is named for the legendary Swiss hero of independence, William Tell. The society purchased more than 4,000 acres of land for $85,000 to encourage the settlement of what was then the "American West" by industrious Swiss emigrants. Although grounds for a spacious city of 90,000 were platted, Tell City has not yet reached a tenth of that size. Cross streets honor a variety of historically important personages—Franklin and Fulton, Watt and Humboldt, Schiller and Mozart. Furniture, river barges, and electrical equipment are produced here, and some of the local businesses have been in the hands of the same families for more than 100 years.

56.6 Roadcut to right (southwest) of highway exposes sandstone, shale, clay, and coal of the Mansfield Formation. This coal belongs to the St. Meinrad Coal Member and is 0 to 2 feet (0 to .6 m) thick here; nearby, where it is somewhat thicker, this coal and a lower one have been mined in numerous small drifts. From a bank near the Ohio River just southwest of this point, the first coal known to be mined in Indiana was taken in 1812. It was taken on board the first steamboat to descend the Ohio and Mississippi Rivers, the *Orleans,* built by Robert Fulton in Pittsburgh. Whether the coal was used as fuel or was merely considered a curiosity is not known; for many years, rivermen disdained coal because there was an abundance of wood and the rivermen believed that coal would not "raise steam."

57.1 Enter town of Cannelton. In 1837 the American Cannel Coal Co. was chartered by the State of Indiana to mine the semi-splint coal here (it is not truly a cannel), and shortly thereafter the town of Cannelton was platted. Coal was offered to prospective industries at 1 cent per bushel. Towers of the elaborate and massive cotton mill building, begun by the company in 1849, are visible to the right. This industry was intended to serve the needs of southern cotton plantations, but due in part to the disruptive effects of the Civil War (1861-1865) on the cotton trade and on the river trade generally, it was never commercially successful, although the building continued in use until 1965. The cotton mill, the church (on the left at traffic light), and many of the older residences are built of local sandstone from the Mansfield Formation, each stone neatly and precisely hand-trimmed.

More than 8 million tons (7.3×10^6 MT) of coal have been mined in Perry County, most of it from lands of the American Cannel Coal Co. in the hills northeast of Cannelton, and most of it from the St. Meinrad Coal Member, also known locally as the Lower Cannelton coal (Hutchison, 1971). Though this production may seem small by today's standards, it is large for coals in the Mansfield Formation; it also should be remembered that nearly all of this was removed by hand in small underground mines where the coal beds were mostly 2 to 4 feet (.6 to 1.2 m) thick. No mines are currently operating in the area.

Cannelton's main industry today is a sewer-tile factory. Until 1957 this plant used clay from the lower part of the Mansfield Formation taken from drift mines in the nearby hills; clay now is brought across the river from surface mines in Kentucky.

58.1 Entry to toll bridge; continue ahead on Indiana Route 66.

59.8 Cannelton Dam and Locks. Completed in 1970 by the U.S. Army Corps of Engineers, these structures control the flow of and facilitate navigation on this part of the Ohio River, the most heavily travelled waterway in the world. The locks are 110 feet (34 m) wide and 600 and 1200 feet (183 and 366 m) long; they were designed to handle the largest practicable tows in one locking operation. This structure with its 25-foot (7.6-m) lift replaces three older structures upstream, and it is now possible for tows to travel from this lock 115 river miles (185 km) upstream to Louisville, Kentucky, without passing through another lock.

The locks are founded on limestone near the middle of the Buffalo Wallow Group (fig. IN-2); the dam is founded partly on bedrock and partly on outwash sand and gravel of the valley fill, because bedrock is deeper at the far end of the dam than at the near end. A measured section at this place (Gray, 1979) is presented in figure IN-12.

60.3 Turn left (north) on access road; ascend hill past exposures of sandstones and shales of the Mansfield Formation.

61.3 Rest stop. Turn left (east) and park in parking lot; proceed ahead (south) on foot to the overlook platform.

61.3 Leave rest stop. Proceed west down steep hill past exposures of sandstones and shales of the Mansfield Formation.

61.6 Turn right (west) onto Indiana Route 66.

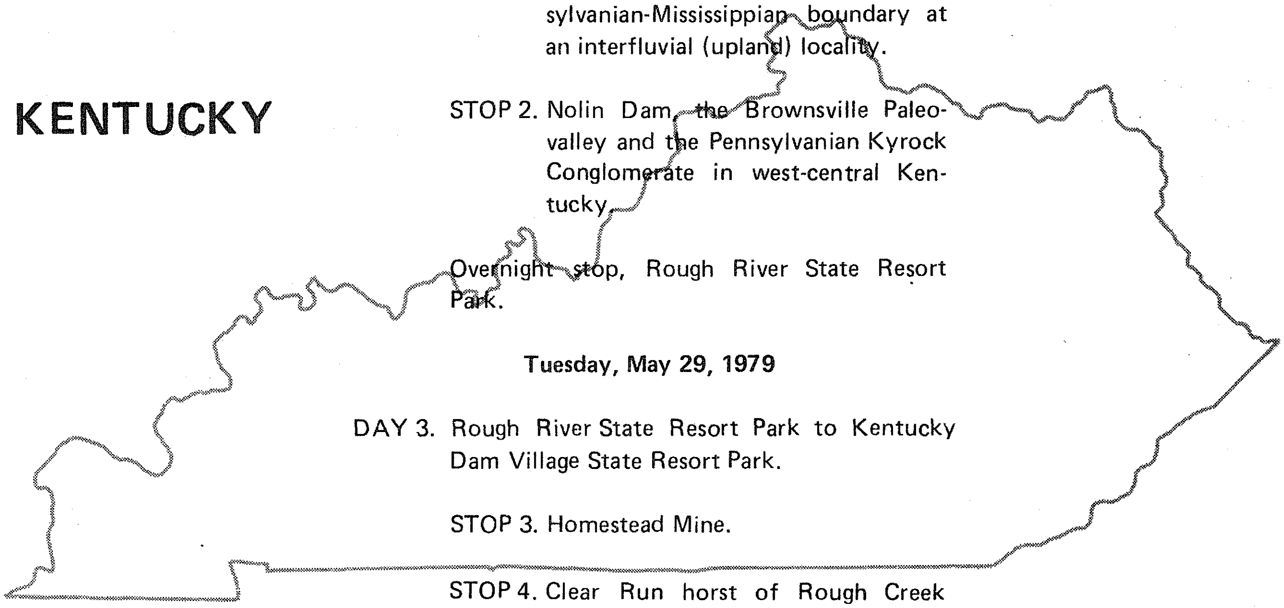
62.1 Turn left (south) onto Indiana Route 237; approach to Lincoln Trail Bridge.

62.5 Cross Ohio River and enter Kentucky. We hope you enjoyed Indiana. Come again!

Figure IN-12. Cannelton Locks Section: S½ Sec. 14, T. 7 S., R. 3 W., Perry County (Cannelton Quadrangle). Summarized from more detailed descriptions and measurements alongside and in excavations for locks, May 1964, by Henry H. Gray and Harold C. Hutchison. Top of section 615 feet (190 m) altitude.

Thickness Feet (Meters)	Description
	PENNSYLVANIAN SYSTEM
	Mansfield Formation—217 ft (66.2 m) exposed
61 (18.6)	Sandstone and sandy shale, in part poorly exposed or covered, to top of hill at overlook platform
3 (0.9)	Coal, mined, thickness estimated
37 (11.3)	Sandstone and sandy shale; thin coaly shale at base
35 (10.7)	Shale, very thinly interstratified with fine-grained sandstone, medium gray; mica flakes scattered on parting surfaces
33 (10.1)	Sandstone, light yellow-brown; fine grained, well sorted; principally quartz, with some quartz-crystal grain overgrowths
38 (11.6)	Sandstone, in part shaly, light yellow-brown; prominent wavy stratification, parting surfaces conspicuously ripple-marked; grades upward into shaly mudstone with wormy markings abundant on parting surfaces
10 (3.0)	Sandstone, light yellow-brown; medium sets of thin cross-strata; scattered plant fossils and numerous lenses up to 1 foot (0.3 m) thick of conglomerate made up principally of quartz pebbles; base obviously disconformable and as much as 10 ft (3 m) higher to 25 ft (8.5 m) lower in various parts of long exposure; thickness of unit varies accordingly
	MISSISSIPPIAN SYSTEM
	Buffalo Wallow Group—100.4 ft (30.6 m) exposed Tobinsport Formation—61.3 ft (18.7 m)
2.0 (0.61)	Clay, red-brown; soft, probably the residuum of a limestone bed
0.4 (0.12)	Shale, medium olive-gray
2.6 (0.79)	Siltstone, calcareous, yellow-brown; probably the residuum of a silty limestone bed
8.1 (2.5)	Mudstone, shaly at top, medium gray to medium olive-gray
2.1 (0.64)	Siltstone, light yellow-brown
14.2 (4.3)	Shale and mudstone, medium gray to green-gray; thin ironstone bed near middle
2.0 (0.61)	Limestone, shaly, yellow-brown; in two beds with thinly stratified gray shale between; abundantly fossiliferous
20.5 (6.2)	Shale, medium gray; thin bed of abundantly fossiliferous limestone near middle
9.4 (2.9)	Shale, silty, medium gray; four thin beds of fossiliferous calcareous siltstone near top
	Branchville Formation—39.1 ft (11.9 m) exposed
4.7 (1.4)	Limestone, micritic, medium gray; slightly shaly at base and near top; includes 2 thin beds of gray very fossiliferous shale
1.2 (0.37)	Shale, slightly silty, medium gray; sparingly fossiliferous
2.6 (0.79)	Limestone, micritic, medium gray; sparingly fossiliferous; in two beds separated by a thin bed of brown-gray silty shale with abundant and varied fossils
2.7 (0.82)	Mudstone, gray-green; at top grades into brown-gray silty shale
2.9 (0.88)	Limestone, silty, green-gray; wavy stratification and abundant green clay chips; grades downward into calcareous siltstone
3.8 (1.1)	Shale, silty, gray; in middle part contains lenses and one thin bed of micritic limestone
6.5 (2.0)	Limestone, micritic and slightly silty, green-gray; in three beds separated by two beds of dark green-gray shale
7.9 (2.4)	Mudstone and shale, silty, gray in lower part to green-gray in upper part; thin pelecypod-bearing zone at lower contact
6.8 (2.1)	Shale, silty, green-gray; coaly streaks near top; and at top is 0.2 ft (0.06 m) of bony coal with lenses of pyrite
	Water to base of excavation—5.6 ft (1.7 m)

Rocks exposed to left (north) of road constitute the upper 200 feet of the above section; lowermost Pennsylvanian rocks and all Mississippian rocks are no longer exposed.



Monday, May 28, 1979

DAY 2. Hawesville, Kentucky, to Rough River State Resort Park.

STOP 1. Western Kentucky Parkway, Lower Pennsylvanian paleoslump and Pennsylvanian-Mississippian boundary at an interfluvial (upland) locality.

STOP 2. Nolin Dam, the Brownsville Paleovalley and the Pennsylvanian Kyrock Conglomerate in west-central Kentucky.

Overnight stop, Rough River State Resort Park.

Tuesday, May 29, 1979

DAY 3. Rough River State Resort Park to Kentucky Dam Village State Resort Park.

STOP 3. Homestead Mine.

STOP 4. Clear Run horst of Rough Creek Fault System—Green River Parkway—Milepost 53.

Overnight stop, Henry Ward Inn, Kentucky Dam Village State Resort Park.

Wednesday, May 30, 1979

DAY 4. En route, Kentucky Dam Village State Resort Park to Cave in Rock Ferry, including western Kentucky Fluorspar District.

DAY 2 Hawesville, Kentucky, to Rough River State Resort Park.

Trip leaders: Allen D. Williamson and Preston McGrain, Kentucky Geological Survey.

Monday, May 28, 1979

STOP 1. Western Kentucky Parkway, Lower Pennsylvanian paleoslump and Pennsylvanian-Mississippian boundary at an interfluvial (upland) locality.

STOP 2. Nolin Dam, the Brownsville paleovalley and the Pennsylvanian Kyrock Conglomerate in west-central Kentucky.

Overnight stop, Lodge, Rough River State Resort Park.

This portion of the field trip will traverse the southeastern perimeter of the Illinois Basin, along and near the Mississippian-Pennsylvanian boundary (fig. KY-1). Exposed Carboniferous rocks are predominantly sandstones and shales of the Caseyville Formation (Early Pennsylvanian) and sandstones, shales, and limestones of Chesterian age (Late Mississippian). Rocks of Chesterian age form the uppermost strata of the Mississippian System in Kentucky. Alternating clastic and carbonate units characterize the Chester sequence. Units visible on this part of the trip range from the Big Clifty Sandstone upward to the Kinkaid Limestone (fig. KY-2). Older units are recognized on outcrop to the east and in subsurface sections.

The boundary between Pennsylvanian and Mississippian rocks in this area is uneven, largely because of channels on the pre-Pennsylvanian surface. Basal Pennsylvanian rocks rest on different units of Chesterian age. Some aspects of this relationship will be pointed out at Kentucky Stops 1 and 2.

For many years surface and subsurface stratigraphers have recognized the widespread distribution and great lateral persistence of Chesterian units around and across the Illinois Basin. Excellent outcrop exposures along the eastern, southern, and western margins and thousands of subsurface records derived from oil-field exploration activities have permitted detailed correlations throughout the basin area and a better understanding of the Mississippian-Pennsylvanian relationships. Upper Mississippian rock units identified in an earlier part of the field trip in southern Indiana will be recognized not only immediately across the Ohio River in Kentucky but also on south to Nolin Dam. By contrast, the lithic units of the Caseyville Formation show great variation and inconsistent lateral extent.

The base of the Caseyville Formation is below drainage level (below 358 feet [109 m]) at Hawesville and is approximately 680 feet (207 m) from Cloverport, approximatley 7.5 miles (12 km) to the southeast. The difference in altitudes is due in part to an erosional pre-Pennsylvanian surface, in part to a fault (upthrown on the east) between Indian Lake and Shafer Hill, and in part to the normal westerly regional dip of the rock strata systems.

The topography of the area to be covered on this part of the trip is hilly to rolling. Cliff-forming sandstones of the Caseyville and Tar Springs Formations contribute to the rugged features of the topography. Locally, resistant Late Mississippian sandstones form benches or tablelands. Normal pool elevation of the Ohio River at Hawesville is 358 feet (109 m) above sea level; the adjacent uplands are almost 300 feet (91 m) higher. The highest points along the route are the sandstone-capped hills and ridges which may attain elevations in excess of 800 or 900 feet (244-274 m). Some are capped with Caseyville conglomeratic sandstone and represent erosional remnants of the Pennsylvanian escarpment several miles to the west.

From the earliest settlement of this area, the fossil fuels—coal, oil, and natural gas—have played an important part in the economic development of this part of Kentucky. The first report of the Kentucky Geological Survey (Owen, 1856) includes references to coal and coal mining in the vicinity of Hawesville. Chisholm (1931, p. 235) reported that mines were active as early as 1837. One of the best known early coal mines was in the Breckinridge cannel coal. Some of the early production was for the manufacture of "coal oil," a product replaced by the discovery of petroleum.

Mileage

0.0 Hawesville, Kentucky, at the south end of Lincoln Trail Bridge over the Ohio River. Proceed east on U.S. Route 60. Sandstone of the Caseyville Formation is present in bluffs around the community. It was quarried here at one time for foundations, retaining walls, and miscellaneous uses.

2.2 Lookout above the Ohio River, U.S. 60, east of Hawesville.

2.8 Lookout above the Ohio River, U.S. 60, east of Hawesville. The Cannelton lock and dam is clearly visible from this point.

3.3 Caseyville conglomeratic sandstone (basal Pennsylvanian) in roadcut.

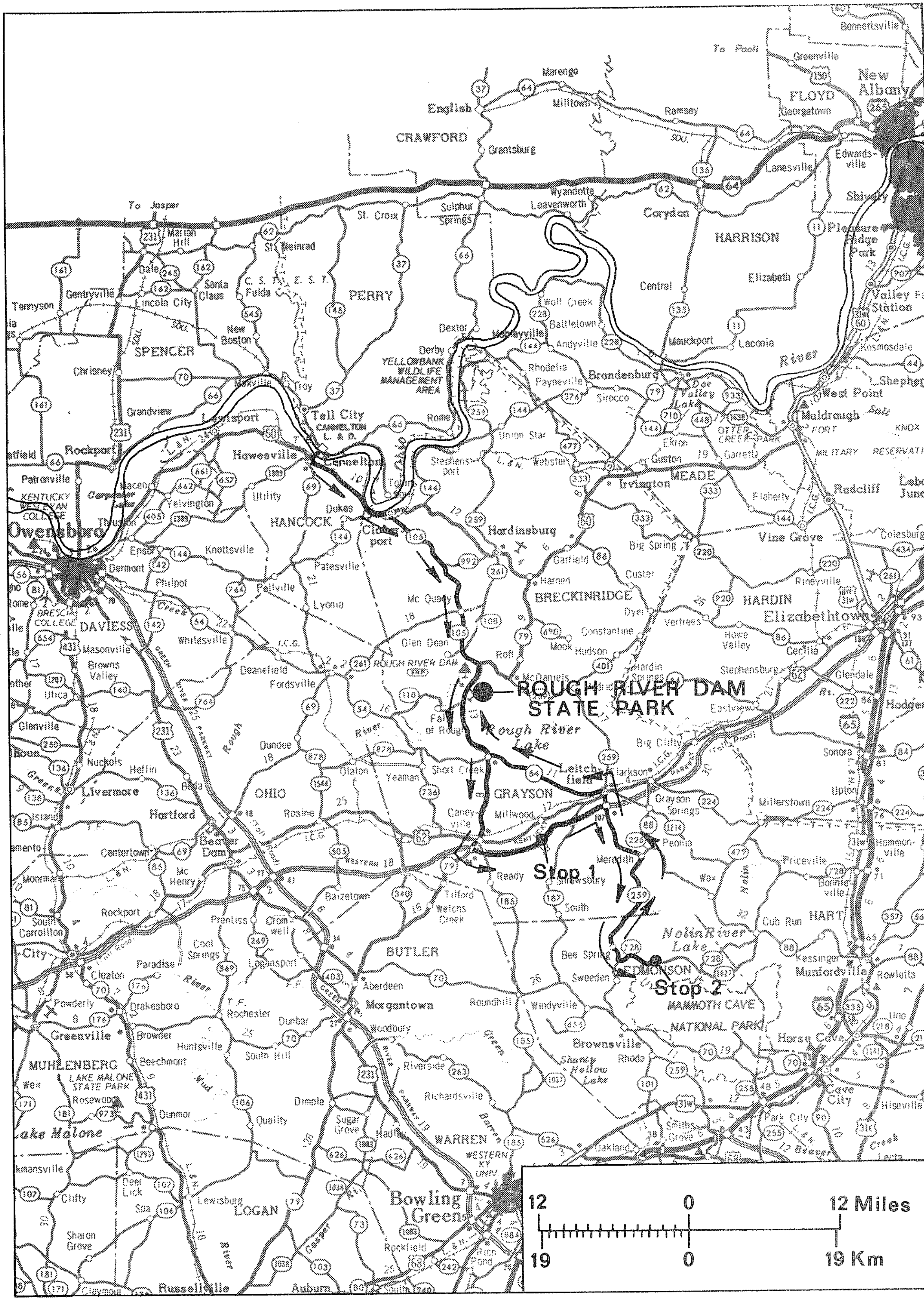


Figure KY-1. Field trip route for Kentucky, Day 2, from Hawesville, Kentucky, to Rough River Dam State Resort Park.

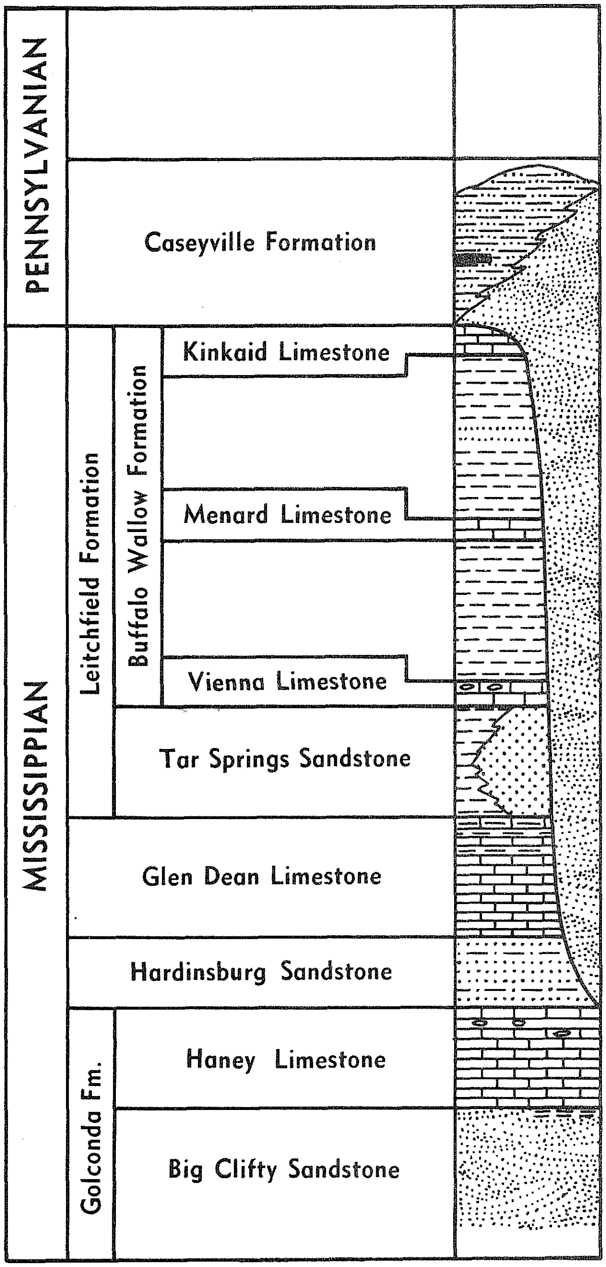


Figure KY-2. Generalized geologic column showing stratigraphic units along the route of the second day of the trip.

4.0 Bluff of Caseyville conglomeratic sandstone (fig. KY-3).

About 5 miles (8 km) south are abandoned works into the Breckinridge cannel coal which during the past century attained some prominence as a coal-oil feedstock.

A one-half-ton block of this coal is on display in the rotunda of the U.S. Geological Survey building in Reston, Virginia.

5.0 Bluff of Caseyville conglomeratic sandstone in Shafer Hill north of highway.

5.9 to 6.4 Exposures of Tar Springs Sandstone (Late Mississippian) on both sides of the highway. It is a gray to tan, massive, fine-grained sandstone. In this area, the basal part of the sandstone is sometimes petroliferous.

9.1 Junction U.S. 60 and Kentucky Route 144; Tar Springs Sandstone in roadcut.

9.6 Enter Cloverport.

This community was once an important shipping point. Beginning as early as 1798, flatboats carried Kentucky tobacco and other goods down the Ohio and Mississippi Rivers to New Orleans. Abraham Lincoln, then a boy of seven, with the rest of his family crossed the Ohio River on a log-raft ferry near here in 1816 enroute to the new family home in Indiana.

10.6 Junction U.S. 60 and Kentucky Route 105 in Cloverport. Turn right (south) on Kentucky 105.

10.7 Tar Springs Sandstone in roadcut immediately south of the railroad crossing.

11.6 Glen Dean Limestone (Late Mississippian) on left.

12.1 Glen Dean Limestone in bluff on right.

18.1 Junction Kentucky Routes 105 and 992.

18.4 Junction Kentucky 105 and 992; continue south on 105.

20.9 to 21.0 Glen Dean Limestone on right; the top of the hill is capped with sandstone of Pennsylvanian age.

23.0 Vienna Limestone (Late Mississippian) on right.

23.4 Junction Kentucky Routes 105 and 261 at McQuady; continue on 105.

26.9 Junction Kentucky Routes 105 and 108. Powell Hill, .75 mile (1.2 km) south of this point, is capped with Pennsylvanian sandstone. The field trip route for the next 50 miles (80 km) skirts the Pennsylvanian border of the Western Kentucky part of the Illinois Basin (fig. KY-4).

29.0 Junction Kentucky Routes 79 and 105; turn right (south) on 79.

29.2 Contact of Hardinsburg Sandstone and Haney Limestone (both Late Mississippian).

29.8 Glen Dean Limestone in roadcut at top of hill. Sand Knob, a Pennsylvanian outlier, is approximately 0.2 mile (.3 km) west of the highway (fig. KY-5).

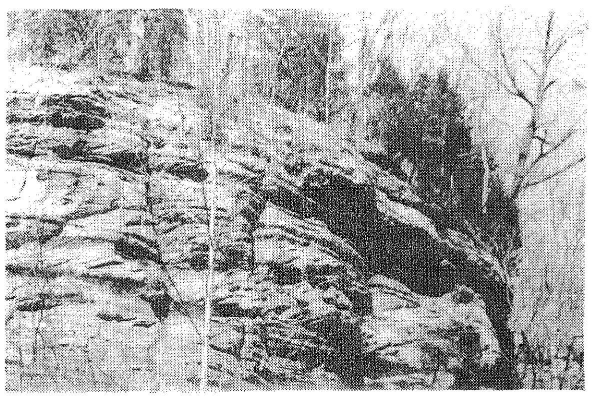


Figure KY-3. Bluff of cross-bedded and honeycombed Caseyville conglomeratic sandstone, U.S. Route 60, east of Hawesville, Kentucky. The low topographic position of the Caseyville at this point is due to channeling and faulting. (Photograph from McGrain and others, 1970, fig. 17.)

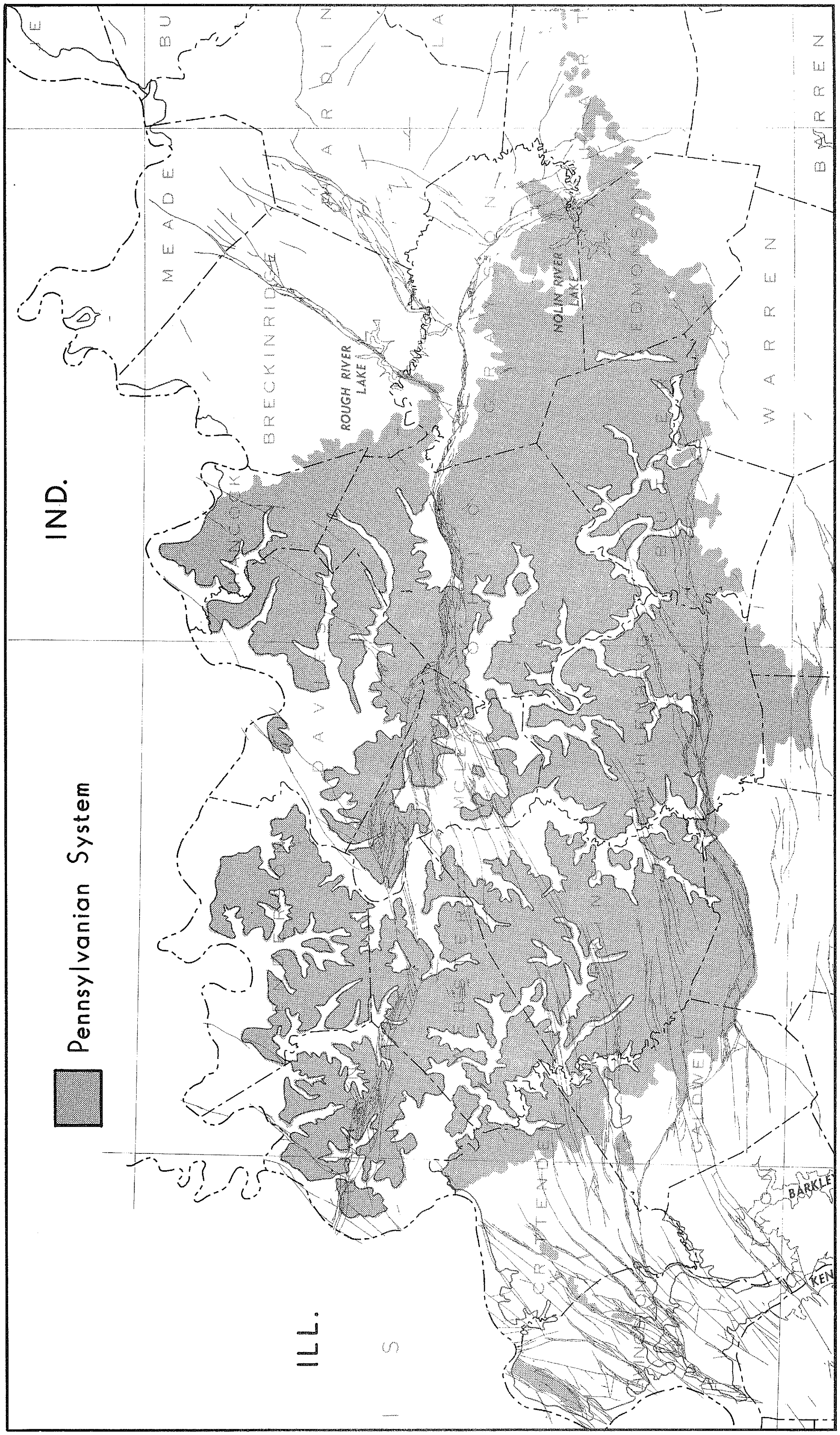


Figure KY-4. Generalized geologic map of western Kentucky showing extent of Pennsylvanian rocks.

Figure KY-5. Sand Knob, an isolated hill capped with more than 100 feet (30 m) of massive Caseyville conglomeratic sandstone. The highest point is 832 feet (254 m) above sea level. The outlier is situated approximately 5 miles (8 km) east of the Pennsylvanian outcrop. The base of the Caseyville is at the approximate position of the Waltersburg Sandstone.

30.8 Rough River Dam. Hardinsburg Sandstone is exposed in roadcut at north end of dam. Haney Limestone and Big Clifty Sandstone (both Late Mississippian) are exposed in the valley below the dam. The spillway cut also exposes Hardinsburg Sandstone.

31.2 Entrance, on left, to Rough River State Resort Park; continue on Kentucky Route 79.

33.9 Junction Kentucky Routes 79 and 736; Hardinsburg Sandstone exposed in roadcut. Continue south on 79.

35.6 to 35.9 Cross Locust Hill fault zone (fault not visible on highway).

38.2 Junction Kentucky Routes 54 and 79 at Short Creek; continue south on 79. Hardinsburg Sandstone exposed in bed of Short Creek.

39.6 to 40.0 Cross Rough Creek fault zone.

43.7 to 43.9 Inactive quarries in Kinkaid Limestone (Late Mississippian) on right.

45.8 Junction Kentucky Route 79 and U.S. Route 62 in Caneyville; continue southwest on Kentucky 79.

46.8 Western Kentucky Parkway overpass. Enter Parkway eastbound.

Lower Pennsylvanian beds, which are at or near road level for the next ten miles, are predominantly dark-gray shale with relatively thin beds of sandstone and an occasional thin bed of coal.

The shale varies from dark gray to medium dark gray with abundant carbonaceous plant debris and ironstone nodules and bands in the darker zones. Sandstone beds are of variable lithology. Most common are thin to thick beds of fine- to medium-grained subgraywacke with low-angle cross-bedding. Macerated carbonaceous plant material is common on bedding surfaces. Lower surfaces are generally erosional; upper surfaces are gradational. The quartz grains are subangular to subround with some euhedral overgrowth. This lithology and structure typical of Pennsylvanian sandstones in western Kentucky is strongly indicative of terrestrial origin. Ripple-bedded, quartzose sandstone (orthoquartzite) bodies with quartz pebbles are common in the basal Pennsylvanian beds. Above the Caseyville, they are rare.

48.1 The sandstone beds in this roadcut are tabular, quartzose, rippled, and fluted with abundant casts of limbs and logs (fig. KY-6). These sandstones are interbedded with dark, fine-grained shale with abundant ironstone nodules containing well-preserved plant fossils (fig. KY-7). Although they lack the diagnostic quartz pebbles, the lithology and bedding structure of these sandstone units are characteristic of the Caseyville Formation (Potter and Glass, 1958).

49.4 Small slump structure enclosed in dark gray

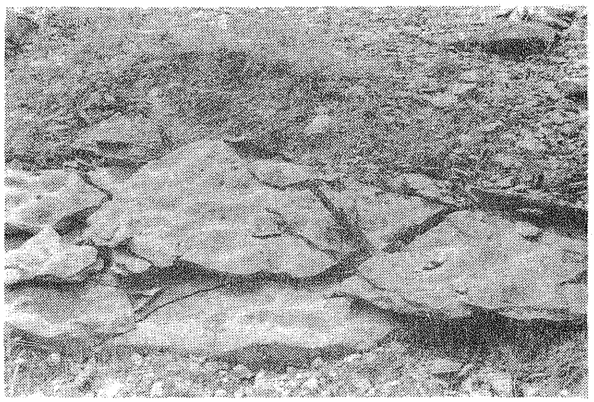


Figure KY-6. Thin, ripple-bedded, orthoquartzitic sandstone in the Caseyville Formation near Milepost 95, Western Kentucky Parkway.

claystone (bay fill) which grades up into a rooted ferruginous sandstone and is capped with a thin, impure coal bed.

51.4 Stop 1.

STOP 1 Western Kentucky Parkway, Lower Pennsylvanian paleoslump and Pennsylvanian-Mississippian boundary at an interfluvial (upland) locality.

Leader: Allen D. Williamson, Kentucky Geological Survey.

Exposed at road level at the center of the roadcut is a gray to dark-brown, dense, fossiliferous limestone (fig. KY-8) in the Upper Mississippian Menard Formation (W. D. Johnson, personal communication). This limestone is absent toward the west, its position occupied by a rooted claystone and thin coal. Above the lower coal is a reasonably coherent sequence of coarsening-upward beds beginning with a dark gray claystone and capped by a seat rock and coal overlain by thin, ripple-bedded, bioturbated sandstone beds and silty gray shale. To the east, bedding is interrupted by a series of irregular sandstone pods. These pods are moderately well sorted, medium- to coarse-grained, orthoquartzitic, and quartz-pebble bearing. Some are rippled, and the lower surfaces commonly bear abundant sole marks, flow rolls, and fluting. Bedding is somewhat irregular with casts of logs, and limbs on bedding surfaces of the sandstone pods exhibit fractures, slickensides, and rhomboidal jointing. Some bedding is convoluted. Isolated coal blocks included in this unit are fragmental and obviously allocthonous.

Eastward, bed continuity is reestablished. Bed lithology shifts from claystone-sandstone-coal to interbedded maroon to greenish-gray claystone and thin greenish-gray, silty, poorly bedded sandstone. Dip increases sharply to approximately 30° at the east end, where bedrock is obscured by recent landslides.

Eastward from the red beds is an undisturbed bay-fill sequence of dark shale, sandstone, seat rock, and coal. Capping the cut, except where removed by recent erosion or landslide, is a thin coal bed and thin-bedded sandstone that is bioturbated in part. The allocthonous coal blocks presumably were ripped from this upper coal and slumped into their present position. Thus, all beds visible in this roadcut, possibly excepting the uppermost sandstone unit, must have been involved in the paleoslump.

Although other depositional models can be developed from available observational data, the rocks here are interpreted as a basal Pennsylvanian slump deposit on an irregular pre-Pennsylvanian surface. The degree of relief on this pre-Pennsylvanian surface is problematical. At Nolin Dam, about 200 feet (61 m) of relief can be demonstrated; at the Leitchfield Toll Station, 6 miles (9.6 km) east of this locality, little or no relief is visible. Willman and others (1975) indicate about 250 feet (76 m) of Upper Mississippian rocks above the Menard Limestone in Illinois. Equivalent beds may have been deposited in western Kentucky as well; however, Bristol and Howard (1971) do not report any Upper Mississippian beds younger than Menard in this area. Some of this apparent hiatus may be due to nondeposition rather than to erosion. The absence of thick, conglomeratic Caseyville sandstones might justify an estimate of erosional relief on the pre-Pennsylvanian surface in tens of feet rather than in hundreds. Pennsylvanian beds present here probably represent repetitive infilling of a shallow interdistributary bay.

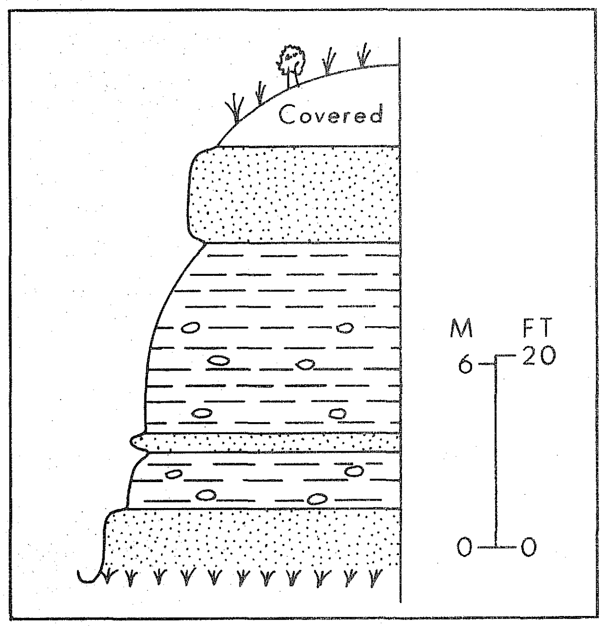


Figure KY-7. Section exposed in roadcut east of Milepost 95 illustrating the alternations of orthoquartzitic sandstone and dark bay fill shale. Photograph in figure KY-6 is of upper sandstone bed in this figure. The Mississippian-Pennsylvanian boundary is less than 100 feet (30 m) below surface.

Two sequences of bay filling, each capped by a coal, are obvious.

The uppermost unit in this cut, bioturbated at the top, may represent a third shoaling sequence. Bed failure and distortion may have resulted from channel incision to the west or northwest. Alternatively, it may have been a response to loading of water-saturated and semi-dewatered sediments on a sloping, rigid pre-Pennsylvanian surface. The occurrence of maroon claystone in close association with dark, organic-rich shales is puzzling, because, as has been pointed out by Walker (1975), red (oxidized) sediments are quickly reduced in the presence of high-pH, organic-laden water. The red clays may have resulted from weathering of an arid pre-Pennsylvanian surface, as suggested by Richard Howard (personal communication).

51.8 Lower Caseyville resting on upper Chester shale. Here the Caseyville is a medium-grained orthoquartzitic sandstone (non-pebbly) over greenish-gray, fossiliferous shale considered characteristic of Upper Mississippian in the Illinois Basin (Atherton et al., 1960). Chesterian sandstones also are generally orthoquartzitic; consequently, without supporting data it would be difficult to determine whether this sandstone is Pennsylvanian or Mississippian.

52.3 Caseyville sandstone at this exposure contains scattered quartz pebbles.

52.6 Menard Limestone overlain by Caseyville orthoquartzite on south side of parkway. The erosional contact is evident. On the north side of the parkway the limestone bed is eroded and the Caseyville rests on older beds.

53.4 Road level still at the systemic boundary, with Caseyville resting on Menard.

53.9 The boundary has dropped below road level. Here Caseyville sandstone overlies Pennsylvanian (?) dark-gray shale. Eastward, Caseyville rests on successively older beds (fig. KY-9).

56.1 Lower Pennsylvanian bay-fill shale and thin coal bed capped by orthoquartzitic sandstone. The dark color of the sandstone is due to tar impregnation. Tar sands are common in the area; one mile north of here at the Community of Blackrock, the sandstone was quarried and retorted for the tar.

56.4 Milepost 104.

59.3 Caseyville sandstone capping the hill here rests directly on a thin coal bed, presumably also Pennsylvanian. Halfway down the hill in this cut are obviously Mississippian limestone and shale beds, with claystone, calcareous sandstone, and dolomitic limestone intervening. The systemic boundary is obscure and here appears gradational from fossiliferous shale and limestone upward into terrestrial coal and

Figure KY-8. Paleoslump west of Milepost 99 on Western Kentucky Parkway at Kentucky Stop 1. View to the south. (1) Horizontal Menard (Mississippian) Limestone just above road level. (2) Gray Pennsylvanian shale and light gray orthoquartzitic sandstone. Arrow indicates isolated coal block. (3) Tilted maroon shale and fine grained sandstone. (4) Horizontal coal, sandstone, and shale.

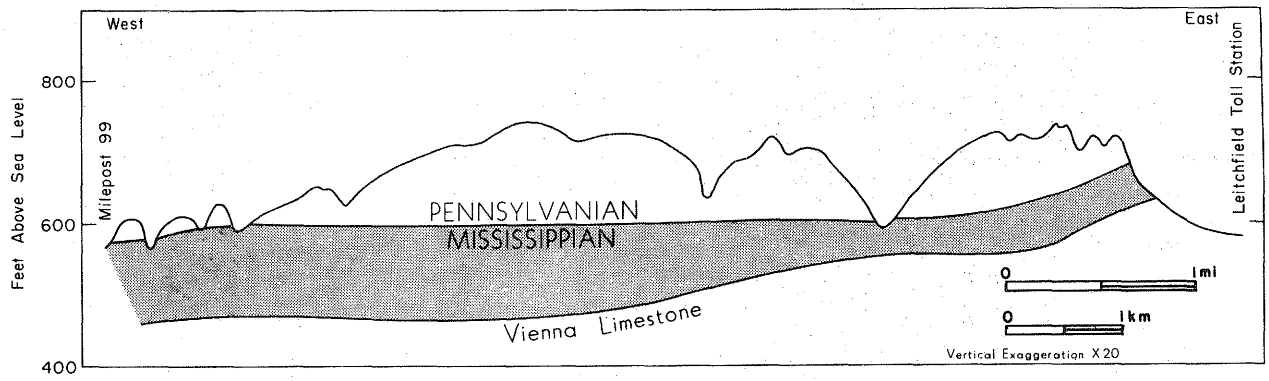


Figure KY-9. Cross section along Western Kentucky Parkway from Milepost 100 to Leitchfield, illustrating eastward thinning of Chesterian beds.

sandstone beds considered diagnostic of the Pennsylvanian.

59.8 Leitchfield Toll Station, Western Kentucky Parkway; turn right on exit ramp.

59.9 Junction Kentucky Route 259; turn left (south). For the next 3 miles the route is principally over the outcrop of the Leitchfield Formation (Late Mississippian). The following 15 miles (24 km) are over a moderately- to well dissected plateau capped with rocks of Early Pennsylvanian age. Outcrops along the highway are scarce until the route descends from the upland surface into the valley of Nolin River.

65.8 Junction Kentucky Routes 259 and 266 at Meredith; turn right (south) on 259.

67.9 Anneta; continue on Kentucky 259.

71.9 Grayson-Edmonson County line.

73.4 Broadway. This is part of the Western Kentucky rock asphalt district. In this area bitumen-bearing rocks are primarily sandstones and conglomeratic sandstones of Early Pennsylvanian age. The headwaters of Dismal Creek, an area of tar seeps cited in the first report of the Kentucky Geological Survey (Owen, 1856), are near this point. Owen (1856, p. 166-167) wrote that the local inhabitants collected the tarry oozes and used the material, when freed from earthy impurities, for greasing wagons, pitching boats, and other such purposes. However, the development of the Kentucky deposits has been almost exclusively for use as paving materials. An area 1 mile (1.6 km) southeast of here has been the site of industry-sponsored experimental work on extractive techniques for oil recovery from the bitumen-bearing sandstones.

75.6 Junction Kentucky Routes 259 and 238 at Bee Spring; continue on 259.

77.0 Junction Kentucky Routes 259 and 728; turn left (east) on 728.

78.7 On left, inactive quarry of Cardinal Stone Company in Glen Dean Limestone. The Leitchfield Formation is visible in the highwall above the quarry face. The highest Mississippian unit exposed at this point is the Vienna Limestone Member; the Vienna is overlain by sandstone of Early Pennsylvanian age.

79.1 On left, spillway for Nolin Dam. The walls and floor of the spillway are Pennsylvanian sandstone. Note the tar seeps in the wall of the spillway and the difference in elevation between this outcrop and the sandstone capping the hill above the inactive quarry.

79.2 Parking area at west end of Nolin Dam. Lunch stop. This interesting area has been known by geologists for more than 100 years (fig. (KY-10), but it has only been since the construction of Nolin Dam and the new highways that it has been readily accessible to students of earth sciences and others. Nolin Dam, completed in 1963, is an integral unit of the comprehensive flood-control plan for the Ohio and Mississippi Rivers. The Nolin River Project was designed to reduce flood stages in Green River Valley and other areas downstream from the dam. Normal pool evelation is 515 feet (157 m) above sea level.

STOP 2 Nolin Dam, the Brownsville Paleovalley and the Pennsylvanian Kyrock Conglomerate in west-central Kentucky.

Leaders: Wayne A. Pryor and Paul E. Potter, University of Cincinnati.

In central Kentucky (Edmonson and Hart Counties) the boundary between the Mississippian and Pennsylvanian sequences is delineated by the well developed Brownsville paleovalley. This paleovalley, cut into Chester rocks, is about 216 feet (66 m) deep, about 3 miles (5 km) wide, and has several well defined benches along its sides. The valley is filled with more than 197 feet (60 m) of Kyrock sandstone (Caseyville), which is a lower pebbly sandstone and an upper sandstone-and-shale unit. The lower unit is interpreted as a low-sinuosity braided-stream deposit and the upper unit is interpreted as a series of high-sinuosity meander-stream deposits.

The Brownsville paleovalley and its Kyrock sandstone fill suggest the cutting of a rather narrow and deep valley during late Chester or Early Pennsylvanian

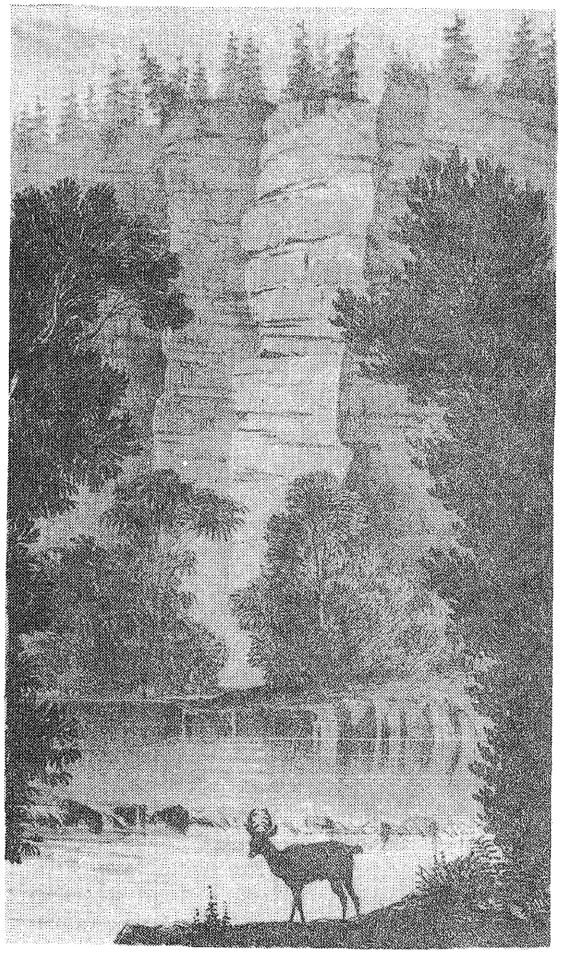


Figure KY-10. Photograph of pen-and-ink drawing of Dismal Rock by David Dale Owen, organizer and State Geologist of the first Geological Survey of Kentucky (Owen, 1856).

time, followed by fluvial deposition of a moderate-sized stream (656 to 984 feet [200 to 300 m] wide and 16 to 33 feet [5 to 10 m] deep) on an alluvial plain in a tropical climate. The change from a braided to a meander pattern is possibly related to changing gradients as alluviation encroached into the Illinois Basin in Early Pennsylvanian time. There are several ways to connect this valley to the Appalachian Basin, none of which can be well established. However, petrologic studies of the Kyrock Sandstone suggest an eastern source. (See Pryor and Potter, this Guidebook, Part 2, p. 49-62 for further description.)

79.2 Turn around and retrace route to Leitchfield.
98.6 Western Kentucky Parkway overpass; continue north on Kentucky Route 259.
99.4 Junction Kentucky Route 259 and U.S. 62 in Leitchfield; continue on Kentucky 259.
99.6 Junction with Kentucky Route 54 at Grayson County courthouse; turn left (west) on Kentucky 54.
101.5 On left, entrance to open-pit and underground operation of Ragland Quarry, Inc., in Glen Dean Limestone. Continue on Kentucky 54.
105.1 Glen Dean Limestone on left.
106.4 Cross Rough Creek fault zone next 0.5 mile (.8 km) (fault not visible on highway). The two hills north and northwest of this point are capped with rocks of Pennsylvanian age; both hills attain elevations in excess of 900 feet (274 m).
108.5 Glen Dean Limestone on right.
109.7 Flat areas on both sides of the highway are developed on the Hardinsburg Sandstone.
110.6 Junction Kentucky 54 and 79. Turn right (north) on 79 and retrace route to Rough River State Resort Park.
117.6 Entrance to Rough River State Resort Park; turn right on park road.
118.0 Lodge at Rough River State Resort Park. Overnight stop.

The park (fig. KY-11) is located in the outcrop area of Chesterian (Late Mississippian) formations. The lodge and adjacent parking lot are on the Hardinsburg Sandstone. Exposures of the Hardinsburg are in the spillway cut and at the north end of the dam. Low bluffs of Big Clifty Sandstone rim the lake just below the lodge. Some of the highest hills and ridges in the immediate vicinity of the Park are capped with Caseyville Sandstone of Pennsylvanian age. These erosional outliers are 5 to 6 miles (8-9.6 km) east of the main Pennsylvanian outcrop. Rough River Lake is a flood-control facility constructed and maintained by the U.S. Army Corps of

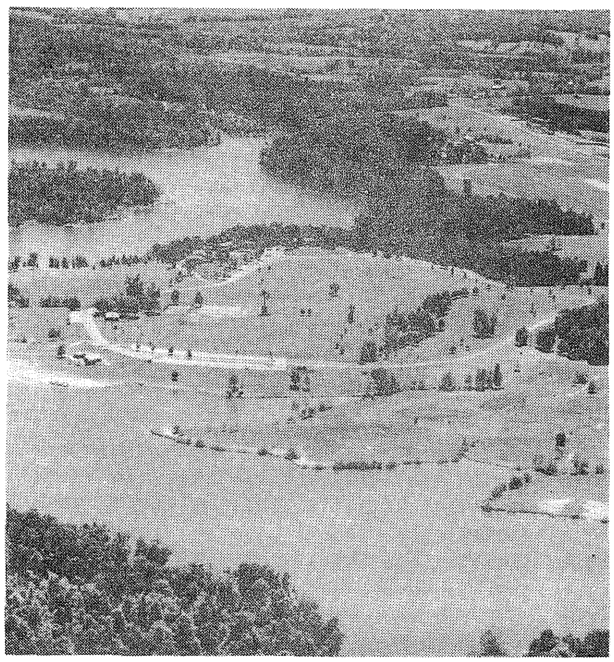


Figure KY-11. Aerial view of Rough River State Resort Park on Rough River Lake, Grayson County, Kentucky. The park is situated on sandstones, shales, and limestones of Chesterian age. Highest hills in the vicinity of the park are capped with sandstones of Early Pennsylvanian age. (Photograph courtesy Kentucky Department of Public Information.)

Engineers. The reservoir, completed in 1961 and an integral part of a comprehensive flood-control plan for the Ohio and Mississippi Rivers, will reduce flood stages downstream from the dam and in Green River Valley. Normal pool elevation of the lake is 495 feet (151 m) and the flood pool is 524 feet (160 m). The elevation of the lodge is approximately 570 feet (174 m). The trim and part of the veneer on the lodge are Hardinsburg Sandstone from Logan County, Kentucky.

DAY 3 Rough River State Resort Park to Kentucky Dam Village State Resort Park.

Trip leaders: Allen D. Williamson and Preston McGrain, Kentucky Geological Survey.

Tuesday, May 29, 1979

STOP 3. Homestead Mine.

STOP 4. Clear Run horst of Rough Creek Fault System—Green River Parkway—Milepost 53.

Overnight stop, Henry Ward Inn, Kentucky Dam Village State Resort Park.

0.0 Leave Rough River State Resort Park. Turn left on Kentucky Route 79.

3.1 Junction Kentucky Routes 79 and 736. Continue south on 79.

7.4 Junction Kentucky Routes 54 and 79. Continue south on 79.

14.6 Junction Kentucky 79 with U.S. Route 62 in Caneyville. Continue southwest on Kentucky 79.

15.6 Enter Western Kentucky Parkway westbound. Milepost 94.

For the next 20 miles (32 km) the field trip (fig. KY-12) will proceed up-section (down-dip) through the Tradewater Formation. At the Caneyville entrance to the Western Kentucky Parkway the Vienna Limestone is about 300 feet (91 m) below surface (Gildersleeve, in press). Rocks exposed at this point are very near the Caseyville-Tradewater contact. At the Beaver Dam Plaza the Vienna is encountered at a depth of about 1050 feet (320 m), reflecting a dip rate of about 40 feet per mile (7.6 m/1 km).

16.6 The thin interbeds of dark gray shale and fine-grained silty sandstone (subgraywacke) exposed in roadcuts for the next two miles suggest deposition in a quiet, restricted bay. Scattered sandstone lenses may indicate the sites of small intra-bay channels.

17.1 The original road was constructed 200 feet (61 m) north on fill composed principally of the dark shale visible here and in the next roadcut. This shale fill proved unstable; despite strenuous efforts, the road collapsed and was relocated at the present site on bedrock.

18.9 Small intra-bay channels in bay-fill shale.

19.8 Thin unnamed coal bed typical of the area.

21.0 This sandstone body may be channel fill; however, the thin tabular beds and gradational upper and lower boundaries are suggestive of splay deposits.

22.6 Low angle trough-type cross-bedding; probably point-bar accretion beds (Milepost 87).

23.9 Coal bed on right is a member of the Elm Lick coal zone which to the west is currently under active exploitation at numerous small to medium surface mines. In the hill to the right, a slightly higher coal was surface mined. One mile south, this coal bed and one about 30 feet (9 m) lower were surface mined. Whether these three coal beds are discrete units or "splits" of the Elm Lick is undetermined; similar occurrences of two or three coal beds in close vertical proximity are common in the Tradewater Formation around the southeastern rim of the Illinois Basin.

26.1 Sandstone-filled channel incised into dark-gray bay-fill shale (fig. KY-13). This sandstone is typical Tradewater and Carbondale channel fill with shale clasts and coal fragments common toward base. Festoon cross-beds dip predominantly eastward. The unit becomes finer grained upward, grading into siltstone and then dark gray shale, suggesting a shifting of the channel followed by a gradual increase of water depth until bay conditions returned.

26.6 The sandstone in this cut demonstrates the eastward flow direction of the channel visible at the last cut. The Elm Lick coal bed poorly exposed at road level is overlain by bay-fill shale with thin overbank sandstone lenses and is interrupted at the top by channel-fill sandstone. A small coal mine into the Elm Lick formerly extracted coal beneath this hill. The resulting bowing and fracture of rocks above the mined areas is evident in the roadcut on the right. From here to Beaver Dam the parkway skirts the north edge of a Caseyville sandstone paleochannel, the Rochester Valley (Davis and others, 1974). Figure KY-14 shows the boundary of the paleovalley and thickness

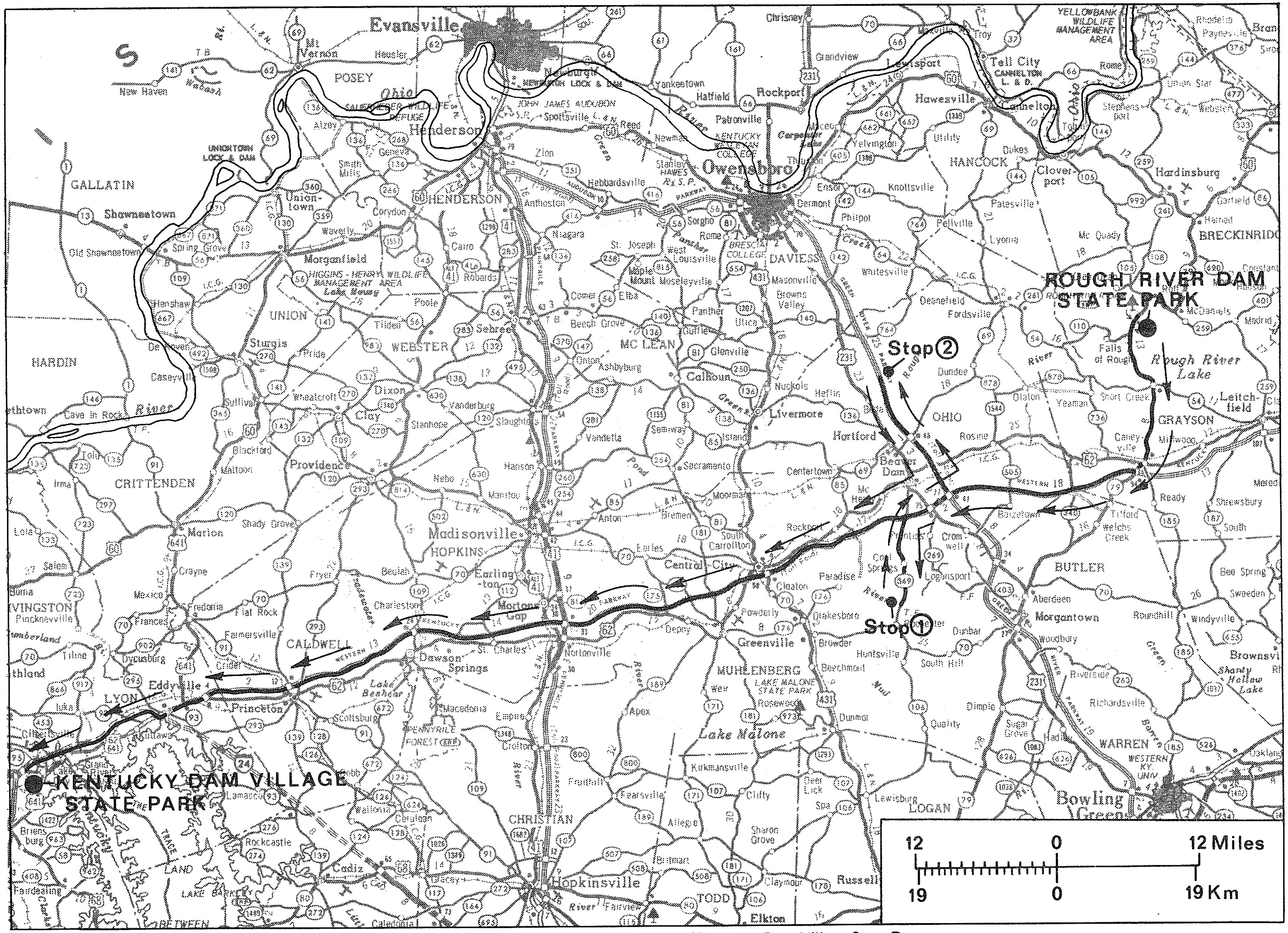


Figure KY-12. Field trip route for Kentucky, Day 3, from Rough River State Resort Park to Kentucky Dam Village State Resort Park.

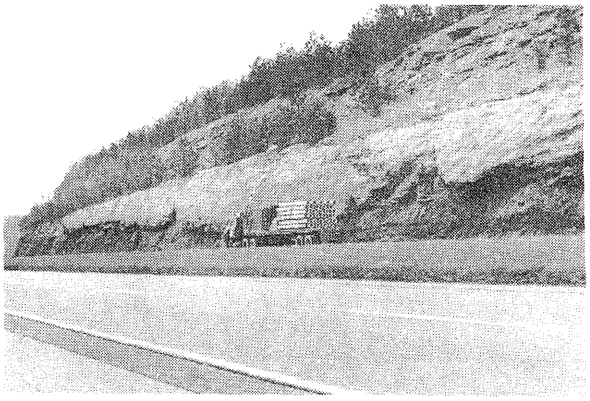


Figure KY-13. Sandstone-filled channel above Elm Lick coal east of Milepost 83. The irregular scoured upper surface of the shale is common in the Tradewater and Carbondale Formations.

of the channel-fill. The Rochester Valley may be the westward (downslope) extension of the Brownsville paleovalley described by Pryor and Potter at Kentucky Stop 2 (this Guidebook, Day 2, p. 35).

27.6 Kentucky Route 505.

27.7 The roadcut on the left illustrates typical Tradewater depositional environments for this part of western Kentucky. The lower coal-underclay couplet is overlain by dark-gray shale with siderite nodules and abundant carbonaceous plant debris grading upward into thin-bedded, fine-grained, silty, rippled, and bioturbated sandstone. The sandstone is succeeded by a second underclay-coal couplet, another dark-gray shale with siderite nodules, and then a black, fissile, carbonaceous shale. This repetitive sequence suggests a slowly subsiding restricted bay in which periodic influxes of detritus produced shoaling and consequent marsh and swamp development.

29.1 Thin coal "roll" over a small sandstone lens. This sandstone may be a small splay deposit.

30.1 Abandoned and reclaimed surface mine in an unnamed coal bed near the top of the Tradewater Formation.

33.4 The Yeargins Limestone exposed in ditches on both sides of the parkway marks the Tradewater-Carbondale boundary in this part of western Kentucky (fig. KY-15).

34.2 Beaver Dam Plaza. Rest Stop. Leave Beaver Dam Plaza westbound.

35.0 Exit from Western Kentucky Parkway; turn north on U.S. Route 231.

37.6 Beaver Dam; turn south on Kentucky Route 369. The Mulford coal (western Kentucky No. 9) caps the low hills on either side of the road.

40.2 Overpass of Western Kentucky Parkway over Kentucky 369.

41.2 Abandoned shallow surface mine is Mulford coal.

45.4 Entrance to Peabody Coal Company's 20th Century Mine.

46.2 Cool Springs community.
About 4 miles (6.4 km) west in Peabody Coal Company's Ken Mine, a "coal-ball" zone was encountered in the Herrin coal (Western Kentucky No. 11) surface-mine pit. In a band about 50 feet (15 m) wide and several hundred feet long, the coal was almost completely replaced by calcium carbonate. The well preserved calcified flora, examined by T. L. Phillips of the University of Illinois, was dominated by Lycopods which comprised about three-fourths of the taxa with minor representations of ferns and pteridosperms. Significantly, the "blue band," a characteristic clay parting, continued uninterruptedly through the calcified peat in the equivalent position which it occupied in the surrounding coal.

46.7 Northern boundary of Peabody Coal Company's Homestead Mine.

48.6 Entrance to Homestead Mine.

STOP 3 Homestead Mine.

Leader: Allen D. Williamson, Kentucky Geological Survey, and Thomas M. Kehn, U.S. Geological Survey.

This stop illustrates the widespread uniformity of lithology and depositional environment of Carbondale and lower Sturgis rocks. The section visible in the highwall corresponds to the rocks exposed at Lynnville (Indiana Stop 1) (fig. KY-16). The Indiana Coal V is equivalent stratigraphically to the Mulford (Western Kentucky No. 9) and Illinois Harrisburg No. 5. The Mulford coal is by a considerable margin the most widespread and uniform coal bed in western Kentucky, accounting for a large part of the region's coal production and reserve base. It is commonly about 5 feet (1.5 m) in thickness, although thicknesses up to 8 feet (2.4 m) or more have been reported in scattered localities. Several Pennsylvanian paleochannels (locally known as "washouts") in which the Mulford coal has been eroded have been encountered during coal-mine exploration and development. Channel incision occurred after deposition and drowning of this coal swamp. Except for these channels and those locations where it has been removed by recent erosion, this bed is thought to be present everywhere within its outcrop boundary in Kentucky.

The Mulford coal characteristically lacks the persistent partings and variation in quality common to many western Kentucky coal beds. It does contain numerous discontinuous thin bands of iron sulfide commonly called pyrite, although it probably contains both pyrite and marcasite.

Directly above the coal are 1 to 3 feet (.3 to .9 m) of tough, fissile black shale which weathers into paper-thin sheets and gives a distinctive appearance to Mulford surface mines. Locally, the shale is fossiliferous, containing well preserved pyritized fossils. Included in the black shale are large elliptical sideritic or pyritic concretions up to 4 feet (1.2 m) in diameter which

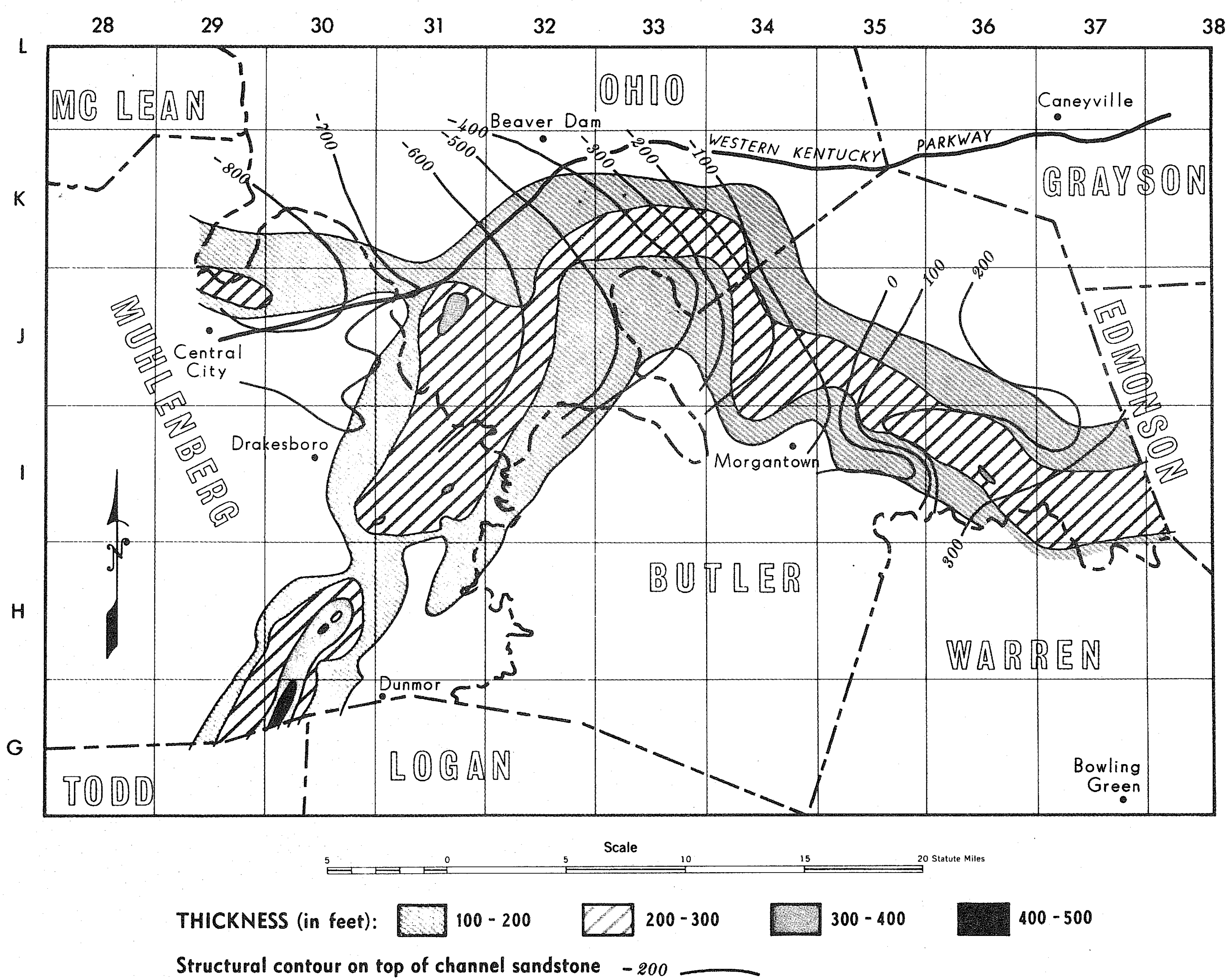


Figure KY-14. Distribution, thickness, and structure on top of the Rochester channel sandstone (after Davis and others, 1974).

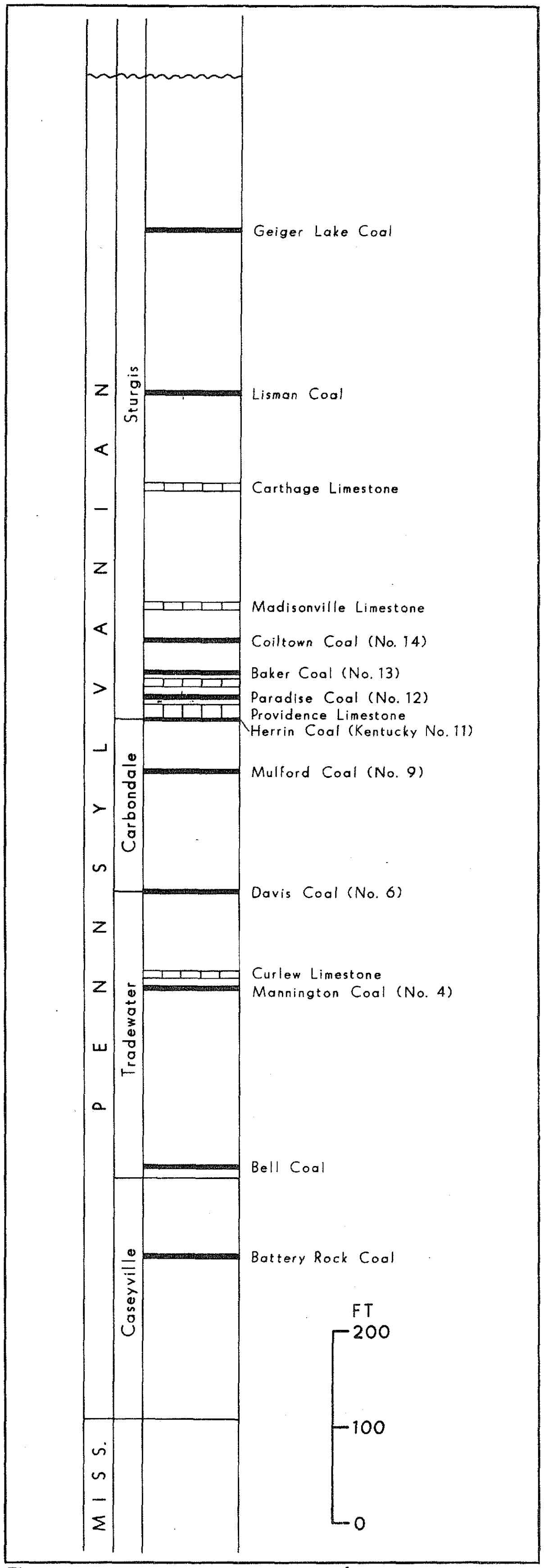


Figure KY-15. Generalized columnar section and coal bed nomenclature for the Pennsylvanian System in northwestern Kentucky.

often extend a few inches into the coal, forming distinctive protrusions in underground mines. These concretions are known as "kettlebottoms" or "heads" by miners. Similar black shale beds also occur above the Davis coal (Kentucky No. 6), the Schultztown, Well (Kentucky No. 8), and Ruff (Kentucky No. 8b) coal beds, all members of the Carbondale Formation. They are generally considered the initial lithic record of marine transgression across a coal swamp.

What is suppressed in the western Kentucky section is, of course, the marine sequence, represented by a black shale/slightly fossiliferous gray shale couplet rather than the four- or five-unit marine sequence of Illinois. This supports the theory that during Carbondale time the Illinois Basin operated as a depositional unit with a seaway to the west and a provenance to the east.

Occurring roughly 100 feet (30 m) above the Mulford is the Herrin coal (Kentucky No. 11), economically second in importance only to the Mulford (fig. KY-17). Although lacking the widespread uniformity and occurrence of the Mulford, this seam is generally present and mineable in its outcrop area along the southern and southeastern margin of the Illinois Basin. The coal is bright and blocky with relatively thick (0.2 to 0.5 inches [5 to 13 mm]) vitrain bands that are more common in the upper half, and contain numerous claystone partings, the most notable of which is the ubiquitous "blue band" that is coextensive with the coal.

At one locality in the Homestead Mine, underclay has displaced and brecciated the Herrin coal. Apparently this feature is similar to the "mud lumps" of the Mississippi River described by Coleman (1976).

Overlying the Herrin coal the Providence Limestone is the lowest member of the Sturgis Formation. As defined by Kehn (1973), it includes all limestone above the Herrin coal, up to the top of the highest limestone bed below the Baker coal, and contains at some localities as many as four discrete limestone beds. Other workers have recognized the Providence as a discrete limestone bed between the Kentucky No. 11 and Paradise No. 12 coal beds (Mullins and others, 1965; Franklin, 1967). Mullins and others correlated the limestone bed above the Paradise No. 12 with the Conant of Illinois; Franklin (1967) designated it as "an unnamed limestone." These two limestone beds are widespread and distinctive. The lower unit may be correlative with the Brereton Limestone of Illinois; the upper limestone may be correlative with the Bankston Fork of Illinois (M. E. Hopkins, personal communication).

The lowest limestone bed, which is the most widespread and distinctive unit of the Providence, commonly rests almost directly on Kentucky No. 11 coal, separated from it by a few inches of carbonaceous claystone. It is generally medium to dark gray, argillaceous,

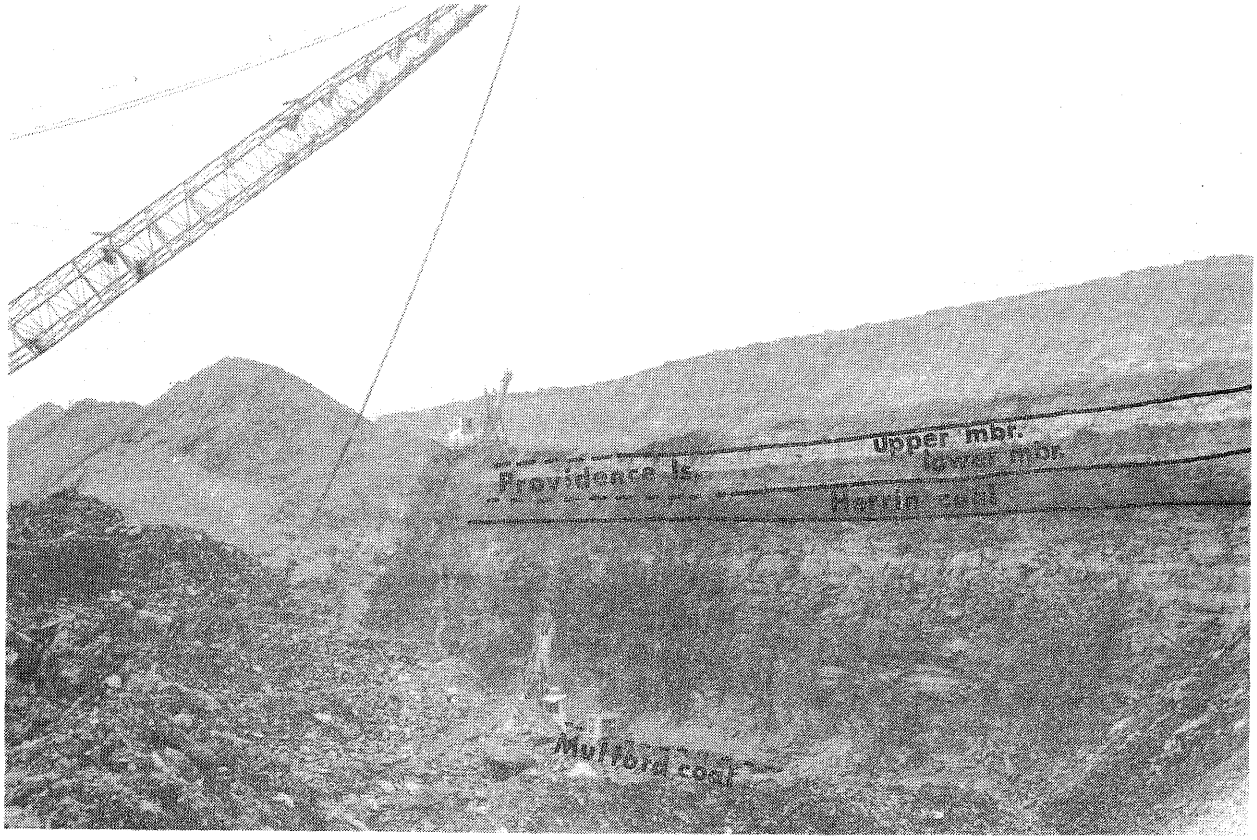


Figure KY-16. Highwall at Peabody Coal Company's Homestead Mine, Ohio County, Kentucky. Small power shovel at bottom of photograph is digging and loading Mulford coal (Western Kentucky No. 9). Boom of large stripping dragline on left. The power shovel at upper center is removing overburden above the Herrin coal (Western Kentucky No. 11) visible near the top of the highwall. Light-colored band is upper bench of Providence Limestone.

Figure KY-17. Herrin coal at road level along haul road in Homestead Mine. Two benches of Providence Limestone, separated by gray shale, are exposed above the coal.

and micritic with an abundant and diverse marine fauna. It is generally overlain by a few inches to a few feet of claystone (underclay) separating it from the Paradise coal. This bed is mined extensively in the southern part of the Western Kentucky coal field; however, the thickness is variable. Where the coal is absent, its position is generally occupied by a thin carbonaceous claystone. In areas where the coal is thick in Hopkins and Muhlenberg Counties, it is overlain by a thick, dark gray shale. Where the coal is thin or absent, the dark gray shale bed is also thin and is overlain by marine limestone that is commonly light gray to brown, crystalline, and skeletal. (Steven A. Austin, personal communication).

The Paradise coal is considered correlative with the Jamestown coal of Illinois; its Indiana correlative is unknown. Ten to 40 feet (3 to 12 m) above the Paradise is the nonpersistent Baker coal zone (Kentucky No. 13). Although generally a single seam, two or more splits are reported locally, separated by gray claystone.

A gray siltstone or silty shale generally overlies this coal bed; however, over a wide area of western Kentucky a medium- to coarse-grained sandstone with conglomeratic lenses replaces the siltstone.

48.6 Exit from Homestead Mine.
51.8 Turn east on 20th Century Mine haul road.
52.2 Abandoned Herrin coal highwall. Optional Stop.
52.4 Continue on haul road. Bear left at bottom of hill.
53.4 Slope mine into Mulford coal with overlying paleoslump beds. Optional Stop.
55.0 Return to Kentucky Route 369; turn north.
61.8 Turn right on U.S. Route 231 and return to Beaver Dam Plaza.
65.0 Beaver Dam Plaza. Lunch. Leave Beaver Dam

Plaza eastbound.

66.2 Exit from Western Kentucky Parkway onto Green River Parkway northbound.

68.3 Milepost 43.

69.0 Overpass over Illinois Central Railroad and Muddy Creek. About 2 miles (3.2 km) east, the Elm Lick Creek empties into Muddy Creek. This is the type area for the Elm Lick coal mined extensively in the immediate area.

69.8 Overpass over U.S. 62.

70.1 "Fusulina chert." This limestone bed was named for the distinctive intercalated bands and nodules of black chert containing white fusulinids.

70.3 Milepost 45.

71.3 Milepost 46. Charborn Coal Company surface mine in Elm Lick coal. In this area, two and possibly three coal beds have been designated and mined as Elm Lick.

72.7 Elm Lick Coal in road ditch.

73.0 Hartford Toll Station.

73.3 Milepost 48. The thin coal exposed on the east side of the parkway is probably the northern limit of the Elm Lick.

74.3 Milepost 49.

74.6 Bridge over Rough River.

76.4 Denton Coal Company surface mine in an unnamed Tradewater coal bed lying about 750 feet (229 m) above the Vienna Limestone. This coal, and one occurring about 25 feet (7.6 m) below it, are exposed in the low roadcut 0.2 mile (0.3 km) north of the mine.

77.2 Milepost 52. The two southward-dipping coal beds exposed here are unidentified; however, they are probably lower Tradewater.

78.3 Milepost 53. Stop 4.

STOP 4 Clear Run horst of Rough Creek Fault System—Green River Parkway—Milepost 53 (fig. KY-18).

Leaders: H.-F. Krausse and W. John Nelson, Illinois State Geological Survey; and Howard R. Schwalb, Kentucky Geological Survey.

General setting

The Rough Creek Fault System extends westward from eastern Grayson County, Kentucky, to the Ohio River west of Morganfield, and into Illinois, where it is called the Shawneetown Fault. The total length of the system, including the Shawneetown Fault, is at least 125 miles (200 km), and the width varies from less than 1 mile (1.5 km), to more than 5 miles (8 km). Displacements average several hundred feet (about 100 m) in Kentucky and locally exceed 2,000 feet (600 m) in Illinois. Strata of the Pennsylvanian System are generally downthrown to the north. The fault zone generally consists of a series of narrow horsts and grabens, in which rocks as old as Devonian and as young as Permian lie at the surface. More detail is given in Krausse and Treworgy, this Guidebook, part 2, p. 115-120.

The Rough Creek Fault System represents an ancient zone of weakness where repeated movement has occurred since the Middle Cambrian time or possibly earlier; the complete stratigraphic section has never been penetrated in the trough. Data from deep oil wells drilled in recent years provide a basis for interpreting some of the structural history of the fault system and the effect of deformation on the stratigraphic sequence adjacent to the system.

The oldest dated sedimentary rocks in the Illinois Basin are found in the subsurface south of the Rough Creek Fault System in Grayson County, Kentucky, where trilobites of Middle Cambrian age have been found in arkosic shale 2,360 feet (700 m) thick. North of the Rough Creek Fault System, Middle Cambrian rocks are absent and strata of Upper Cambrian age rest on the crystalline rocks of the basement. The Middle Cambrian shales probably represent the first marine invasion of the trough bounded by the Rough Creek and the Pennyrile Fault Systems. The trough was filled with marine sediments and buried by Upper Cambrian time. The deposition of clastic sediments was followed by accumulation of carbonates of the Cambro-Ordovician Knox Megagroup and Middle Ordovician Ottawa Megagroup which are similar in lithology throughout the midwest. A submarine channel extended from Indiana southwestward across Kentucky in Upper Ordovician time. This channel was filled with shale of the Maquoketa Formation (Upper Ordovician), resting on Plattin Limestone. The channel crosses the fault system at almost a right angle and shows little or no lateral offset across the fault system. This fact contradicts the suggestion of Heyl (1972) and others that the Rough Creek Fault System is part of a zone of major strike-slip faulting.

From early Silurian through Devonian time vertical movement occurred along the Rough Creek Fault System, with the southern block moving downward. This is indicated by pronounced thickening of sedimentary units that were deposited into the trough south of the fault system. Before the deposition of the Upper Devonian New Albany Shale, a scissors-type hinge movement occurred normal to the trend of the system with uplift greatest to the east. Subareal erosion eastwardly beveled almost all of the Devonian carbonates on the north side of the system, and the onlapping New Albany Shale buried this unconformity, while practically no erosion is evident in the trough. South of the Pennyrile Fault System, similar hinge movement and erosion took place, but at a slightly earlier time.

There is no evidence at the present time of fault movement during Mississippian and Pennsylvanian time; the present structural configuration was developed after the Pennsylvanian Period.

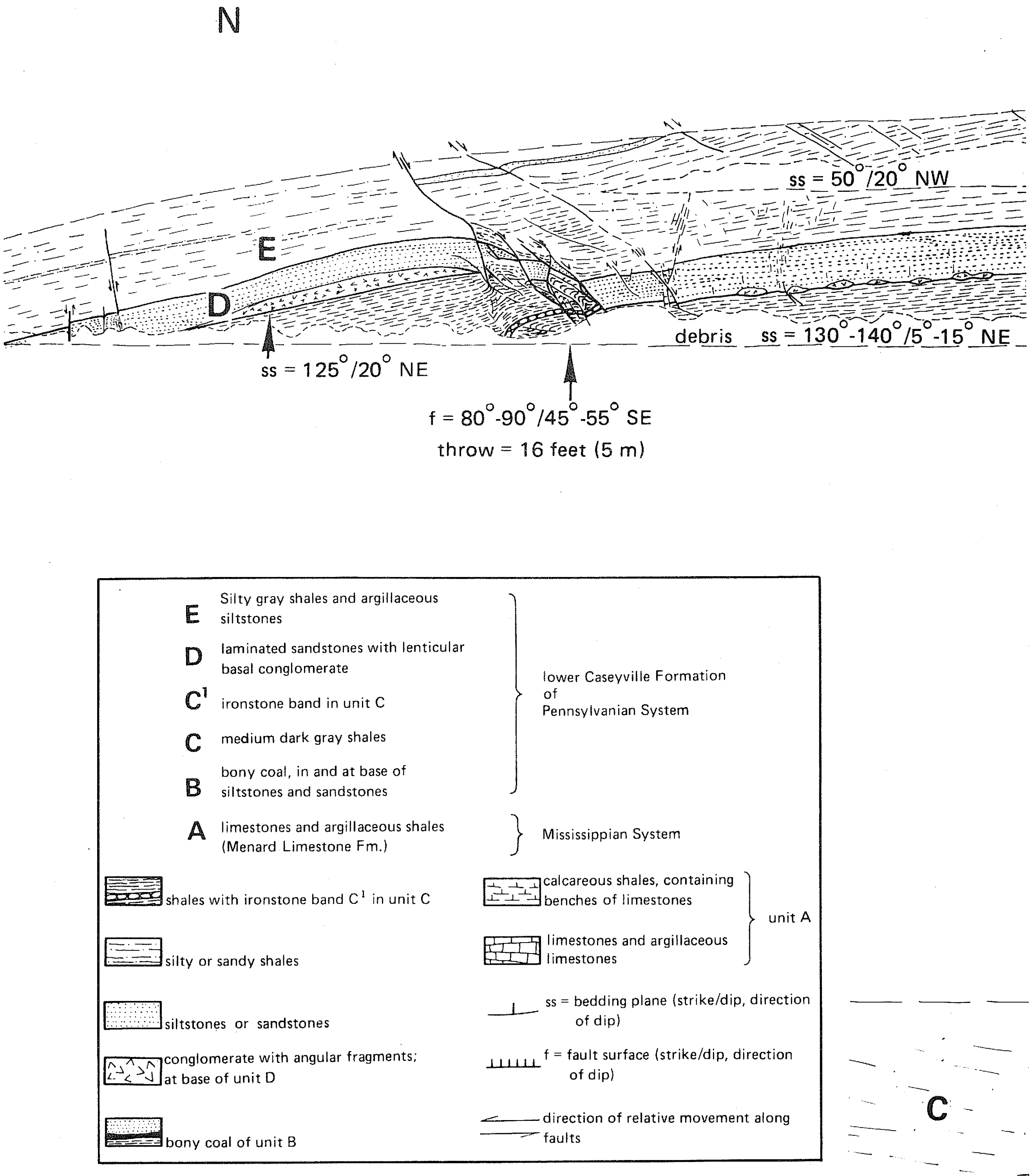
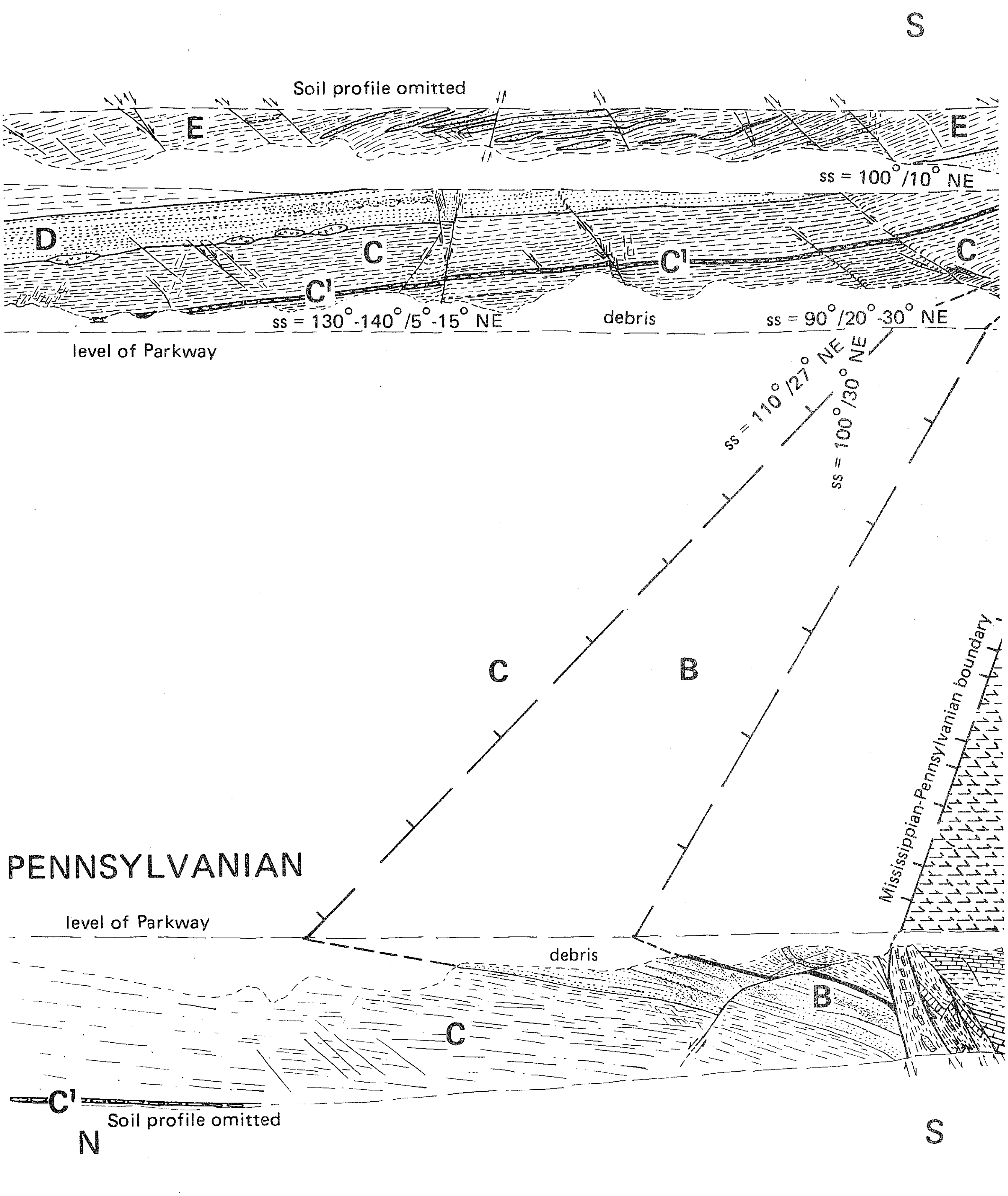


Figure KY-18.

Clear Run horst of Rough Creek Fault System. Exposure of folded and faulted Menard Limestone and lower Caseyville Formations at Milepost 52 of the Green River Parkway. The major bounding faults of the horst lie outside the exposed sections and trend east-westerly through the upper tributary valleys of the Clear Run Creek. For purposes of this illustration, sections of east and west side of Parkway have been folded outwards away from Parkway.

(Figure continues on four pages.)



S
Soil profile omitted
E
E
ss = 100°/10° NE
D
C
C'
C'
C
ss = 130°-140°/5°-15° NE
debris
ss = 90°/20°-30° NE
level of Parkway
ss = 110°/27° NE
ss = 100°/30° NE
C
B
Mississippian-Pennsylvanian boundary
PENNSYLVANIAN
level of Parkway
debris
B
C
C'
Soil profile omitted
N
S

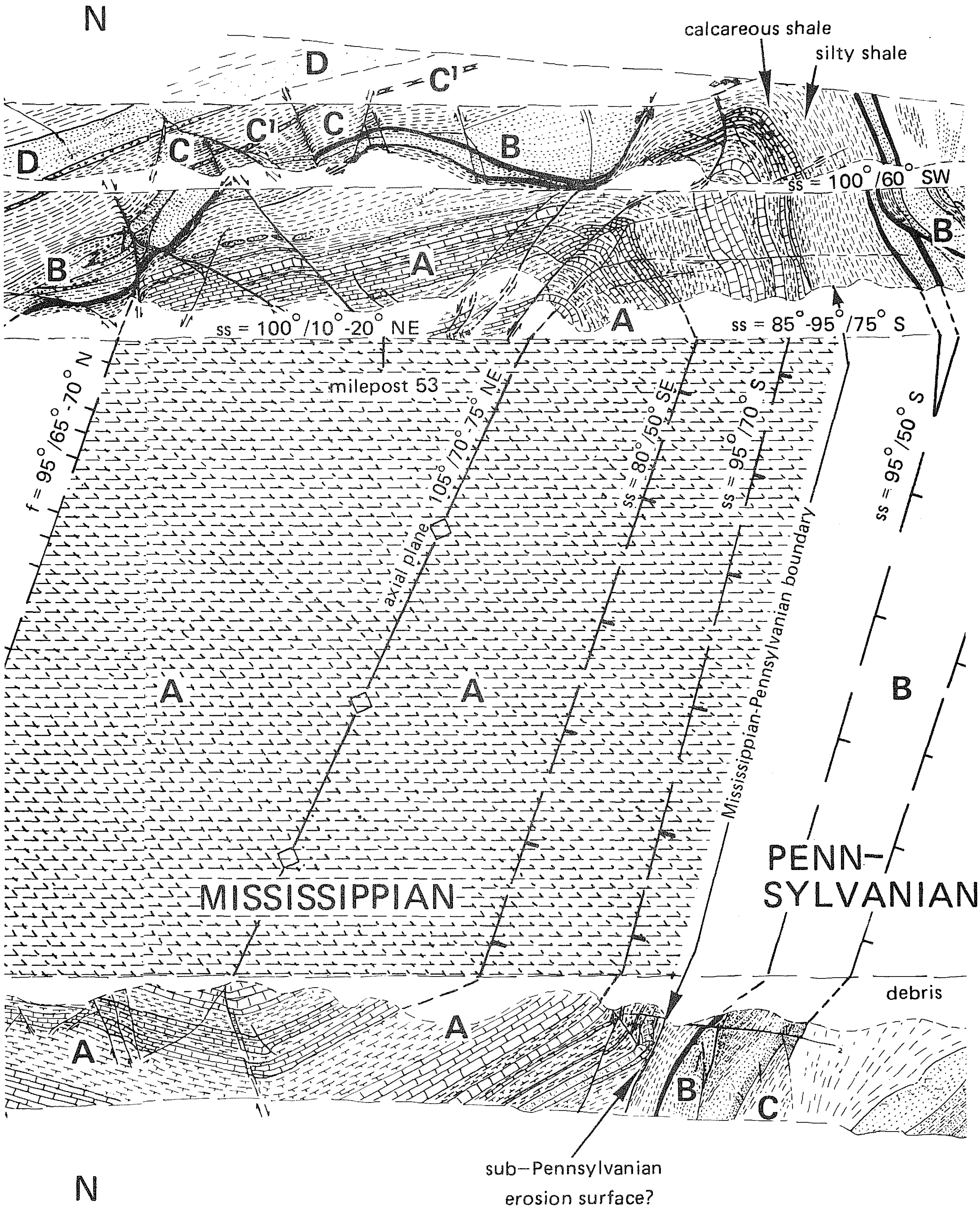
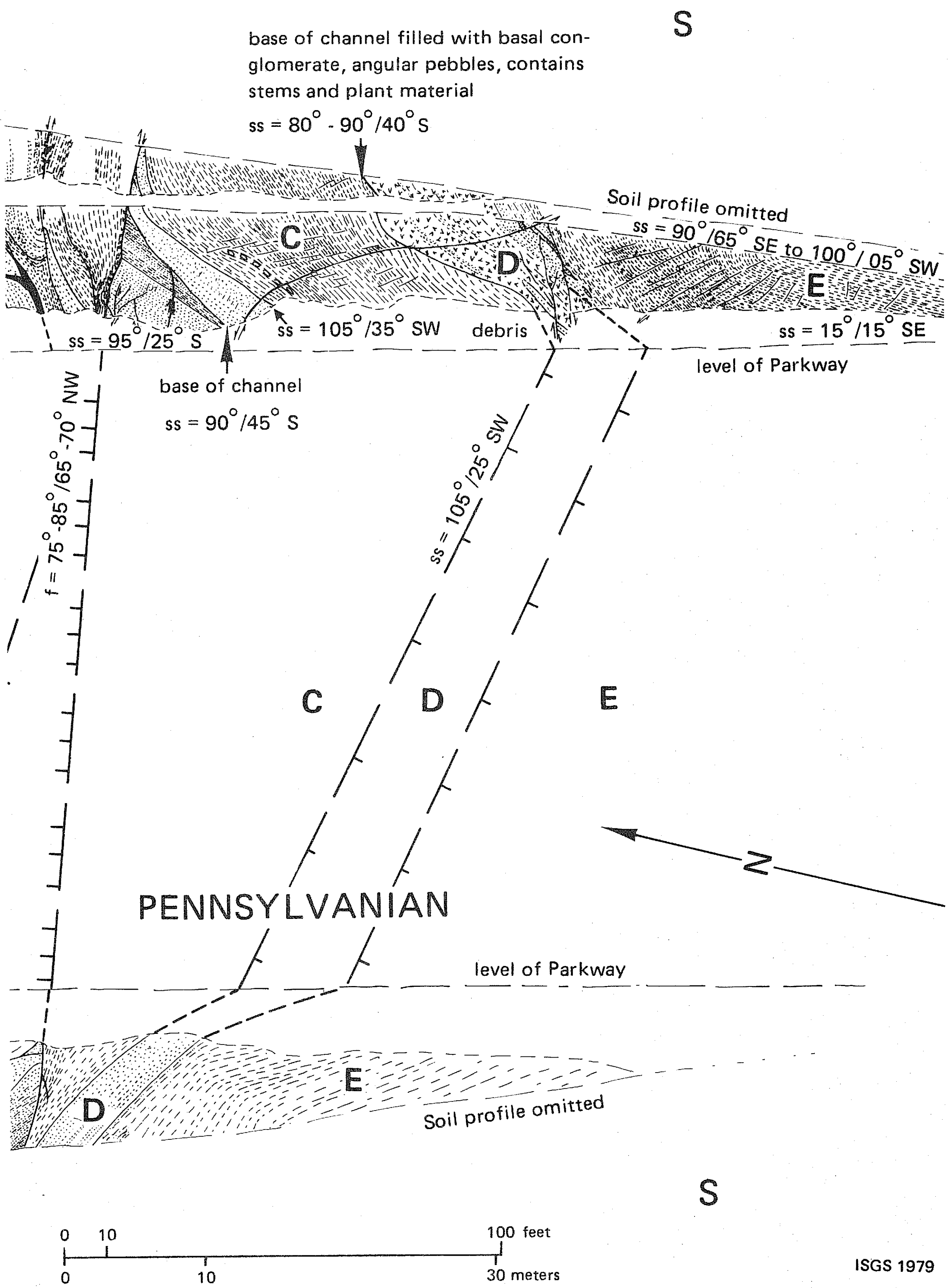


Figure KY-18. Continued.


S
base of channel filled with basal conglomerate, angular pebbles, contains stems and plant material
ss = 80° - 90°/40° S
Soil profile omitted
ss = 90°/65° SE to 100°/05° SW
C
D
E
ss = 95°/25° S
ss = 105°/35° SW
debris
ss = 15°/15° SE
level of Parkway
base of channel
ss = 90°/45° S
f = 75°-85°/65°-70° NW
ss = 105°/25° SW
C
D
E
N
PENNSYLVANIAN
level of Parkway
D
E
Soil profile omitted
S
0 10 100 feet
0 10 30 meters

ISGS 1979

Strata of the Permian System were recently described for the first time in the Illinois Basin by Douglas, this Guidebook, part 2, p. 15-20. The presence of these Permian rocks in a downthrown fault block in Union County, Kentucky, indicates that the final major movements along the Rough Creek Fault System occurred after early Permian time, with overall displacement down to the north.

Structures exposed in roadcut (Fig. KY-18)

At Kentucky Stop 4, faulted and folded strata of the Mississippian and Pennsylvanian Systems are exposed. The roadcut displays only a narrow slice in the southern part of the Rough Creek Fault System, which is more than 1 mile (1.5 km) wide along the Green River Parkway.

Just south of the center of the roadcuts, an anticline containing limestone and shales of the Menard Limestone Formation (Chesterian Series) permits interpretation of a portion of the complex deformational history. The limbs of the asymmetrical anticline are intensely sheared and faulted mainly by normal faults. The core of the anticline is fractured and sheared by numerous minor faults reflecting predominantly normal and some reverse movements in a wide variety of structural attitudes. The Mississippian strata are bounded on the north and south by large high-angle normal faults, and lower Pennsylvanian strata are brought against them.

North and south of the large bounding faults are strata of shale, siltstone, sandstone, and conglomerate of the Caseyville and Tradewater Formations. These beds dip steeply on either side of the anticline (65° S and 25° N). Inclination decreases rapidly away from the faults (15° S and 10 to 15° N). The Pennsylvanian rocks are broken by numerous, mainly normal subsidiary faults with high to moderate angles of dip. They are generally tensional shear faults. Near the major faults, however, especially to the south, large high-angle reverse faults have been recognized.

On both sides of the anticline, near the base of the exposed Pennsylvanian strata, are thin very carbonaceous black shales, rich in vitrain streaks, which are intensely squeezed and deformed along the faults. Available evidence strongly suggests that these black shale beds in both flanks are identical. If this is true, the Mississippian and the Pennsylvanian strata apparently form one single faulted fold in which the Mississippian strata moved upward somewhat more than the Pennsylvanian strata.

Because the faults are generally dip-slip faults, as evidenced by the slickensides and the almost horizontal fold axes, the major movements are believed to have been essentially vertical (with compression in the core of the fold and extension in the flanks). The overall displacements along the large faults are not known, because the stratigraphic interval that exists between the carbonaceous black shale (near the base of the Pennsylvanian) and the exposed top of the Menard Limestone has not been determined. However, vertical displacement is certainly greater than the height of the roadcut and may be somewhere between 100 to 250 feet (30 to 75 m). Because the majority of the visible faults, shear planes and associated structural features in the anticline are extensional structures, it may be assumed that the anticline was caused by drag action and upward squeezing along major faults of the Rough Creek Fault System. These major faults bound the entire exposed folded block and lie outside the exposure along two small valleys just north and south of the roadcut. No evidence exists for either regional lateral compressional stresses or significant strike-slip movement.

79.1 Leading edge of fault. The Upper Mississippian limestone beds exposed here are crumpled and overturned. The Middle Pennsylvanian beds which underlie the valley and hill to the north are essentially horizontal.

80.8 Return to Beaver Dam Plaza.

96.6 Enter Beaver Dam Plaza. Rest Stop. Exit westbound on Western Kentucky Parkway.

97.0 Milepost 74.

97.6 Ruff coal (Western Kentucky No. 8b) on right. At this locality there are two splits separated by 6 feet (1.8 m) of claystone, rooted in the upper half. Overlying the upper coal unit are 4 to 5 feet (1.2-1.5 m) of fissile carbonaceous shale, possibly equivalent to Excello Shale of Missouri and Illinois. It contains diverse and abundant nektonic fauna (Rainer Zangerl, personal communication). Although the 8b appears as two splits here, it usually appears as a single coal bed. The Mulford coal, about 70 feet (21 m) higher, has been surface mined from the hill crests north and south of the parkway.

100.0 Kentucky Route 369 overpass. The Mulford coal has been surface mined on both sides of the parkway.

101.9 Mulford coal in road ditch on right. Resting on the coal is the characteristic fissile carbonaceous shale grading upward into dark-gray shale containing siderite nodules. This is the typical sequence of beds overlying the Mulford in western Kentucky. Compare this with the sequence in the next roadcut.

102.2 In this cut a Pennsylvanian paleochannel eroded the bay fill almost to the top of the Mulford. The channel fill here consists of conglomeratic graywacke containing shale and limestone clasts, siderite nodules, coal fragments, and casts of logs and limbs. Some shale and limestone clasts are deformed, suggesting erosion and redeposition prior to lithification. The unit grades upward into siltstone and mudstone. Here, as at other localities where determination was possible, the channel was incised after peat deposition and drowning of the Mulford coal swamp. The presence of deformed limestone pebbles and cobbles in the "lag gravel" suggests channel incision shortly after deposition of the Providence Limestone.

103.7 Milepost 69.

104.0 Kentucky Route 1245. Baker coal member of the Sturgis Formation here is overlain by crossbedded sandstone which replaces the coal near the east end of the roadcut. In the next roadcut, this coal bed is about 5 feet (1.5 m) thick and is overlain by black shale.

104.7 Baker coal zone on left. This coal is thought to be equivalent to the Danville No. 7 coal of Illinois and coal VII of Indiana. In those states it marks the upper boundary of the Carbondale Formation. Prior to 1950, this formational boundary was commonly placed in the Illinois Basin at the top of the Herrin coal bed (Western Kentucky No. 11). In Illinois and Indiana the boundary was raised to the Danville No. 7 (Kosanke and others, 1960); in Kentucky the older usage is retained.

At this locality the coal zone consists of interlaminated coal and very carbonaceous shale and is overlain by 2 to 3 feet (.6 to .9 m) of very fissile black shale containing nektonic and trace fossils. Beneath the coal zone are 6 feet (1.8 m) of dark-gray claystone with dolomitic and calcareous concretions containing excellent plant impressions.

106.9 Green River Bridge and Muhlenberg-Ohio County boundary. The Paradise steam-electric generating plant visible to the south has a generating capacity of 2,558,200 kilowatts and consumes 24,000 tons (21,772 MT) of coal per day. Built in 1963, it was one of the first in the United States to be sited specifically to take advantage of local coal and water. Operated by the Tennessee Valley Authority, it is, despite recent coal price increases, one of the most efficient and economical electrical generating plants in the United States.

108.5 Baker coal on left. Here the coal has thickened to more than 6 feet (1.8 m) with a few thin carbonaceous clay partings (fig. KY-19). It is overlain by 10 feet (3 m) of interlaminated siltstone and shale. Above the siltstone is a dark red-weathering conglomerate consisting of tabular clay-ironstone pebbles and cobbles as much as 5 inches (12.7 cm) in diameter in a matrix of coarse-grained ferruginous sandstone with many white quartz granules and pebbles (Palmer, 1972).

113.4 Central City Toll Station.

115.6 Milepost 56. U.S. 62 underpass.

115.8 Central City Sandstone. Festoon crossbed sets range from one to two feet, dip west to southwest. Peabody Coal Company's River Queen

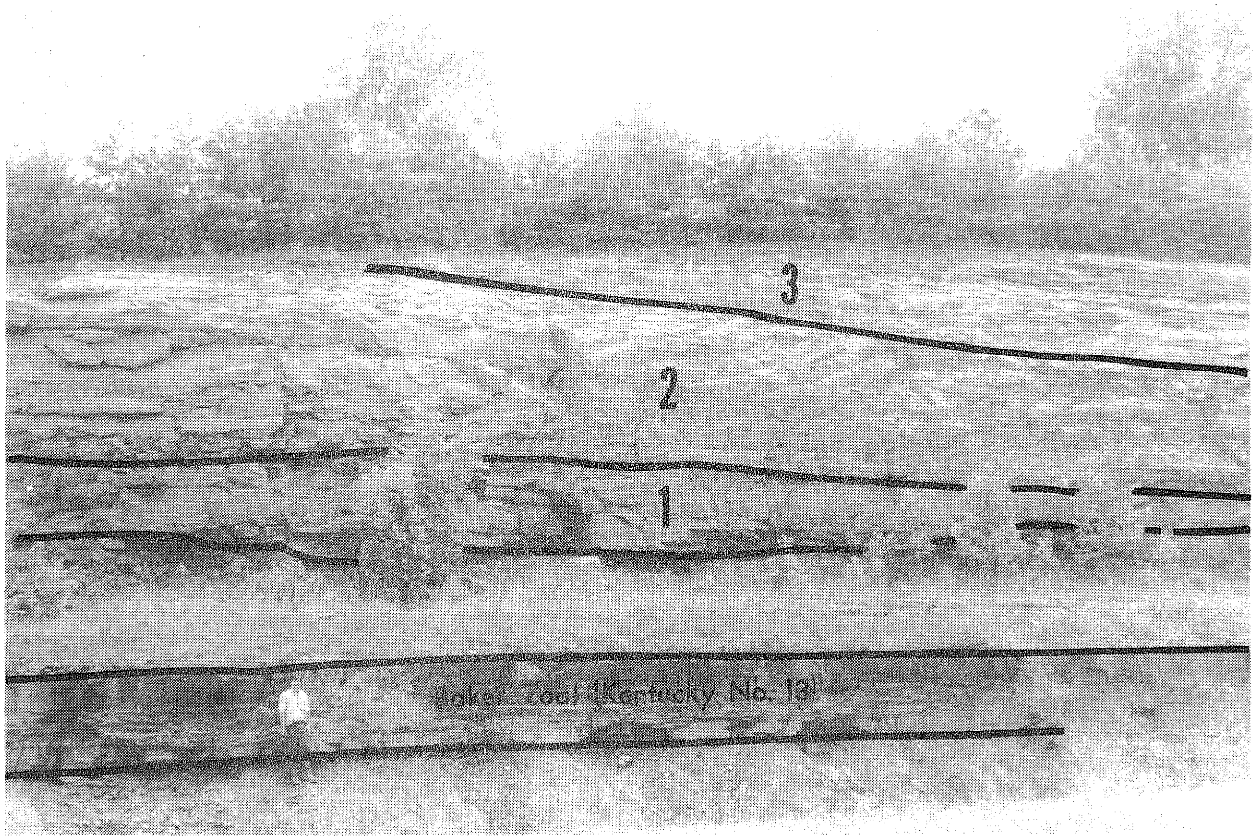


Figure KY-19. Baker coal (Western Kentucky No. 13) near Milepost 68. The sandstone above the coal here can be separated into: (1) a basal, tabular-bedded, coarse-grained unit containing claystone and coal clasts; (2) a middle unit, finer grained, festoon cross-bedded; and (3) an upper thin-bedded, silty, fine-grained unit.

Mine, on the right for the next few miles, is typical of large western Kentucky surface-mining operations. Three coal seams are mined: the Mulford, the Herrin, and the Paradise. The area visible was mined and reclaimed 5 or 6 years ago.

120.8 Milepost 51. The Herrin and Paradise coal beds have been surface mined on both sides of the parkway. The Paradise is visible in the roadcut; the Herrin coal and Providence Limestone are poorly exposed in the road ditch (fig. KY-20). The Paradise coal and the Providence Limestone are in the Sturgis Formation. The Herrin marks the top of the Carbondale Formation (Kehn, 1973).

121.8 Milepost 50. The route has dropped downsection into the Carbondale Formation, which will be traversed for the next few miles. The Mulford coal outcrops on south side of parkway. This outcrop illustrates the inhibiting effect on plant life of the black shale above the coal and of the toxic effluent issuing from the coal-underclay interface. This effluent, known as "copperas water" by miners, is commonly used as a guide for coal exploration in vegetated areas.

122.4 Typical lower Carbondale beds; bay-fill and splay deposits near the level of the DeKoven No. 7 coal.

122.9 Kentucky Route 175.

123.0 Milepost 48.

124.2 South Graham fault. This is the south boundary of a narrow graben trending about N 75° E. Throw here is about 500 feet (152 m) with lower Carbondale rocks against Sturgis. A small drag fold is exposed in the south side of the fault.

125.3 North boundary of the Graham graben. Vertical displacement here is about 200 feet (61 m). The Mulford coal is near the surface and has been surface mined for the next 2 miles (3.2 km).

125.9 Vegetation on south side of parkway conceals Mulford coal bed outcrop. However, its location is indicated by the reddish-brown "copperas water."

128.6 The parkway here parallels the St. Charles fault, with Carbondale beds to the north against Sturgis beds to the south. Displacement here is about 300 feet (91 m), down to the south.

129.5 Milepost 43.

129.6 Bridge over Pond River, Muhlenberg-Hopkins County line.

130.2 Small storm channel cut through bay-fill sediments.

130.7 Typical Pennsylvanian channel-fill sandstone in Sturgis Formation. The festoon crossbeds dip west to northwest. Bed sets are 0.5 to 1.5 feet (0.2 to 0.6 m) thick.

131.4 Abandoned underground mine in Mulford coal bed on left (Parkway Mine). The White Plains gas pool north of the road produces from the Tar Springs Sandstone (Chesterian) at a depth of about 1,400 feet (427 m).

131.9 Coiltown coal (Kentucky No. 14) in Sturgis Formation. This bed, approximately 200 feet (61 m) above the Mulford (No. 9), is the youngest coal to be seen on the Kentucky segment of the trip. This seam lacks the areal persistence and regularity in thickness of the Mulford and Herrin coal beds; nevertheless, it is important economically where present. It commonly reaches a thickness in excess of 8 feet (2.4 m), and has been reported to be as much as 14 feet (4.3 m) thick in some localities. Madisonville Limestone caps the small hill south of the parkway. The Coiltown coal (Western Kentucky No. 14) is normally about 50 feet (15 m) below the Madisonville Limestone; however, here a small down-to-the-south fault has dropped the Madisonville down to within 20 feet (6 m) of the coal.

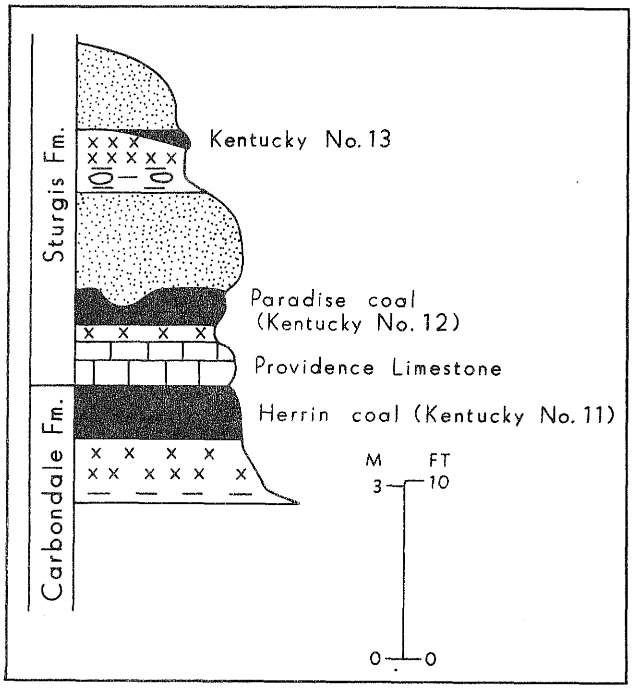


Figure KY-20. Sturgis-Carbondale boundary at Milepost 51, Western Kentucky Parkway. The Paradise coal, absent in the Homestead Mine, is here as much as 5 feet (1.5 m) thick.

133.4 Milepost 40.

134.7 Exit to U.S. Route 41.

134.8 Entrance to parkway from U.S. 41. Mortons Gap oil pool. Mulford coal was surface mined from the crests of low hills south of the parkway. In the higher hills to the north, the Herrin and Paradise coals were removed.

140.3 Mulford, Herrin, and Paradise surface mining north of parkway. The route for the next few miles is in a graben in which Mulford coal is preserved. North and south of the graben the Tradewater Formation is at the surface. Tradewater coal beds are thinner and less common than in the Carbondale.

140.4 Channel fill above Mulford coal. Unit is about 40 feet (12 m) thick and consists of medium- to coarse-grained sandstone that is cleaner and more quartzose than usual in the Middle and Upper Pennsylvanian. Festoon cross-beds in sets up to 3 feet (0.9 m) in thickness dip predominantly eastward in lower half and westward in the upper half. Individual bed sets fine upward, as does the entire unit, which grades upward into siltstone. At this locality the channel base is sharp and even. The basal one foot contains abundant coal fragments; however, this channel fill lacks the lag conglomerate and casts of logs common in basal channel deposits over the Mulford coal in the area around Homestead and 20th Century mines.

142.2 In this roadcut, the channel-fill sandstone unit exposed in previous cuts is 12 to 14 feet (3.6-4.3 m) above the Mulford coal (fig. KY-21). A smooth, undulant basal surface of the sandstone is apparent here. Compared to channel fill to the east, this sandstone unit has an even basal surface, is relatively homogeneous, and is quartzose. It lacks the lag conglomerate and coal "spars" common near the base of most Pennsylvanian channels.

148.5 Mulford coal was surface mined on both sides of the parkway here. This is the westernmost exposure of this coal and is essentially the edge of the Western Kentucky coal field. The route will drop steadily down-section westward to Kentucky Dam State Resort Park.

149.7 Dawson Springs Toll Station.

150.4 Milepost 23. Mannington coal (Western Kentucky No. 4) was surface mined on either side of the parkway; however, vegetation has been reestablished and little evidence of mining remains. This coal bed has been mined extensively in the vicinity of Dawson Springs, where it was known as the Dawson No. 6, and was formerly thought to be correlative with the Davis coal (Western Kentucky No. 6) near the Ohio River at DeKoven. However, Kehn and others (1967) demonstrated that this coal bed lies some 200 feet (61 m) below the Davis and correlates with the No. 4 coal of the DeKoven type section.

151.6 Enter Caldwell County. Bridge over Tradewater River. Although scarcely 50 feet (15 m) wide and now choked with brush and trees, during the late 18th century it was an important transportation link between the isolated backwoods farms and the civilized world. Hence the name Tradewater, which was adopted by L. C. Glenn (1912) to describe Pennsylvanian rocks in the area.

152.0 Festoon cross-bedded to planar-bedded sandstone, typical of the Lower Tradewater Formation.

154.1 Fault. Massive Caseyville Sandstone faulted against Lower Tradewater with approximately 70 feet (21 m) of throw. This is the western limit of the Pennsylvanian along the parkway. Westward the route will traverse Upper and Middle Mississippian rocks to Kentucky Dam Village.

154.3 Upper Mississippian. Kinkaid Limestone.

154.7 Palestine Sandstone.

155.2 Menard Limestone.

155.4 Milepost 18.

157.2 Tar Springs Sandstone resting on Glen Dean Limestone.

158.4 Milepost 15. For the next several miles the route traverses terrain underlain by Middle Mississippian (Meremacian) beds composed of medium- to light-gray, dense- to medium-crystalline limestone with abundant chert nodules and oolitic lenses. It weathers to a reddish-brown to dark red clay with residual chert.

160.6 Princeton Toll Station. Princeton is situated at

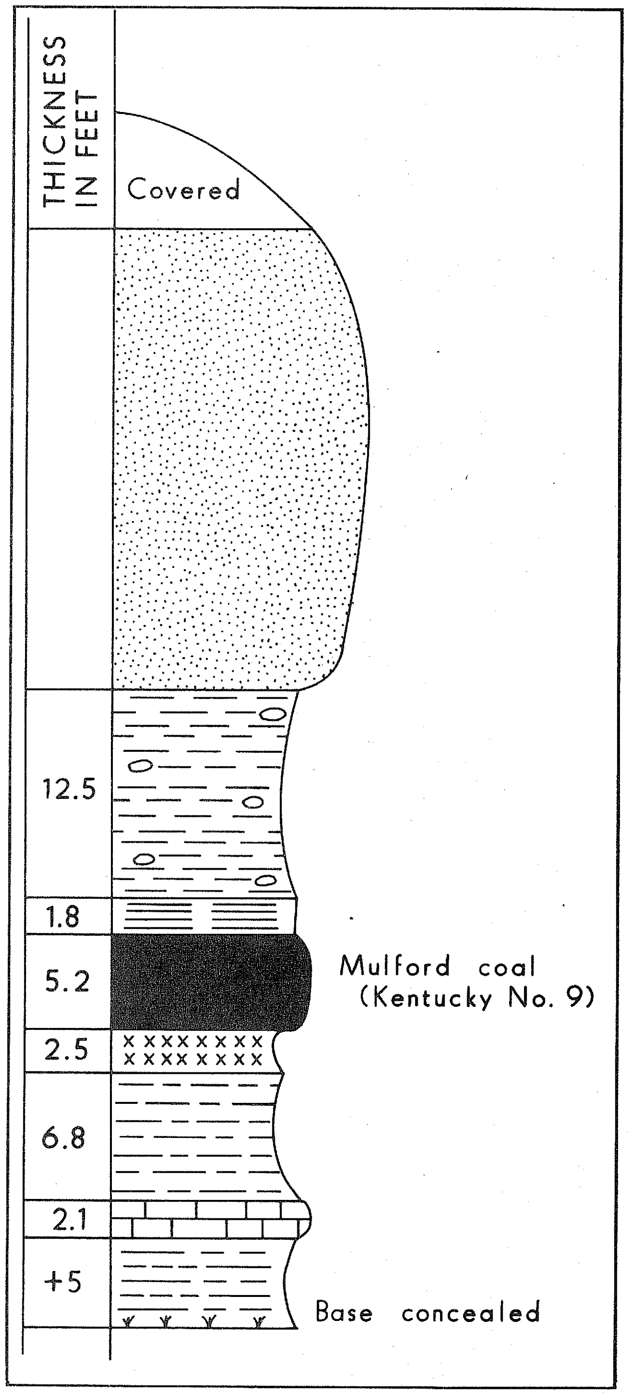


Figure KY-21. Section east of Milepost 32 on Western Kentucky Parkway illustrating typical sequence of beds above and below the Mulford coal.

the southeastern corner of the Illinois-Kentucky fluorspar district, the largest producing fluorspar region in the United States. (A brief description of the Western Kentucky fluorspar district is presented in this road log, p. 55).

164.9 Caldwell-Lyon County line at overpass.

166.9 Junction Western Kentucky Parkway and U.S. 62; turn right on U.S. 62.

168.5 Junction U.S. 62 and 641; continue southwest on 62 and 641.

170.1 Eddyville.

172.2 Interstate 24 overpass; continue on U.S. 62 and 641.

173.2 Kuttawa.

173.6 Warsaw Limestone on left.

175.3 Suwanee. This locality is near the northern end of a narrow belt of brown iron-ore deposits in western Kentucky. The mineral appears to be bog ore formed in the basal Cretaceous on the post-Mississippian erosion surface. Remnants of several old iron furnaces in Lyon and Trigg Counties are of historic interest. In 1851 a furnace was built 200 yards (61 m) northwest of this point by William Kelly, where he reportedly discovered a method for making steel that is now known as the Bessemer process. The furnace, fueled by charcoal, operated until 1857.

179.0 Cumberland River Bridge at Livingston County line. Barkley Dam, which impounds Cumberland River to form Lake Barkley, is 0.7 mile (1.1 km) south of the bridge. Barkley Lake provides flood control, navigation, power, and recreation. The dam and locks, constructed by the U.S. Army Corps of Engineers, are 2.5 miles (4 km) from the Tennessee Valley Authority's Kentucky Dam. A canal, 2 miles (3.2 km) upstream from Barkley Dam, connects Barkley Lake with Kentucky Lake for navigation and to permit operating the two flood-control reservoirs as a unit.

179.4 Tuscaloosa Formation (Cretaceous) on right. Here the Tuscaloosa is composed of chert gravel, chert sand, and tripolitic silt. At the base of the cut, the Tuscaloosa rests on limestones of Mississippian age. Most of the chert has come from rocks of Mississippian and Devonian ages.

180.0 Reed Crushed Stone Company's limestone quarry on right. The face, more than 200 feet (61 m) high, exposes limestones of the St. Louis, Salem, and Warsaw Formations, all Mississippian in age. Stone is quarried primarily from the Warsaw and Salem limestones, producing crushed limestone for concrete aggregate, roadstone, riprap, railroad ballast, and agricultural limestone.

181.7 Kentucky Dam and Kentucky Lake. Kentucky Lake, formed by a concrete, earth, and rock-fill dam across the valley of the Tennessee River, forms a body of water 184 miles (296 km) long with a shoreline of 2,300 miles (3,700 km). It is a multiple-purpose reservoir for flood control, navigation, power, and recreation, and has the largest flood-storage capacity in the Tennessee Valley Authority system.

183.1 Junction U.S. Routes 62 and 641; turn right and proceed south on 641.

183.6 Kentucky Dam Village State Resort Park (fig. KY-22). Turn left at entrance to Henry Ward Inn.

183.8 Henry Ward Inn; overnight stop.

Kentucky Dam Village State Resort Park is a 1,200-acre (486 hectare) park situated near the northeastern edge of the Mississippi embayment, an area of outcrop of unconsolidated Cretaceous and Tertiary sediments. The eastern margin of the embayment is fre-

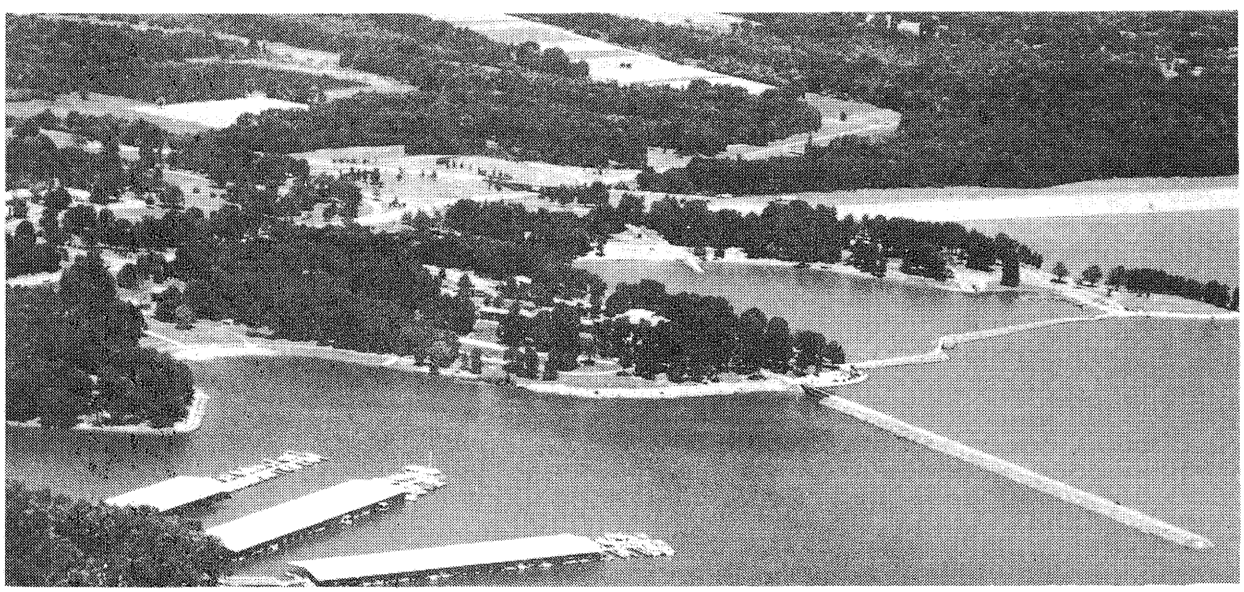


Figure KY-22. Aerial view of Kentucky Dam Village State Resort Park on Kentucky Lake, Marshall County, Kentucky. Pleistocene loess, brown, chert gravel of Tertiary (?) age, Upper Cretaceous silts and sands, and Mississippian carbonates outcrop within the park area. (Photograph courtesy Kentucky Department of Public Information.)

quently taken as Kentucky Lake, but in the areas a few miles to the north and east, hills and ridges are frequently capped with Cretaceous sands and gravels. Thus, the region of Kentucky Lake is a transition between the indurated Paleozoic rocks and the unconsolidated Cretaceous and Tertiary embayment sediments.

DAY 4 En route, Kentucky Dam Village State Resort Park to Cave-in-Rock Ferry, including Western Kentucky Fluorspar District.

Trip leaders: Robert D. Trace and Preston McGrain, Kentucky Geological Survey.

Wednesday, May 30, 1979

En route.

0.0 Henry Ward Inn at Kentucky Dam Village State Resort Park. Exit park.

0.2 Junction park road and U.S. Route 641; turn right (north) on U.S. 641 (fig. KY-23).

0.3 Bear right on U.S. 62 and 641.

0.6 Cross Kentucky Dam and travel northeast on U.S. 62 and 641, retracing approximately 14.3 miles (23 km) traversed the previous day. Points of geologic interest are noted on that road log.

14.9 Junction U.S. 62 and 641; turn left (north) on 641. For the next 9.5 miles (15 km) the route is over the outcrop of St. Louis and Ste. Genevieve (Mississippian) limestones. The terrain is characterized by numerous sinkholes; surface streams are rare because much drainage is diverted to subterranean routes.

20.7 On right, road to the open-face operation of Fredonia Valley Quarries, Inc. Continue on U.S. 641. The quarry, located in an erosion outlier of the Dripping Springs escarpment, is entirely in the Fredonia Member of the Ste. Genevieve Limestone. The escarpment in the background (east) is capped by the Bethel Sandstone (Mississippian).

23.5 Junction U.S. 641 and Kentucky Route 91 in Fredonia; turn left and continue on these highways.

24.4 to 24.6 Cross Tabb fault system (not visible on highway). The most productive area for fluorspar in the Western Kentucky fluorspar mining district is located in the Tabb fault system 2 miles (3.2 km) west of here. Sites included U. S. Steel's Lafayette Mine (fig. KY-24) and Alcoa's Haffaw Mine. (No mines were operating in this area at the time this itinerary was prepared.)

25.3 Cross Livingston Creek; enter Crittenden County. Palestine Sandstone (Mississippian) on right. For the next 0.8 mile (1.3 km) the highway ascends a dip slope on the Palestine Sandstone.

26.1 to 26.5 Mexico fault system (not visible on highway). (Junction of U.S. 641 and Kentucky Route 70 is in the middle of the Mexico fault system.) Continue north on U.S. 641 and Kentucky Route 91. For the next 2.4 miles (3.9 km) the route is over Cypress Sandstone (Mississippian). The isolated knobs to the right (east) are capped with Hardinsburg Sandstone.

28.5 Crayne (at post office).

28.9 Cross unnamed fault; Cypress Sandstone on south against Tar Springs Sandstone on the north (fault not visible on highway).

30.6 Exposures of Tar Springs Sandstone.

30.7 Cross Chapel Hill fault (not visible on highway) at Crooked Creek.

32.7 Cross Clay Lick fault system (not visible on highway).

32.9 Junction with U.S. Route 60 in Marion; continue north in Marion on Kentucky Route 91 and U.S. 641.

33.2 Crittenden County Courthouse in Marion on left. Marion was the rail hub for shipments of fluorspar ore in the past. Turn left on Kentucky 91 at the traffic light.

34.5 Hardinsburg Sandstone on right.

34.7 to 34.8 Cross Moore Hill fault system.

36.2 to 36.4 Exposures of Ste. Genevieve Limestone on left.

37.2 Cross northeast end of Crittenden Springs fault system, locally called the Memphis area. (Fault not visible on the highway.)

39.4 Scattered exposures of limestone and shale of the Golconda Formation.

39.5 Scattered exposures of thin-bedded Hardinsburg Sandstone.

41.5 Cross Commodore fault system (not visible on highway).

42.5 On left, an open trench or cut along fault in the St. Louis Limestone that produced substantial quantities of barite (Mico Mine).

43.6 Edge of Ohio River floodplain. Outcrop of St. Louis Limestone in clump of trees on left.

44.5 Ohio River at Cave-in-Rock ferry.

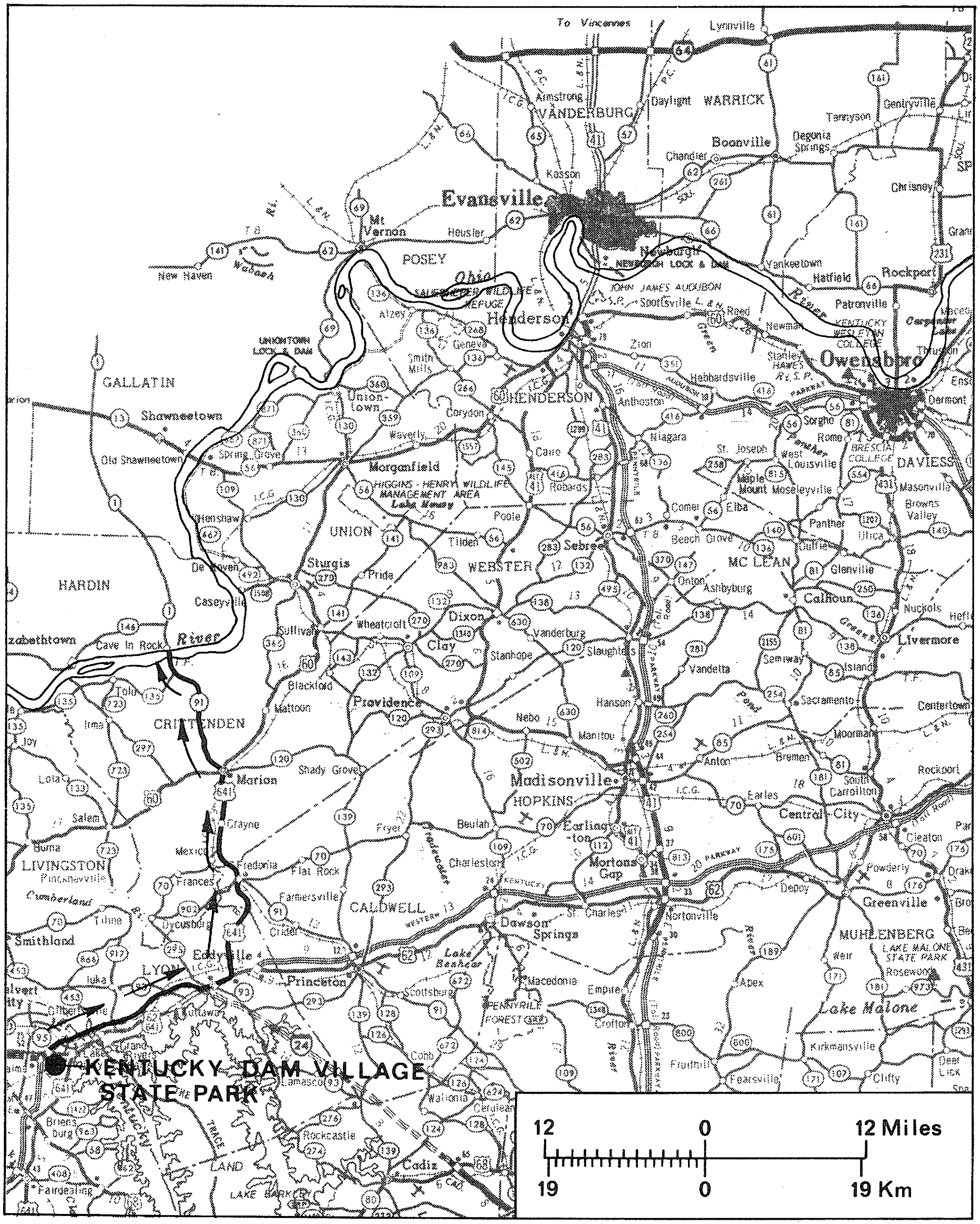


Figure KY-23. Field trip route for Kentucky, Day 4, from Kentucky Dam Village State Resort Park to Cave in Rock, Illinois.

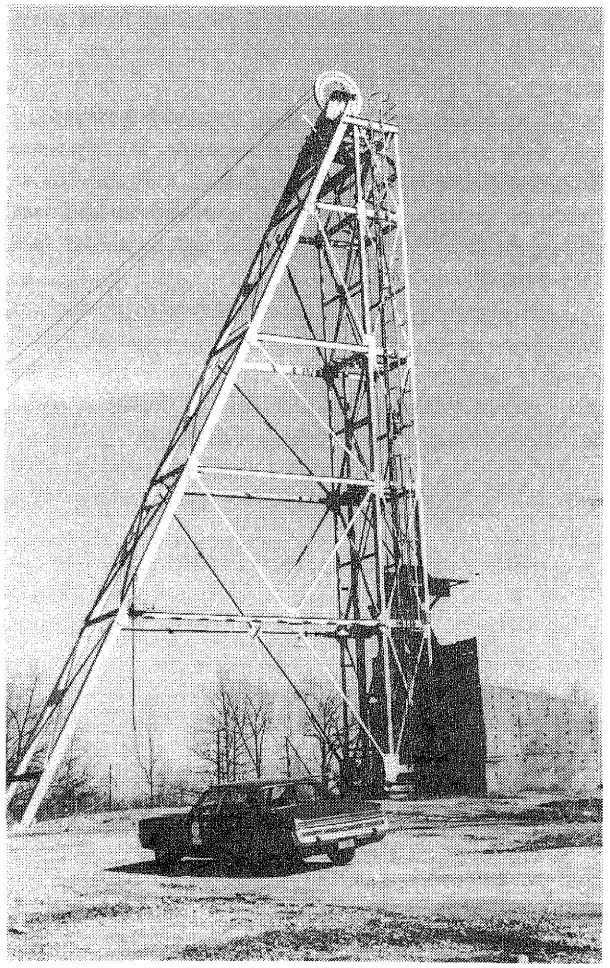


Figure KY-24. Tabb No. 1 shaft of Lafayette mine (inactive). This has been the main opening on the Tabb fault system.

Western Kentucky Fluorspar District.[1]

Robert D. Trace, Kentucky Geological Survey.

Introduction

The Western Kentucky fluorspar district is a part of the Illinois-Kentucky fluorspar district, which is the largest producer of fluorspar in the United States. The Kentucky district is in Crittenden, Livingston, and Caldwell Counties of western Kentucky, near the towns of Marion, Salem, Smithland, and Princeton.

About 3.25 million short tons of fluorspar concentrate have been produced since mining began in about 1873. Small quantities of zinc, barite, and lead also have been produced. The earliest mining was for lead and was done at the Columbia Mine in 1835 (Ulrich and Smith, 1905, p. 115). The earliest mining for fluorspar was at the Yandell Mine in 1873 (Ulrich and Smith, 1905, p. 20). Only small amounts of fluorspar were produced from 1873 to about 1890, when an expanded market was created by the development of the basic open-hearth steel furnace in which fluorspar was used for flux. Production since 1890 has been erratic (Trace, 1974, p. 61).

Geologic maps at a scale of 1:24,000 are available for the entire district. These 7.5-minute geologic quadrangle maps, which were prepared as part of the Kentucky Geological Survey-U.S. Geological Survey cooperative mapping program, were completed in 1976.

Geology

Sedimentary rocks exposed in the district range in age from Lower Carboniferous limestone to Quaternary fluvial and lacustrine deposits. Most of the rock units at the surface are Carboniferous (largely Mississippian), although some Lower Pennsylvanian rocks are present also. Small amounts of unconsolidated sand, silt, clay, and gravel of Cretaceous and Tertiary ages and loess and alluvium of Quaternary age are present locally.

About two-thirds of the Mississippian rocks are fossiliferous marine limestone and the remainder are composed of clay- to sand-size terrigineous clastic material. Meramecian marine limestone is at the surface in about half of the district and Chesterian marine and fluvial to fluvio-deltaic clastic sedimentary rocks and marine limestone underlie about a third. Mississippian rocks are about 3,000 feet (914 m) thick. The Upper Carboniferous (Pennsylvanian) rocks are dominantly fluvial clastic rocks—shale and sandstone with a few thin coals—and are as much as 600 feet (183 m) thick. Most of the ore deposits occur where the wall rocks are of either late Meramecian or early Chesterian age.

Many mafic dikes and a few mafic sills are present. The mafic rocks are mostly altered mica peridotites or lamprophyres and are composed of carbonates, serpentine, chlorite, and biotite with some hornblende, pyroxene, and olivine. Most of the dikes are in a 6- to 8-mile-wide (9.7-12.9 km), northwest-trending belt. Commonly the dikes strike N 20° to 30° W, dip from 80° to vertical, and are 5 to 10 feet (1.5-3 m) wide. Based on radioisotopic study, the dikes have been determined to be Early Permian in age (Zartman and others, 1967, p. 860-861).

The dominant structural features of the district are a northwest-trending domal anticline, the Tolu Arch, and a series of normal faults or fault zones that trend dominantly northeastward and divide the area into several elongated northeast-trending grabens. Development of these grabens was the major tectonic event in the district.

Vertical displacement along the faults varies from

[1] Previously published in *A symposium on the geology of fluorspar,* Kentucky Geological Survey, 1974.

a few feet to as much as 3,000 feet (914 m), although commonly no more than a few hundred feet. Available data suggest that the horizontal component of displacement is relatively minor compared to the vertical displacement. Many cross faults of small displacement trend northwestward and are occupied at places by mafic dikes. Faulting was mostly post-Early Permian to pre-Middle Cretaceous in age, although some movement continued through the Cretaceous and Tertiary to the present (Rhoades and Mistler, 1941, p. 2046-2047; Amos, 1967).

Nearly all of the faults are normal; generally they dip 75° to 90°, although rarely they are inclined as low as 45°. Locally, the direction of dip may be reversed. Fault zones that consist of several subparallel and sinuously intersecting fractures are especially common along the edges of many of the grabens (Hook, 1974, fig. 3). These zones are commonly a few hundred feet wide, although at places they are more than 1,000 feet (305 m) wide. The total displacement attributable to a fault zone is distributed irregularly among the several individual faults, classified as step faults, antithetic faults that form small grabens within or along the edge of the fault zones, and cross faults (Hook, 1974, p. 79-81).

Ore Deposits

Most of the fluorspar-zinc-barite-lead ore bodies are steeply-dipping to vertical vein deposits along faults and "gravel" deposits that resulted from concentrations of fluorite in residuum above vein deposits. A few deposits occur as very gently dipping to nearly horizontal bedding-replacement deposits in lower Chesterian or upper Meramecian rocks.

Most of the vein-ore deposits are along northeast-trending faults; a few veins are along northwest- and north-trending fissures or faults that at places contain mafic dikes. The fluorspar veins commonly are fissure fillings in fault breccia, accompanied by replacement of vein calcite and some limestone wall rock. A typical vein is lenticular, pinches and swells erratically, and is composed of fluorite, calcite, and country-rock fragments. Locally, the vein may be entirely calcite or fluorite. Commonly, contact with vein walls is sharp; however, at places, veinlets of fluorite and calcite extend a few hundred feet beyond a vein into slightly brecciated wallrock. In many veins, sphalerite, galena, and barite are minor minerals; in a few veins, sphalerite or barite is the major constituent. Mine-run ore commonly contains from 30 to 40 percent fluorite, and, at places, 2 to 3 percent zinc and 0.5 to 1 percent lead.

The width of most fluorspar veins is 3 to 10 feet (.9-3 m), and mined ore shoots commonly range from 200 to 400 feet (61-122 m) in length and 100 to 200 feet (30-61 m) in height. Deposits have been mined to depths of about 700 feet (213 m). Based on stratigraphic relations, the age of mineralization is post-Early or Middle Pennsylvanian and pre-Late Cretaceous.

A few bedding-replacement deposits are present in the Kentucky district. These deposits are elongate bodies that trend north to northeast; they may be as much as 2 miles (3.2 km) long and 150 to 250 feet (46-76 m) wide with thicknesses of 5 to 10 feet (1.5-3 m) (Trace, 1974, p. 69).

More than two-thirds of the fluorspar production within the district has come from five areas of 1 to 5 miles (1.6-8 km) along a fault zone. Several other areas also have produced small quantities of fluorspar, and a few areas have produced only zinc or barite.

End of Kentucky portion of field trip.

ILLINOIS

Wednesday, May 30, 1979

DAY 4. Cave in Rock, Illinois, to Carbondale, Illinois.

STOP 1. Hicks Dome and the Illinois-Kentucky Fluorspar District.

STOP 2A. Garden of the Gods Access Road (Optional stop).

STOP 2B. Garden of the Gods Recreation Area; overview of Eagle Valley Syncline; structural history of the Illinois Basin; depositional environments of the Caseyville Formation.

STOP 3. Pounds Hollow Recreation Area (lunch stop).

STOP 4. Channel and sheet phases of the Anvil Rock Sandstone Member—Eagle Surface Mine.

STOP 5. Shawneetown Fault Zone, north limb of Eagle Valley Syncline.

STOP 6. Will Scarlet Mine, Peabody Coal Company (optional stop).

Overnight stop, Holiday Inn, Carbondale, Illinois.

Thursday, May 31, 1979

DAY 5. South-central Illinois.

STOP 7. Mississippian-Pennsylvanian Unconformity, U.S. Route 51.

STOP 8. Caseyville Formation (lower Pennsylvanian), Interstate 57.

STOP 9. Ferne Clyffe State Park (lunch stop).

STOP 10. The Abbott and Caseyville Formations (lower Pennsylvanian), Interstate 24.

STOP 11. Herrin (No. 6) Coal Member (Carbondale Formation) and associated strata at Delta Mine, AMAX Coal Company.

Overnight stop, Holiday Inn, Carbondale, Illinois.

Friday, June 1, 1979

DAY 6. Carbondale, Illinois, to southwestern Illinois area.

STOP 12. Channel fill and associated deposits of the Walshville channel and an Anvil Rock channel.

STOP 13. View of Mississippi River floodplain and Fountain Bluff (optional stop).

STOP 14. Sedimentary features of the Caseyville Formation, Kinkaid Lake Spillway.

STOP 15. Upper Desmoinesian strata, Burning Star No. 4 Mine.

STOP 16. Reclamation practices, Captain Mine, Southwestern Illinois Coal Company.

End of field trip.

DAY 4 Cave in Rock, Illinois, to Carbondale, Illinois.

Trip leaders: James E. Palmer and C. Brian Trask, Illinois State Geological Survey.

Wednesday, May 30, 1979

STOP 1. **Hicks Dome and the Illinois-Kentucky Fluorspar District.**

STOP 2A. **Garden of the Gods Access Road (optional stop).**

STOP 2B. **Garden of the Gods Recreation Area; overview of Eagle Valley Syncline; structural history of the Illinois Basin; depositional environments of the Caseyville Formation.**

STOP 3. **Pounds Hollow Recreation Area (lunch stop).**

STOP 4. **Channel and sheet phases of the Anvil Rock Sandstone Member—Eagle Surface Mine.**

STOP 5. **Shawneetown Fault Zone, north limb of Eagle Valley Syncline.**

STOP 6. **Will Scarlet Mine, Peabody Coal Company (optional stop).**

Overnight stop, Holiday Inn, Carbondale.

Welcome to Illinois!

Mileage

0.0 Assemble field trip vehicles in large parking lot immediately to right (east) of ferry landing. Proceed north on Illinois Route 1. See figure IL-1 for a map of today's route.

The portion of Illinois covered in the field trip figured prominently in the early history of the state. Illinois was admitted to the Union on December 3, 1818. Previously, it had been part of the Northwest Territory, a county of Virginia, Indiana Territory, and the Illinois Territory. Its name is derived from a confederacy of Indian tribes, the Ininiwek, meaning "the men" or "superior men." This was modified to Iliniwek and then to Illinois by the French. The confederacy included six tribes—Cahokia, Kaskaskia, Michigamea, Moingwena, Peoria, and Tamaroa. Four Illinois cities, including the original state capital (Kaskaskia), derived their names from these tribes. Several other place names in Illinois reflect the influence of early French explorers: St. Libory, Beaucoup Creek, Prairie du Rocher, Carondolet, Prairie du Lang Creek. French explorers traveled into the region from their Canadian settlements. At the close of the French and Indian War, France surrendered the area to Great Britain in 1763. The area was ceded to the United States of America in 1784 following the Revolutionary War.

Early settlers came from the eastern seaboard and nearby states of Kentucky and Tennessee to the fertile land of southern Illinois. Germans, English, Irish, and Colonial Americans traveled down the Ohio River and entered the Illinois frontier through Shawneetown, bringing many of their eastern names with them.

0.1 Enter village of Cave in Rock, Illinois. Turn right (east). Note several rock and mineral shops. The Illinois-Kentucky Fluorspar District has yielded some of the largest and most perfectly developed crystals of the mineral fluorite found anywhere in the world.

Cave in Rock, Illinois, was settled late in the 18th century as a pioneer river settlement and ferry crossing. Its name is derived from the cave located about 0.3 mile (0.5 km) upstream (east) of this location.

This area of Illinois is referred to as "Egypt" or locally "Little Egypt." This name may have been given because of the names of southern Illinois towns (Cairo, Karnak, Thebes, Dongola). A second possible explanation lies in an account of late spring and early fall frosts to the north, which shortened the growing season and forced people to come south for corn and wheat. Farmers driving the wagons said they were "going down to Egypt for corn," as did the biblical sons of Jacob.

0.2 T-intersection. Turn right (south) toward Ohio River.

0.3 Entrance to Cave-in-Rock State Park. Numerous outcrops of St. Louis Limestone of the Valmeyeran Series (middle Mississippian) occur at park entrance and throughout park. Rock strata in the park dip about 3° NE.

This park was established in 1929 and is one of many within the Illinois state park system. Trees within the park include catalpa, locust, shag hickory, oak, ash, sycamore, cypress, sugar maple, and elm. Abundant karst topography has developed on limestone strata at and near Cave in Rock. Soil here is partly loess derived.

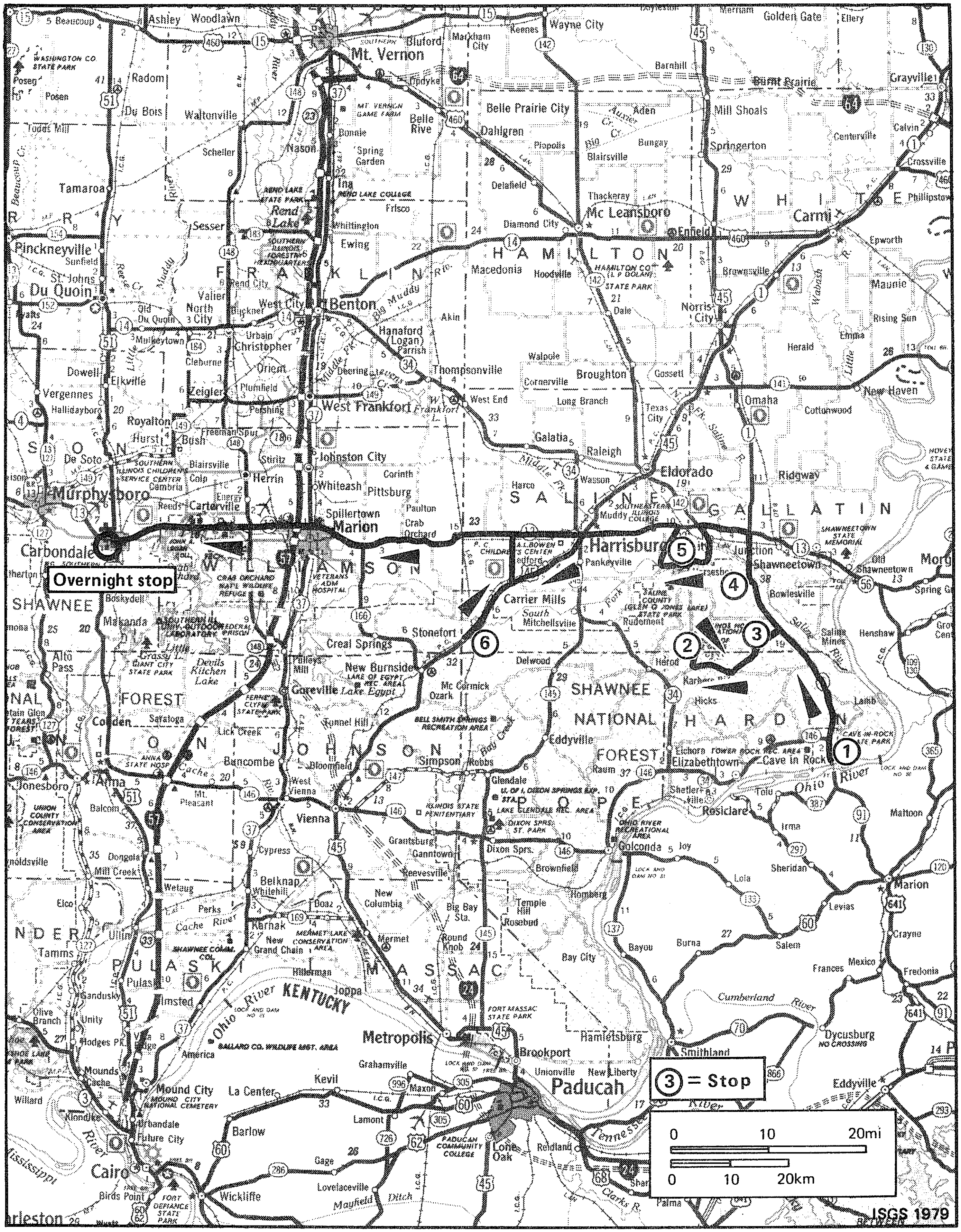


Figure IL-1. Field trip route for Illinois, Day 4, from Cave-in-Rock ferry to Carbondale, Illinois.

Would you know the thrilling stories,
Know the deeds of bold adventurers,
Deeds of bloody river pirates,
Deeds of skulking bluff-cave bandits?

From "Ballads from the Bluffs"
by Elihu Nicholas Hall (1948)

Cave in Rock (fig. IL-2) has a colorful history. Its position, accessibility, and ease of defense made this small but picturesque limestone cavern ideally suited for a succession of illicit enterprises. First described by the French early in the 18th century, "Caverne dans le Roc" became a headquarters for outlaw gangs and river pirates after the Revolutionary War. From the cave, these gangs preyed on riverboats moving down the Ohio River mainly toward New Orleans. It harbored such "establishments" as Samuel Mason's "Wilson's Liquor Vault and House of Entertainment." A gang of counterfeiters occupied the cave until 1831. After the pirate gangs were removed from the riverfront, the cave served as shelter for westward-bound pioneers and, during the mid 19th century, as a storage place for potatoes awaiting transport downriver.

0.9 Turn right (south). Park concession stand on left.

Small hills just beyond concession stand are Indian burial mounds, probably of the Shawnee Indians who lived in this region. The community of Old Shawneetown, located about 20 miles (32 km) farther north on the Ohio River, first developed in 1810 as a Shawnee Indian trading post. It prospered during the period of immigration by settlers from the east and contained the first bank in Illinois territory. This bank has the distinction of having turned down an application for a loan from a fledgling settlement on Lake Michigan on the grounds that it was too remote from Shawneetown to amount to anything. That settlement was Chicago.

Shawneetown is one of several place names in southern Illinois derived from the Shawnee Indians. Shawnee means south. The Shawnees lived in the southern part of the United States and moved to Pennsylvania and Ohio during the 18th century. In 1745, driven from their eastern homes by the powerful Iroquois, they migrated to southern Illinois, where they stayed for less than twenty years. A Shawnee Indian village stood at or near the site of Old Shawneetown.

1.1 Disembark buses and assemble in parking area.

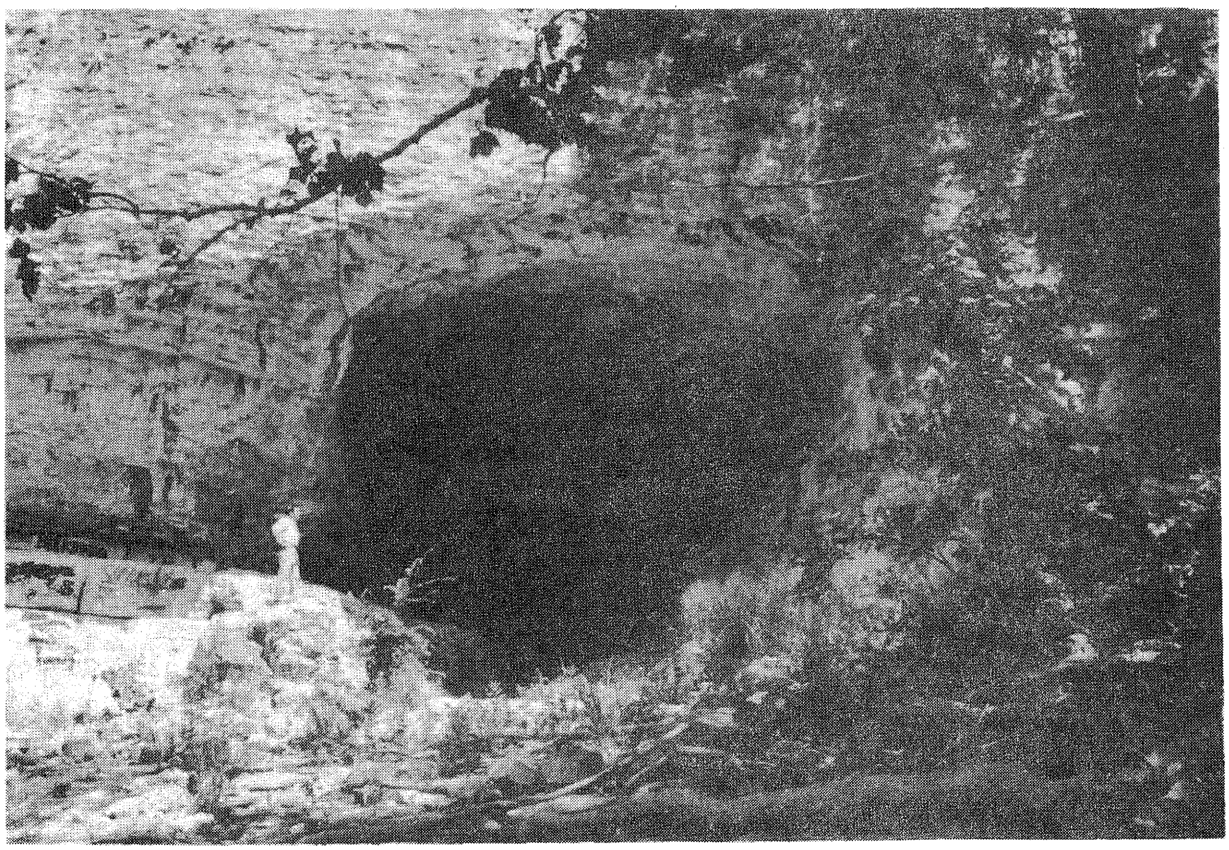


Figure IL-2. Entrance to Cave in Rock, Cave-in-Rock State Park. Cave opens in St. Louis Limestone cliff about 70 feet (21 m) from Ohio River at normal pool level. It extends into cliff for 150 feet (46 m) and is from 25 to 30 feet (7 to 9 m) wide and about 15 to 20 feet (4.5 to 6 m) high throughout most of its length. The rear part of the cave is connected to the surface through a sinkhole which at the surface is surrounded by a rock wall and covered by a screen.

STOP 1 Hicks Dome and the Illinois-Kentucky Fluorspar District.

Leaders: James W. Baxter, Illinois State Geological Survey; and Stanley E. Harris, Jr., Southern Illinois University at Carbondale.

The Illinois-Kentucky Fluorspar District is in a complexly faulted area located between one of the deeper portions of the Illinois Basin to the north and the Mississippi Embayment to the southwest. The Ozark Uplift lies to the west, the Nashville Dome and Cincinnati Arch to the southeast and east, respectively. The district lies astride a broad northwesterly-trending domal anticline (Heyl et al., 1965). The anticline is transected by the Rock Creek Graben, which extends northeastward through a sag between the anticline's two apices; it is truncated on the northwest by the Dixon Springs Graben. Each graben is bounded on the northwest by a major fault or fault zone showing evidence of high-angle reverse movement. In some areas the southeast sides of the major grabens are marked by a series of step-like faults that accumulate downthrow to the northwest. Where unaffected by faulting, the sedimentary rocks dip to the northeast and north into the Eagle Valley Syncline then rise along the Shawneetown Fault Zone located farther to the north.

The structural configuration of the district seems to have begun with warping and igneous activity coincident with the Appalachian Revolution in Permian time. Major faulting appears also to have begun about this time and may have continued into the Mesozoic. By Gulfian (late Cretaceous) time, when warping occurred again, major fault movements and the structural details of the mineralized district seem to have been largely completed.

Igneous activity during the Permian (Zartman et al., 1967) presumably uplifted the low, northwest-trending anticline and injected periodite and lamprophyre dikes into trending fractures. An explosive phase of igneous activity uplifted Hicks Dome approximately 4,000 feet (1,200 m) and produced isolated intrusions of breccia throughout the Illinois portion of the fluorspar district. The latter apparently followed the dike intrusion, at least in part. Fragments of ultramafic rock in intrusive breccia indicate that dike intrusion preceded brecciation at two localities and possibly at others.

Evidence of igneous activity at Hicks Dome includes numerous bodies of intrusive breccia and one lamprophyre dike. Most of the breccias are of local derivation, consisting of silicified fragments of the immediately enclosing host rock in a matrix of finely comminuted rock and microcrystalline quartz. They are believed to be "burst breccias," caused by the rapid dilation of fractures by gaseous explosions. A few of the breccia bodies are of deep-seated origin and consist of igneous rock and mineral fragments, plus varying amounts of sedimentary rocks, in a carbonate matrix (calcite, dolomite, siderite). These are believed to be "carbonatitic breccias," formed by the upward streaming of CO_2-rich gases emanating from an alkalic magma.

Mineralization at Hicks Dome is largely confined to breccias of the central area underlain by Devonian limestone and the immediately surrounding belt of the overlying New Albany Shale Group. Fluorite and barite are the most common epigenetic minerals, and an abandoned fluorite mine is located on the east flank of the dome at the edge of the central area. Other minerals in the breccias include sphalerite and galena in minor amounts, monazite and florencite (identified in one body), and the beryllium silicate, bertrandite, identified in a central area breccia and in a breccia dike in the New Albany Shale. In addition, chemical analyses have revealed above-normal amounts of Nb in one of the central area breccias.

Fluorspar deposits of three major types occur in the mining district: (1) bedded or "blanket" deposits formed primarily by selective replacement of limestone beds, (2) fissure-filling or vein deposits along faults, and (3) residual or "gravel spar" derived by weathering of either primary type.

Vein deposits

The primary controlling factor determining the location and extent of mineralization of vein deposits was faulting. Major deposits have been found in northeast-trending faults of moderate displacement (25 to 500 feet, 7 to 152 m).

Bedding-replacement deposits

The bedding-replacement deposits are located near and on the southeast side of a major northeast-trending structural element, the Rock Creek Graben. The deposits follow the course of a group of fractures and minor faults that trend N 45° E to N 60° E and N 30° W to N 85° W. The widest and most persistent ore bodies follow the northeast-southwest trends, parallel to the graben. The restriction of bedded replacement deposits to certain stratigraphic levels indicates that some beds were particularly favorable sites for replacement processes.

From direct stratigraphic evidence, the ore deposits are post-Pennsylvanian in age, predate erosional cycles that truncate the veins, and are capped by the Mounds Gravel of Pliocene-Pleistocene age (Willman and Frye, 1970).

1.1 Board buses and proceed west on park road.

1.2 T-intersection with park access road at stop sign. Turn left (west) to return to village of Cave in Rock.

1.4 T-intersection with Illinois Route 1 at stop sign. Turn right (north) on Illinois Route 1.

1.9 Cemetery on right.

The large closed depressions on both sides of the road are solution sink holes developed in the St. Louis Limestone of the Valmeyeran Series (middle Mississippian). Karst topography is common wherever the St. Louis Limestone lies at the surface in the midwestern United States. Mammoth Cave National Park in western Kentucky is one spectacular example of such solution phenomena.

2.3 Several small exposures of the St. Louis Limestone are present along the west (left) side of the road. The limestone is weathered by solution, leaving a thick dark-red residual clay called "terra rosa." The soil derived from this clay is one of the most common types in the Illinois-Kentucky Fluorspar District, and is low to medium in agricultural productivity. The St. Louis Limestone as exposed here is medium to dark gray, fine to medium crystalline; contains abundant chert nodules and minute veinlets of fluorite; and is very fossiliferous. Fossils include bryozoans, brachiopods, gastropods, crinoids, and colonial rugose corals (*Lithostrotion* sp. abundant). A bed of hard chert present in the St. Louis Limestone is used as a reliable marker by drillers in the Illinois Basin. In the past, many oil test holes were terminated at this horizon because petroleum-bearing rocks are much less common in lower stratigraphic units.

3.1 Country road to the right leads to the Rigsby and Barnard Quarry, from which crushed stone of Ste. Genevieve Limestone is produced; the Ste. Genevieve Limestone forms the high escarpment visible to the right of the road. The bulk of the production from this quarry is used for construction aggregate and agricultural limestone. The limestone is about 150 feet (46 m) thick; most beds are oolitic and very fossiliferous. The Genevievian index fossil *Platycrinus penicillus* is abundant. Other fauna are similar to those found in the underlying St. Louis Limestone, discussed previously. The Ste. Genevieve is generally a high calcium ($CaCO_3 > 90\%$) limestone in this and surrounding regions. It was deposited in an open, shallow marine environment. This limestone is overlain by the Chesterian Series (upper Mississippian), an alternating sequence of deltaic sandstones, marine limestones, and shales, which were deposited in and near deltas of the ancient Michigan River System. These deltas repeatedly advanced into shallow epicontinental seas during late Mississippian time (Swann, 1963). The Chesterian Series is about 1,000 feet (305 m) thick and has yielded more than 60 percent of the petroleum produced to date in the Illinois Basin. Formations of the Chesterian Series will be visible in roadcuts for the next 4 miles.

3.6 Cross contact between Ste. Genevieve Limestone and Aux Vases Sandstone. The Aux Vases Sandstone here is light to medium gray and brown, generally medium grained; grains are well rounded and well sorted; units are thick to thin bedded and flaggy; ripple marks are locally abundant. Casts of *Lepidodendron* sp. and *Calamites* sp. are present locally. Sandstone is calcareous in the lower part near the contact.

4.1 Crest of hill, capped by Bethel Sandstone, Chesterian Series.

4.9 Cypress Sandstone, Chesterian Series, crops out along highway on right for a distance of about 100 feet (30 m). It dips northeastward at about three degrees. The Cypress Sandstone is light orange-brown, thin and irregularly bedded at this outcrop. This porous and permeable sandstone has yielded almost one-fourth of all petroleum produced in Illinois (1.5 billion barrels or 0.2 million metric tons) where it is present in the subsurface in central Illinois.

5.4 Bridge over Sheridan Branch. Stream alluvium covers the concealed contact between the Cypress Sandstone and the overlying Golconda Group.

5.6 Large roadcut. Conformable contact between upper sandstone (6 ft, 1.8 m) and lower siltstone (7 ft, 2.1 m) units of Hardinsburg Formation (fig. IL-3). The lower unit consists of siltstone, orange-brown, limonitic, ripple marked; siltstone weathers to small flakes and platelets, many of which display sole marks. Shallow water deposition is indicated. The overlying sandstone is orange-brown, medium grained; grains generally well rounded and well sorted, thin to medium bedded; locally contains channel-fill structures. Dip is about 8° NE. The Hardinsburg Sandstone is a prolific producer of natural gas in western Kentucky.

5.8 Shewmaker School (left).

6.2 Tar Springs Sandstone, Chesterian Series (small outcrop in roadcut).

6.5 Shaly facies of the Tar Springs Sandstone; mostly shale with many siltstone platelets.

7.1 Crossroads by "76" sign. Continue straight.

The Minerva No. 1 Mine of Allied Chemical Company is located about 0.75 mile (1.2 km) southeast (right). Fluorite, along with some galena and sphalerite, occurs as bedding replacement ore at a depth of about 1,000 feet (305 m). The deposits follow the course of a group of fractures and minor faults that trend N 45° E to N 60° E and N 39° W to N 85° W. The widest and most persistent ore bodies follow northeast-southwest fractures that parallel the Rock Creek Graben, which lies about one mile (1.6 km) northwest. Host rock for the major ore horizon is the Downeys Bluff Limestone of the Chesterian Series (upper Mississippian).

7.3 Bridge over tributary creek to Rock Creek.

7.6 Cross Peters Creek Faults, enter Rock Creek Graben.

At this point, the field trip route crosses from the Menard Limestone (upper Mississippian) to the Caseyville Sandstone (lower Pennsylvanian). Vertical displacement is about 500 feet (152 m), downthrown to the north. Prominently slickensided sandstone is present in a small outcrop at left side of road. The Rock Creek Graben, about 2 miles (3.2 km) wide here, is the easternmost of the two major down-dropped blocks that transect the Illinois fluorspar district. In this area the graben trends approximately N 55° E and is bounded on the northeast by the Hogthief Creek and Goose Creek Faults, and on the southeast by the Peters Creek Faults or by step-fault branches of the Peters Creek Faults.

7.7 Bridge over tributary creek to Rock Creek. Mt. Zion Church ahead on left.

8.8 Abbott Formation (middle Pennsylvanian). Ten feet (3 m) of dark orange-brown sandstone, overlain by about 10 feet (3 m) of dark gray to black shale and siltstone. A small fault ($<$ 5 feet [1.5 m] vertical displacement, downthrown to north) is visible here (fig. IL-4). Horizontal slickensides occur in small stream to right (east) of this exposure. The faulting appears to be compressional in origin, and evidently occurred when the Rock Creek Graben was formed.

9.7 Sharp, wide curve to left (northwest). Goose Creek Fault. Vertical displacement about 500 feet (152 m), downthrown to the south. Slickensided fault surface (sandstone) is exposed by natural erosion about 150 feet (46 m) west of the highway. Exposed interval in large roadcut is mainly shale (fig. IL-5) with numerous channel-fill sandstones (figs. IL-6, 7, and 8). Two thin coals are present in the upper part. Coals of the Caseyville Formation are generally very thin and lenticular, and are less common than those in overlying strata. Field trip route here crosses from the Abbott Formation to middle part of the Caseyville Formation. Total section exposed is about 140 feet (43 m), extending from just above the Battery Rock Sandstone Member to the Pounds Sandstone Member.

Two coals and associated strata in the upper part of this highway cut provide the first opportunity to observe cyclic sedimentation in Illinois. The lower coal, about 8 inches (20 cm) thick, is underlain by 1.4 feet (0.4 m) of medium gray, noncalcareous underclay which lies directly on a cross-bedded channel-fill sandstone. A medium gray clay-shale about 4 feet (1.2 m) thick overlies the coal; this clay-shale grades upward into light gray underclay upon which the upper coal, about 9.5 inches (24 cm) thick, was deposited. Apparently two successive coal swamps occupied the area, separated only by clay-shale which may have been deposited as lake-bottom sediments. The upper coal is overlain by medium to dark gray, partly brittle, carbonaceous shale that grades upward into light-brown, sandy shale which contains interbeds of sandstone in its upper part. The carbonaceous shale contains both fine clastic and

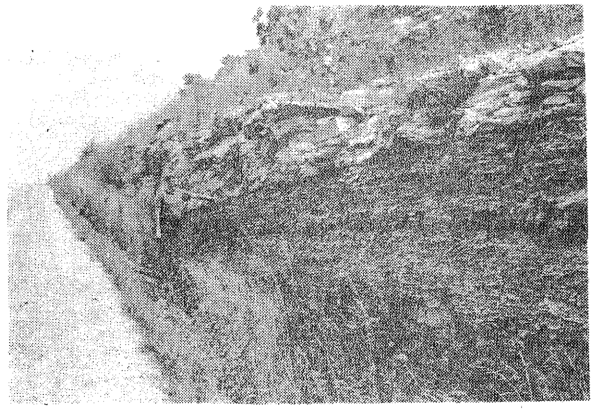
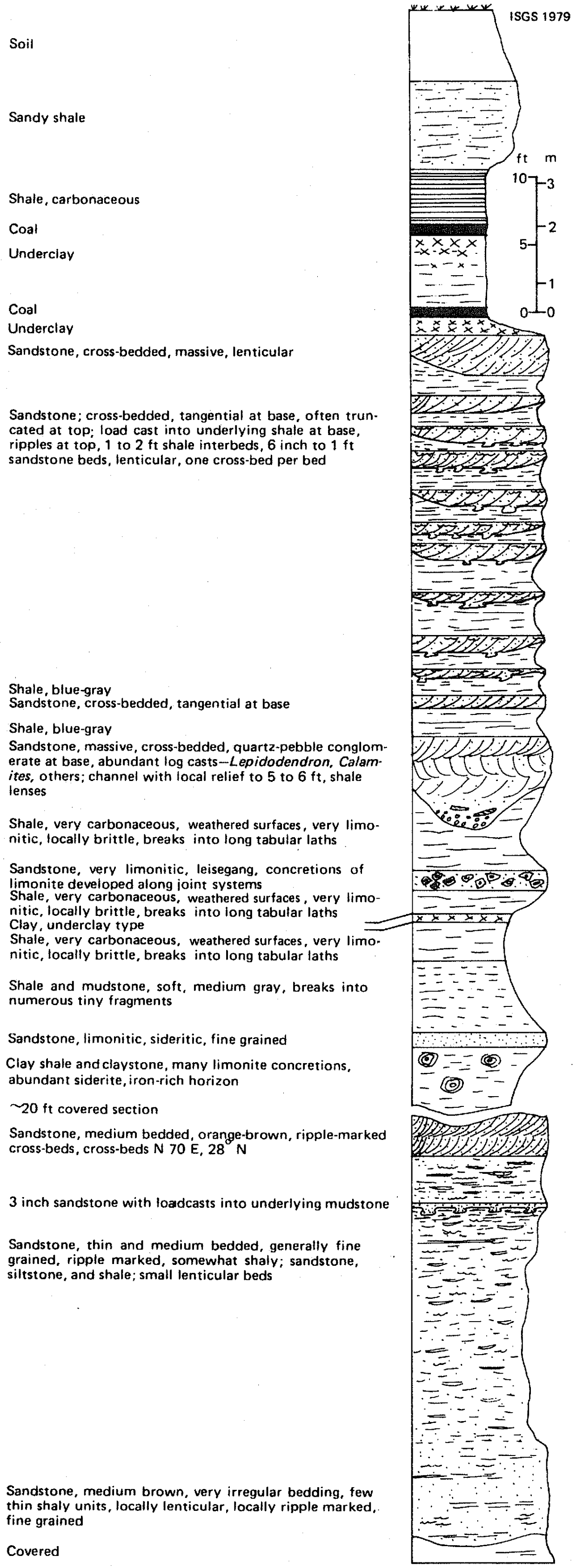


Figure IL-3. Siltstone and sandstone of the Hardinsburg Formation. The lower unit is a limonitic, ripple-marked siltstone. The upper unit is a medium-grained, well-sorted sandstone with local lenticular (channel-fill) beds.

Figure IL-4. Flexures associated with small fault in shale of the Abbott Formation at mileage 8.8. Right (north) side is downthrown about 2 feet (0.6 m). (Scale: one foot and one inch units.)

organic matter and apparently was deposited immediately after the coal swamp became inactive. Subsequently the site was buried by sand and clay which appear to be overbank deposits from nearby streams.

The relatively complex succession of cyclic strata classically referred to as an "ideal or complete cyclothem" (Willman and Payne,



1942) (fig. IL-9) is not typical for the Caseyville Formation. Most notably absent are marine limestones and shales; this absence is apparently due to the predominance of nonmarine fluvial processes in deposition of the Caseyville Formation. The coals of the Caseyville Formation were evidently deposited in relatively small, local swamps or marshes that occurred on a broad plain crossed by meandering streams. The marine environment appears to have been somewhat distant to the south and west during most of Caseyville time. However, at least one limited marine transgression did occur in this area, as evidenced by the local occurrence of the marine Sellers Limestone Member in the upper part of the Caseyville Formation (Fraunfelter, this Guidebook, part 2, p. 73-75).

In younger formations of the Pennsylvanian System, beginning near the base of the Spoon Formation, the marine influence becomes more evident with the occurrence of regionally extensive marine limestones, shales, and coals. Regionally uniform depositional processes are evident in the Carbondale Formation (middle Pennsylvanian), which contains coals and marine strata that underlie essentially the full extent of the Illinois Basin. These remarkably uniform depositional conditions produced distinctive, relatively uniform sequences of strata that are known as "cyclothems."

10.7 Gradational contact between Caseyville and Abbott Formations (concealed). Scattered highway outcrops for the next 6 miles are in the Abbott Formation.

11.3 Enter Gallatin County. Established in 1812; named for Swiss-born Albert Gallatin, U.S. Secretary of the Treasury from 1801 to 1814.

13.8 Broad area of reclamation to right and front (north and northwest). The Davis and De Koven Coals (Spoon Formation) have been mined from the reclaimed area at right. The Harrisburg (No. 5) and Herrin (No. 6) Coals (Carbondale Formation) have been mined in the area to the front. These coals dip north and northeast at about 10° into the Eagle Valley Syncline.

14.0 County Road 13 to Karbers Ridge on left. Turn left (southwest). Pounds Motel on right. Field trip route extends southwestward along

Figure IL-5. ← Columnar section of Pounds Sandstone Member and underlying siltstone-shale succession of Caseyville Formation exposed along Illinois Route 1 in northern Hardin County, Illinois. At least three cycles of sedimentation are exposed in this roadcut. The lower cyclic unit is predominantly a siltstone-shale sequence with development of an underclay but no coal. The middle cyclic unit is predominantly sandstone sequence with a disconformable lower boundary and a coal and underclay developed above the topmost (leached) sandstone. The top unit has only shale and underclay separating the coal from the coal of the underlying unit.

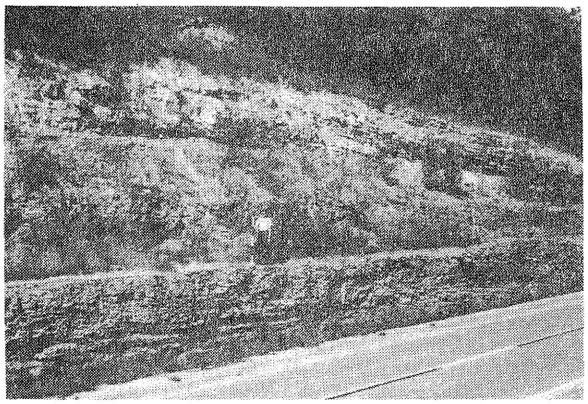


Figure IL-6. Sandstone and shale overlying the Battery Rock Sandstone Member of the Caseyville Formation at base of section at mileage 9.7. This exposure is located on the northwest side of the Evansville Valley (Bristol and Howard, 1971), a large paleovalley at the Mississippian-Pennsylvanian unconformity cut down to the Menard Formation (upper Mississippian). A few lenticular beds of cross-bedded sandstone are scattered through this section of predominantly sandy shale and shaly sandstone (see fig. IL-7).

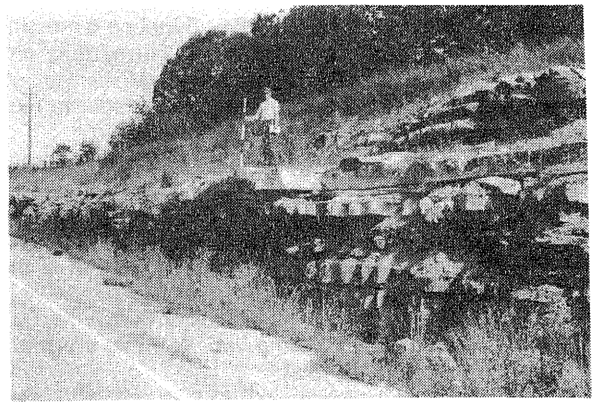


Figure IL-8. Pounds Sandstone Member of Caseyville Formation. Cross-bedded, lenticular sandstone units interbedded with shale. Each sandstone unit consists of one set of cross-beds, tangential at the base and truncated at the top. Commonly, there are ripple marks at the top of each sandstone unit, and the sandstone is load cast into underlying shale. Exposure is 80 feet (24 m) above base of section.

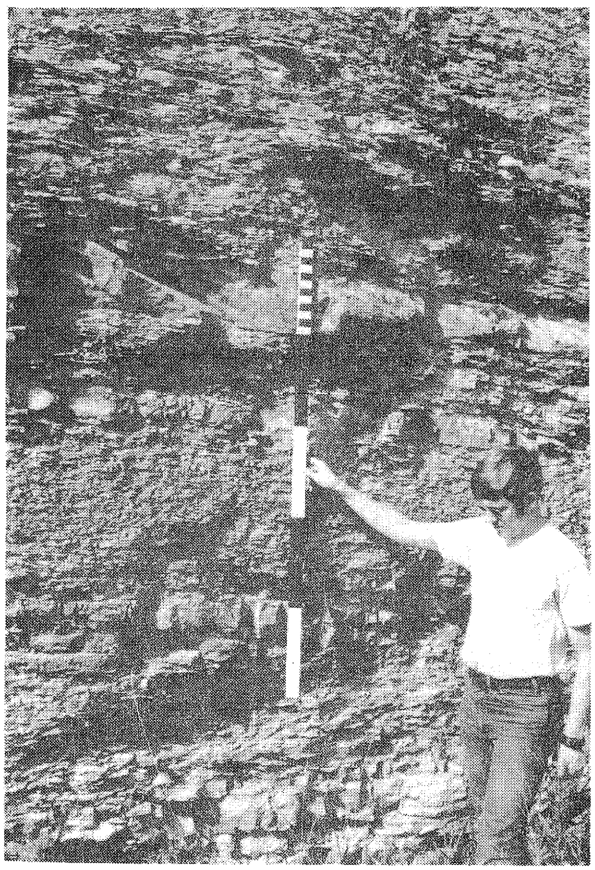


Figure IL-7. Several lenticular, cross-bedded sandstone units at the top of the sandstone and shale outcrop illustrated in figure IL-6. These units were probably deposited in channels during local influxes of sand or by winnowing of the underlying sandy mud to produce sand waves on a dominantly mud bottom. This exposure is 25 feet (7.6 m) above base of section. (Scale: one foot and one inch units.)

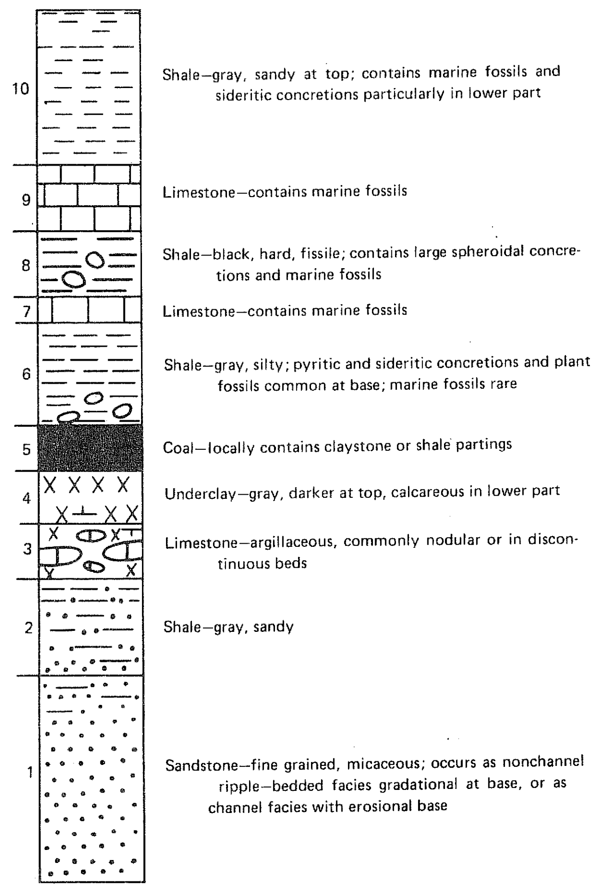


Figure IL-9. Arrangement of lithologic units in a cyclothem. (After Willman and Payne, 1942.)

south rim of Eagle Valley Syncline traversing the Abbott and Caseyville Formations and Chesterian Series strata (upper Mississippian). The strike of these units is subparallel to field trip route.

14.5 Enter Shawnee National Forest. Evergreen forest on both sides of road.

16.1 Entrance to Pounds Hollow Recreation Area on right. Continue straight. Trip will return here for lunch following stop at Garden of the Gods Recreation Area.

16.6 Contact between Abbott and Caseyville Formations; Pounds Sandstone Member crops out at right side of road.

17.1 Concealed scissors fault, about 100 feet (30 m) northwest (right), parallels road here. Downthrown to northwest.

17.2 Road on right to Indian Wall and Rim Rock Trail. Continue straight.

17.9 Crest of Caseyville escarpment. Elevation is about 700 feet (213 m) above sea level. This area is typical of high escarpments formed on the Caseyville Formation at the southern margin of the Illinois Basin.

18.0 Country store on left; elevation 735 feet (224 m) above sea level. Lowlands to south formed on Mississippian strata. Route descends here from Caseyville strata southwestward across upper units of Chesterian Series.

18.7 Russel Cemetery on right. Concealed scissors fault of mileage 17.1 trends northeastward, underlies area of cemetery. Vertical displacement is about 50 feet (15 m), downthrown to northwest.

19.4 Tar Springs Sandstone exposed on both sides of a fault zone. Scissors fault of mileages 17.1 and 18.7; vertical displacement about 50 feet (15 m) downthrown southeast.

20.2 Karbers Ridge School. Hardinsburg Sandstone crops out on right. View of Caseyville escarpment to right (north).

20.4 Dogwood Campground and Gift Shop on left. Large valley south of road is eroded in soft shale of the Golconda Group.

21.0 United States Post Office, Karbers Ridge, left.

Karbers Ridge, a thriving community at the time of the American Civil War (1862-1865), supported four general stores, a blacksmith shop, funeral parlor, feed mill, and two churches.

Hardin County and this region of southern Illinois was much more densely populated about 100 years ago than at present. Early settlers, equipped only with wooden plows, were unable to break the thick prairie sod farther north in Illinois and chose this rocky, but more easily cultivated soil. As cultivation of rich, glacially-derived soil to the north developed through introduction of the steel plowshare, this land became subeconomic and was abandoned.

21.1 Road intersection; continue straight. High Knob to right (north). Roadbed here is on Hardinsburg Sandstone; deeper valleys on route reach the underlying Golconda Group.

22.6 Prominent escarpment on the right (north) formed by Caseyville Sandstone along south limb of Eagle Valley Syncline.

22.9 Turn right (north) toward Garden of the Gods Recreation Area. Field trip route crosses formations of the upper part of the Chesterian Series. These units dip northward at about 7°. The northward-facing slopes observed adjacent to route here are dip slopes.

23.1 Tar Springs Sandstone caps hill. Caseyville Sandstone bluffs (Buzzard's Point) may be seen ahead.

23.4 Menard Limestone in valley of Rose Creek. Well exposed section at right past bridge. Limestone is bluish gray, generally finely crystalline, medium to thick bedded, very fossiliferous; fossils include *Archimedes* sp. (abundant), horn corals, crinoids, blastoids, pelecypods, and brachiopods.

Archimedes sp. is restricted to Mississippian and older rocks in the midcontinent of the United States. An interesting early use of the science of paleontology was made by David Dale Owen of the New Harmony Scientific Community; he advised farmers of the region that if the easily identified *Archimedes* sp. was present in rocks cropping out on a farm, no coal could be expected. While certain exceptions did occur due to other geological factors, this fossil was important in the early determination of the extent of coal-bearing strata in the midcontinent.

23.6 Palestine Sandstone on right. Ten feet (3 m) is exposed in roadcut; dip about 7° N.

23.8 Clore Formation (shale) is exposed in deep gully on right in front of house. The Caseyville Formation (Pennsylvanian) here directly overlies Clore (Mississippian). Two additional Chesterian (upper Mississippian) formations, Kinkaid Limestone and Degonia Sandstone, are absent due to erosion of the Inman Valley (Bristol and Howard, 1971) prior to deposition of the Pennsylvanian System.

24.0 Contact between Clore Formation (Mississippian) and Caseyville Formation (Pennsylvanian) concealed by slump blocks of the cliff-forming Battery Rock Sandstone Member. Basal Lusk Shale Member crops out on right in curve.

24.2 Garden of the Gods access road.

STOP 2A Garden of the Gods Access Road (optional stop).

Leaders: C. Brian Trask, Illinois State Geological Survey; and Lewis R. Morrow, Southern Illinois University at Carbondale.

The sub-Pennsylvanian unconformity in the Illinois Basin contains a linear drainage pattern of valleys eroded into the upper Mississippian Chesterian Series and older strata. These paleovalleys, which have cut as much as 450 feet (137 m) into Chesterian strata, trend generally southwesterly (Bristol and Howard, 1971; Potter and Desborough, 1965; Siever, 1951). The

Evansville Valley (Bristol and Howard, 1971, fig. 4) in southeastern Illinois (fig. IL-10) is incised as much as 250 feet (76 m) into Chesterian rocks (Potter and Desborough, 1965). The valley bottom is in the Menard Formation, and interstream divides are composed of the Kinkaid and Degonia Formations. Inman Valley to the west probably joined Evansville Valley (fig. IL-10) south of the present outcrop belt (Potter and Desborough, 1965). Inman Valley bifurcates at the outcrop to pass around an island or shoal of Degonia and Kinkaid Formations.

Inman Valley was eroded about 50 feet (15 m) into the Chesterian strata (fig. IL-11). The Lusk Shale Member at the base of the Caseyville Formation rests on the Clore Formation, the Degonia Formation, and the Negli Creek Member of the Kinkaid Limestone. Cross-bedding measurements taken by Potter and Desborough (1965) from the Lusk Shale Member indicate a transport direction to the southwest, parallel with the axis of the valley. This valley apparently had a minimal effect on transport direction of younger sediments of the Caseyville Formation. This is particularly true of transport direction in the Battery Rock Member (figs. IL-12 and 13).

The Lusk Shale exposed at this locality is an interbedded sequence of sandstone, siltstone, and shale (fig. IL-14). Locally, sandstone becomes dominant, forming

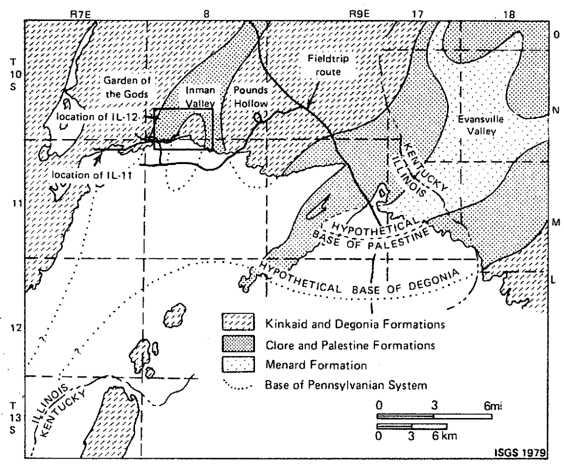


Figure IL-10. Simplified sub-Pennsylvanian geology north of Cave in Rock, Illinois, showing location of Evansville and Inman Valleys. (Modified from Potter and Desborough, 1965.)

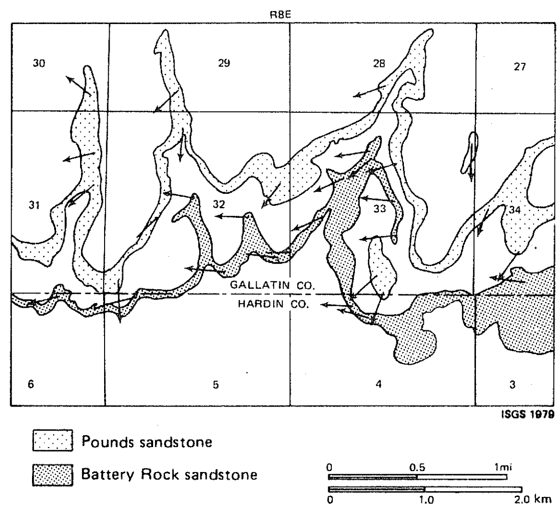


Figure IL-12 Cross-bedding directions in Battery Rock and Pounds Sandstones in a small area overlying Inman Valley in Gallatin and Hardin Counties, Illinois. Field trip route passes about 0.5 mile (0.8 km) south of the southern edge of this map. (Potter and Desborough, 1965.)

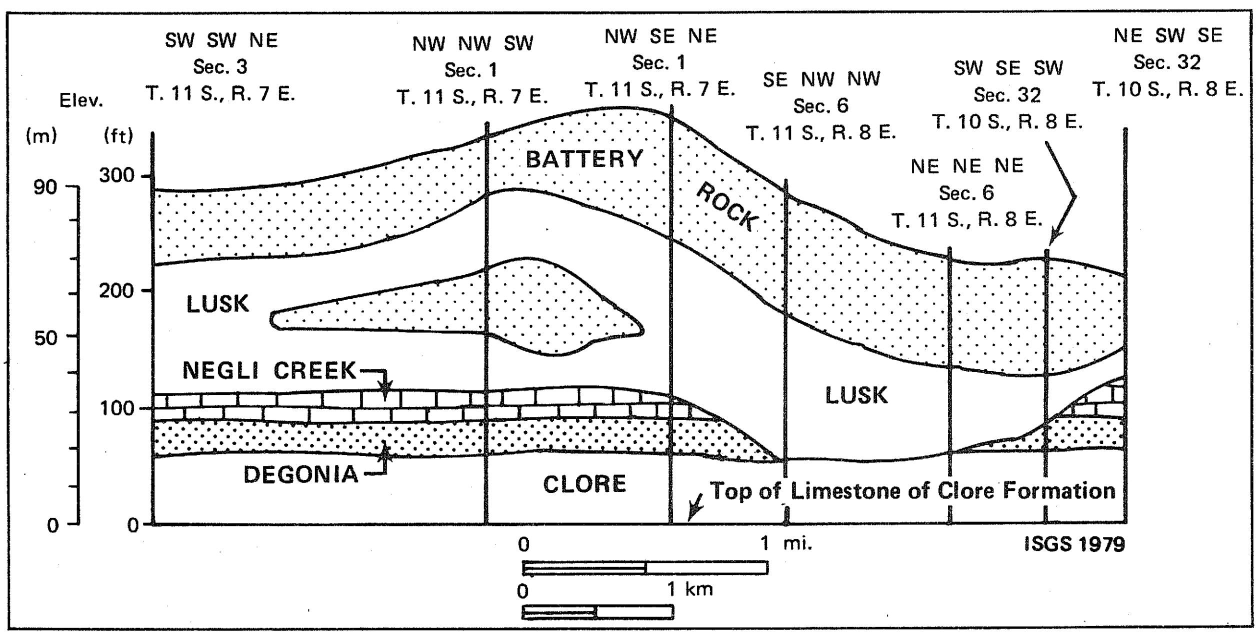


Figure IL-11. Cross section, based on outcrop mapping, of a part of Inman Valley adjacent to field trip route in portions of Pope, Hardin, and Gallatin Counties, Illinois. See figure IL-10 for location of cross section. (Potter and Desborough, 1965.)

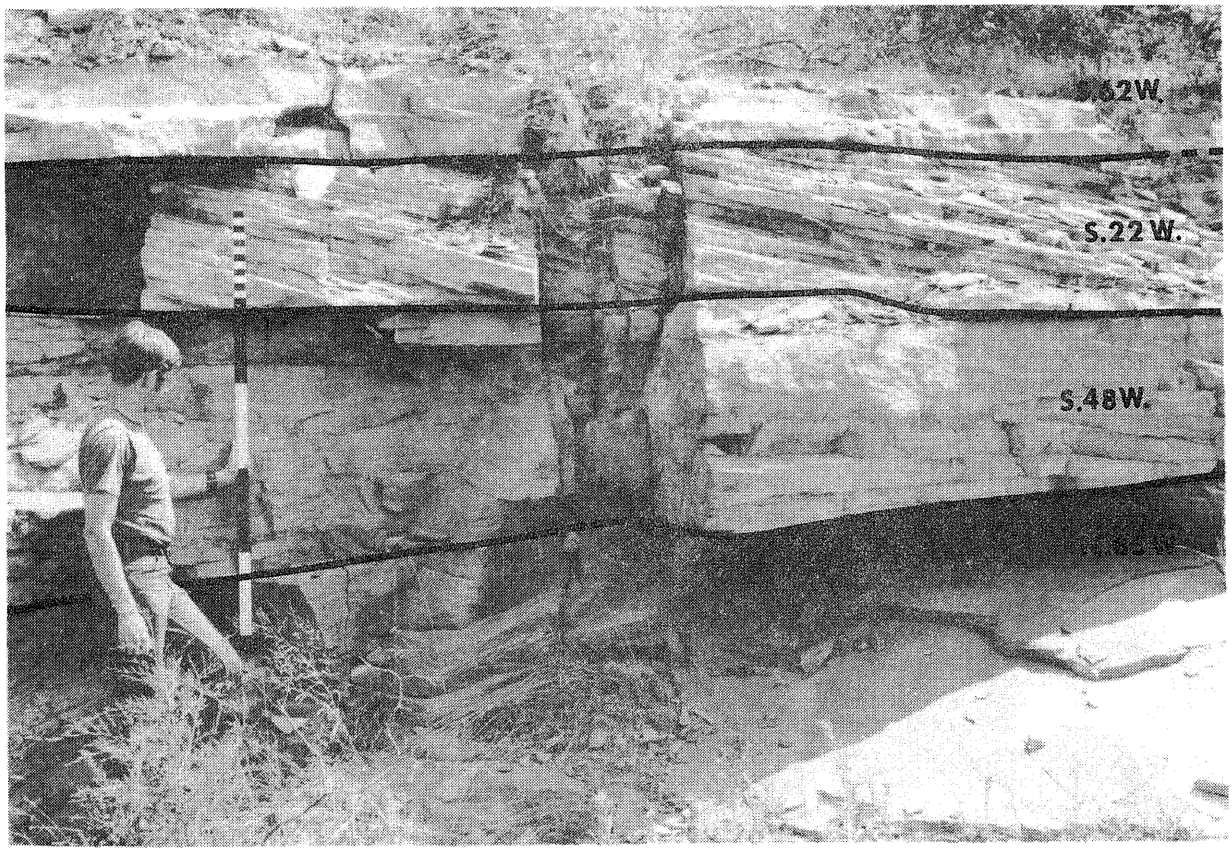


Figure IL-13. Extensively cross-bedded Battery Rock Sandstone Member of Caseyville Formation in interval about 90 feet (27 m) above base of exposed section along Garden of the Gods access road. Four tabular sets of planar cross-beds are shown. The direction of maximum dip (not corrected for structural dip) of the cross-beds is shown on the right margin. Deposition of the sandstone evidently was not influenced by the trend (south-southwest) of the underlying Inman Valley. (Scale: one foot and one inch units.)

lenticular beds and low bluffs. Ripple marks are abundant, particularly in the siltstone and shale. Approximately half of the interval is Lusk Shale.

The Battery Rock Sandstone is a prominent cliff-forming unit throughout southern Illinois. The lower 8 feet (2.4 m) of Battery Rock Sandstone in this exposure is a massive, coarse sandstone containing both trough and planar cross-bedding and many quartz pebbles, locally becoming conglomeratic. This unit grades upward into a cliff-forming, thickly bedded, medium-grained sandstone, somewhat cross-bedded at the base of and becoming extensively cross-bedded upward. Cross-bedding is dominantly planar, locally trough. White quartz pebbles are locally abundant. This grades up into thinly bedded and cross-bedded sandstone and ripple-marked shaly sandstone. This fining-upward sequence is typical of modern fluvial deposits.

24.2 Board buses, proceed west on Garden of the Gods access road. View of Eagle Valley Syncline on right (north).
24.9 Enter Garden of the Gods Recreation Area.
25.4 Bluffs of Pounds Sandstone Member (Caseyville Formation) adjacent to highway on right (fig. IL-15).
25.6 Gate to parking lot, Garden of the Gods Recreation Area.

STOP 2B Garden of the Gods Recreation Area; overview of Eagle Valley Syncline; structural history of the Illinois Basin; depositional environments of the Caseyville Formation.

Leaders: Thomas C. Buschbach, H.-F. Krausse, James E. Palmer, and C. Brian Trask, Illinois State Geological Survey; and Lewis R. Morrow, Southern Illinois University at Carbondale.

Garden of the Gods is located in rocks of the Pounds Sandstone Member of the Caseyville Formation, on the south limb of the Eagle Valley Syncline, and is one of the most scenic areas of Illinois (front cover). Long-continued erosion of the uplifted southern limb of the syncline has resulted in deeply dissected northward facing dip slopes (dip is about 10° N) and high ridges and knobs that consist of strongly weather-resistant sandstone. Sedimentary features of the Pounds Sandstone Member seen at Garden of the Gods include various types of cross-bedding, ripple marks, graded bedding, bimodal sorting of medium- to coarse-grained sandstone containing white quartz pebbles, and Liesegang banding.

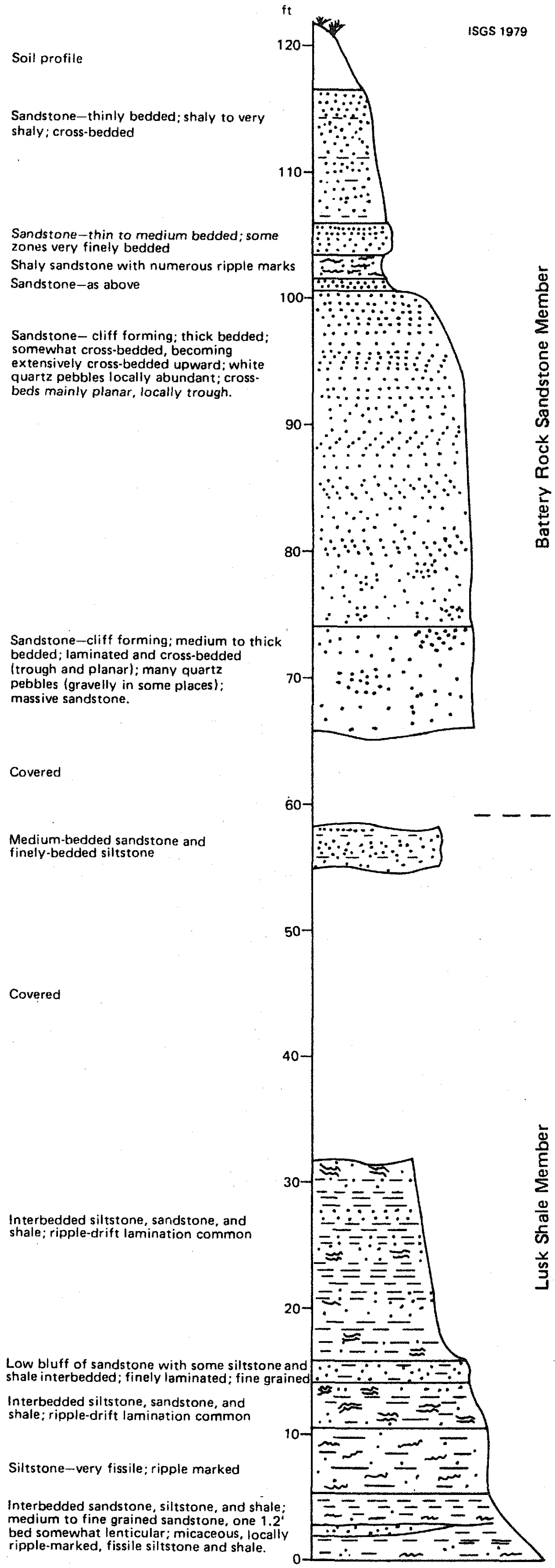


Figure IL-14. **Lusk Shale and Battery Rock Sandstone Members of Caseyville Formation exposed along east side of road into Eagle Valley near turnoff to Garden of the Gods Recreation Area.**

The unusual concentric and parallel Liesegang banding of iron oxide-rich layers or zones in sandstone which is so common on outcrops of the Caseyville Formation is exceptionally well displayed at Garden of the Gods (back cover). This banding is generally attributed to the so-called "Liesegang Phenomenon" in which a laminated or banded precipitate results when a fluid containing a salt is introduced into a colloidal suspension within a porous medium. Precipitation occurs at regular intervals during mixing of the fluid and the colloid when the dissolved salt reaches a supersaturated level.

From the high sandstone pinnacles of Garden of the Gods, the western part of Eagle Valley Syncline can be seen. Toward the northwest, areas of disturbed land are visible where the Harrisburg (No. 5) and the Herrin (No. 6) Coals (Carbondale Formation) and the Davis and De Koven Coals (Spoon Formation) were strip mined. The prominent high ridge visible north and northwest of Garden of the Gods is the north limb of the syncline.

Eagle Valley Syncline is a doubly plunging syncline about 24 miles (39 km) long and 8 miles (13 km) wide. Its axis strikes almost due east. The syncline is strongly asymmetric with a steeply dipping north limb (dip 25° to vertical) and a gently dipping south limb (dip 5° to 15°). The axial plane dips northward at about 60°. The structure is bounded on the north, east, and west by faults of large vertical displacement (500 to 3,500 feet, 152 to 1,067 m); high angle reverse faults occur along the northern margin. Only rocks of Pennsylvanian age crop out within the syncline, but steeply dipping Mississippian and Devonian strata are exposed in bordering faulted areas. The structure is apparently related in both age and origin to the Shawneetown Fault Zone and Hicks Dome.

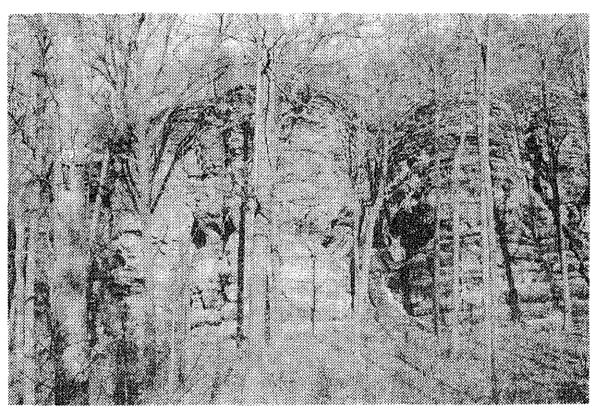


Figure IL-15. Pounds Sandstone Member of Caseyville Formation near Garden of the Gods Recreation Area. The Pounds Sandstone, like the Battery Rock Sandstone below, commonly forms cliffs and high bluffs in areas of outcrop.

25.8 Leave Stop 2B.
25.9 Intersection with access road. Turn right (south) down hill. Retrace route to County Road 13.
27.1 T-intersection at stop sign with road into Eagle Valley. Turn right (south) down hill.
28.5 T-intersection at stop sign with County Road 13. Turn left (east) toward Karbers Ridge and retrace route to Pounds Hollow turnoff.
30.1 Town of Karbers Ridge. Continue straight on County Road 13.
35.3 Turn left (north) toward Pounds Hollow Recreation Area.
35.6 Pounds Hollow Reservoir is down the hill to the right. The dam was built about 40 years ago by the U.S. Civilian Conservation Corps and impounds a 28-acre (11.3-hectare) lake.
35.8 Sandstone of the Abbott Formation exposed on left.
36.0 Parking lot, Pounds Hollow Recreation Area. Unload buses.

STOP 3. Pounds Hollow Recreation Area (lunch stop).

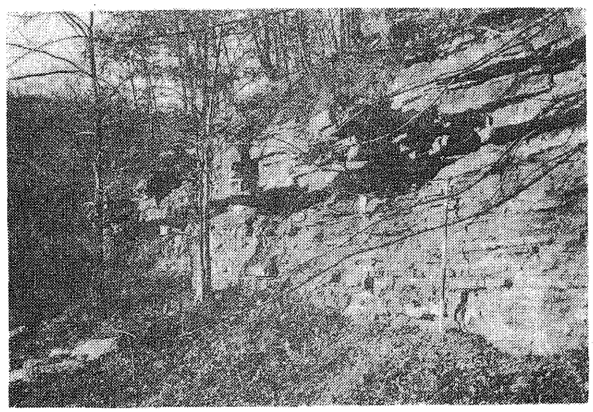
Leader: C. Brian Trask, Illinois State Geological Survey.

The hills to the south are underlain by rocks of the Caseyville Formation which dip northward at about 10° into Eagle Valley Syncline. The parking lot at Pounds Hollow is built on rocks of the Abbott Formation, which also underlie the hill on the north side of the parking lot (fig. IL-16).

The Abbott Formation represents a transition zone between clean quartz sandstones of the Caseyville Formation and the overlying argillaceous, micaceous sandstones of the Spoon and Carbondale Formations (Potter and Glass, 1958). This vertical change in petrographic character is illustrated in figure IL-17.

Sandstones of the Caseyville Formation consist primarily of quartz with secondary carbonate. Commonly these sandstones contain well-rounded quartz pebbles and locally are conglomeratic. Minor amounts of feldspar, matrix clay, and micaceous minerals are present. Quartz forms a mosaic of interlocked grains with common authigenic quartz overgrowths, except locally where carbonate is present as a cement. Dominant cement is silica derived by pressure solution of quartz grains, and abraded quartz overgrowths are locally present (Koeninger and Mansfield, this Guidebook, part 2, p. 76). Secondary carbonate is present as poikilitic grains of calcite enclosing several quartz grains and as scattered anhedral grains of siderite disseminated among the detrital grains. Where carbonate is abundant, quartz grains show extensive replacement by calcite. Dominant heavy minerals are the highly resistant species, zircon and tourmaline, with muscovite the dominant mica. Approximately 35 percent of the tourmaline is rounded (0.6 or greater on the Krumbein [1941] chart). Caseyville sandstones are typically medium to fine grained, mineralogically very mature and much better sorted than the overlying sandstones. Potter and Glass (1958) termed these sandstones "orthoquartzites." They have been called "quartz-rich arenites" by Koeninger and Mansfield (this Guidebook, part 2, p. 76).

The sandstones of the Abbott Formation compared to those in the underlying Caseyville contain more clay, feldspar, mica, and rock fragments. Coal, shale, and fragments of concretions are the dominant conglomeratic materials. Feldspar is present as both fresh and weathered microcline, orthoclase, and plagioclase. Cementing materials are siderite and calcite, and the grains are often held together by a detrital matrix of silt- and clay-sized quartz and clay minerals. Siderite is the dominant carbonate and is locally so abundant as to give the rocks a reddish, ferruginous appearance on



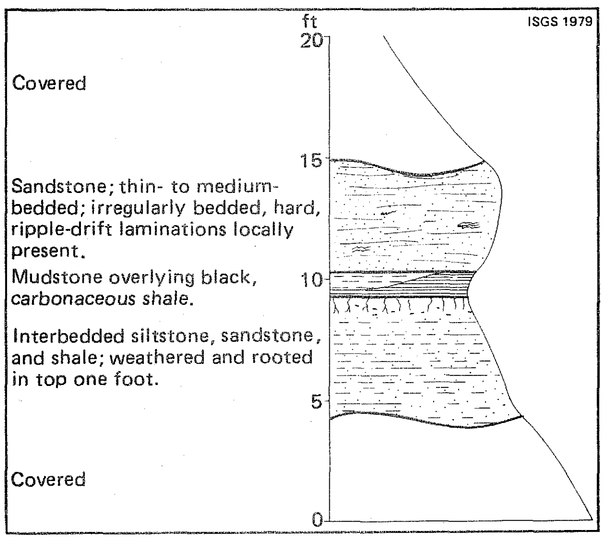


Figure IL-16. Abbott Formation, north side of parking lot, Pounds Hollow Recreation Area. The Abbott Formation is characterized by its more regular bedding (compared with the Caseyville Formation) and greater lateral continuity of individual beds. The lower part of this exposure consists of interbedded siltstone, sandstone, and shale overlain by 1 foot (0.3 m) of very soft mudstone and black carbonaceous shale. The upper contact of the siltstone is rooted and weathered.

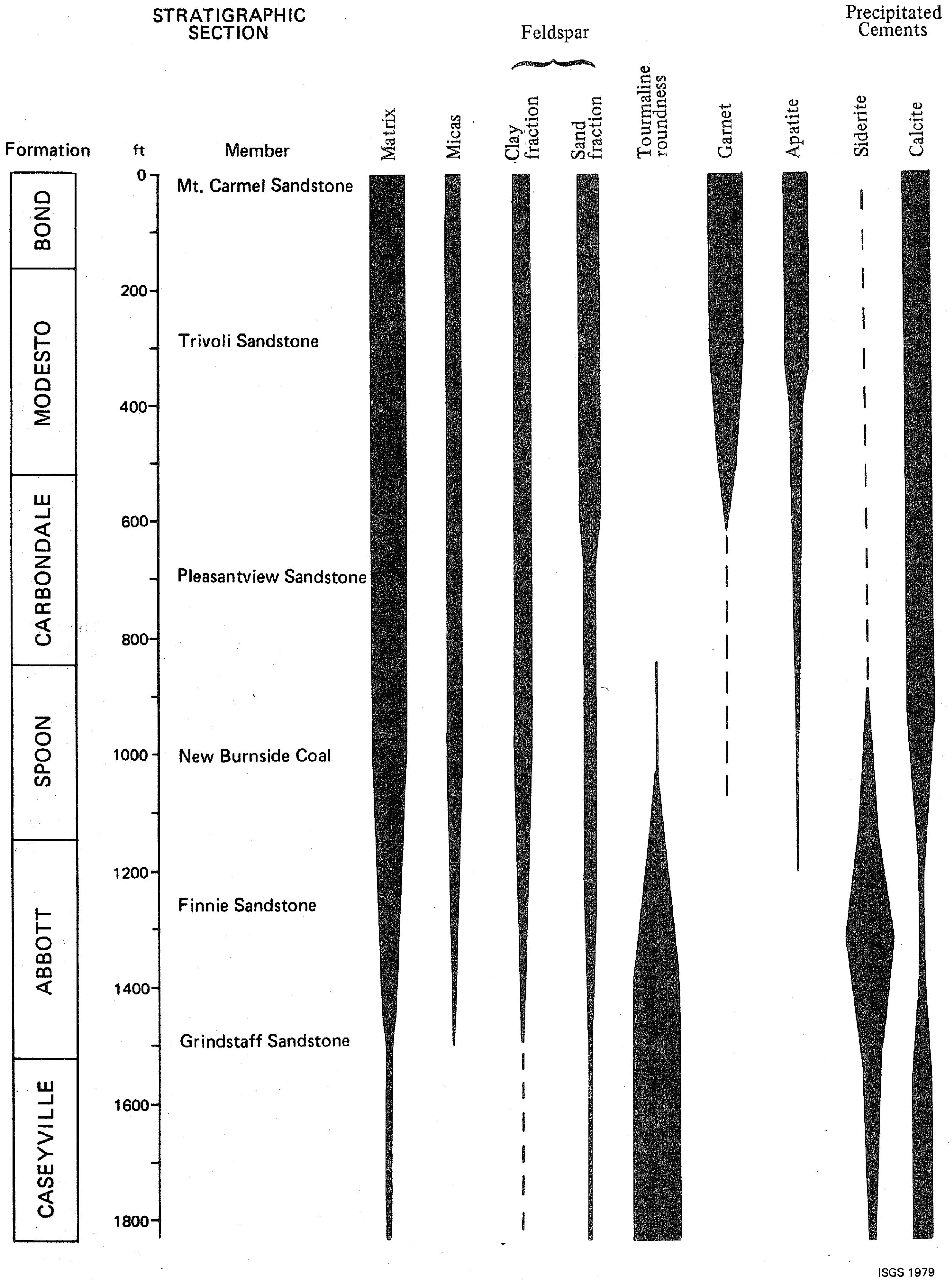


Figure IL-17. Diagrams summarizing vertical variation of sandstone properties in the Pennsylvanian System of southern Illinois. (Potter and Glass, 1958.)

weathering. Heavy minerals are stable zircon and tourmaline, with lesser amounts of less stable apatite. Only 15 percent of the tourmalines are rounded. These sandstones are medium to fine grained and are mineralogically less mature and texturally more poorly sorted than Caseyville sandstones. Potter and Glass (1958) termed these sandstones feldspathic quartzites (Pettijohn, 1954).

Sandstones in the overlying Spoon Formation contain more clay matrix and feldspar, mica, and rock fragments than those below. Locally, the detrital matrix is as much as 26 percent. Feldspars are similar to those of the Caseyville Formation. The matrix of these detrital rocks consists of silt- and clay-sized quartz and clay minerals. Epigenetic minerals present are pyrite, calcite, and siderite. Unlike the lower sandstones, calcite is the dominant carbonate. Zircon and tourmaline grains are similar to those in the Caseyville. However, there is an increase in numbers of biotite, chlorite, garnet, and apatite grains in the upper group. Garnet becomes a major component of the heavy mineral suite at the level of the Pleasantview Sandstone Member. Only 2 percent of the tourmaline is rounded. These sandstones are medium to fine grained, mineralogically more immature, and the most poorly sorted of the three groups. Potter and Glass (1958) termed these sandstones "subgraywackes."

Potter and Glass (1958) note that there is a sharp break petrographically between the two lower groups, while there seems to be a very gradational change between the two higher groups.

As this sequence of sandstones develops upward, it represents a progressive decrease in textural and mineralogical maturity and implies an origin from progressively more immature source beds (Potter and Glass, 1958). The orthoquartzites were derived from preexisting sediments. Components in the subgraywackes indicate the presence of feldspathic igneous or metamorphic rocks in the source area. Garnet increases upward in the section and implies increasing importance of metamorphic rocks in the source area. Potter and Glass (1958) interpret this to indicate progressive uplift and erosion ("unroofing") of a crystalline core.

This is the first opportunity to observe the less mature sandstones overlying the Caseyville orthoquartzites. Note the thin, more even bedding and the very rusty color of the Abbott Formation.

36.0 Leave parking lot at Pounds Hollow Recreation Area. Proceed straight (east) up hill.

36.1 Abbott Formation exposed at left adjacent to road.

36.9 T-intersection at stop sign with County Road 13. Turn left (east) and proceed toward Illinois Route 1.

38.7 T-intersection at stop sign with Illinois 1. Turn left (north).

39.9 Intersection with Peabody Coal Company haulage road. Traffic control tower on right. Turn left (west) and pull to right side of road.

STOP 4 Channel and sheet phases of the Anvil Rock Sandstone Member—Eagle Surface Mine.

Leaders: M. E. Hopkins, Harry Williamson, Inc.; C. Brian Trask and Richard D. Harvey, Illinois State Geological Survey; and Russell R. Dutcher, Southern Illinois University at Carbondale.

As defined by Hopkins (1958), the Anvil Rock Sandstone Member of the Carbondale Formation occurs in two phases—a sheet phase (1 to 20 feet [0.3 to 6 m] thick) and a channel phase (greater than 20 feet [6 m] thick) (fig. IL-18). In southeastern Illinois the sheet phase is present in most of Saline and Gallatin counties. The channel phase occurs in the Eagle Valley Syncline (figs. IL-19 and 20), replacing the coal at several locations. The combination of the channel phase of the Anvil Rock Sandstone and faults (fig. IL-20) associated with the Grindstaff Fault cutting diagonally across the syncline creates difficulty in planning the operation of Eagle Surface Mine. The coal is locally missing, and the floor is extremely irregular.

The Anvil Rock Sandstone is a subgraywacke (Hopkins, 1958). Quartz is the dominant mineral and is mainly in the form of unstrained monocrystalline quartz. Locally quartz overgrowths and sutured (interpenetrated) grains are present. Worn overgrowths are rare. Feldspar is present predominantly as untwinned potash feldspar and twinned plagioclase. Matrix clay is present in quantities of as much as 36 percent. Calcite is the dominant carbonate and occurs mainly as a cement. Siderite is present as a cement and as small spherules scattered in the matrix. Rock fragments include chert, metaquartzite, and argillaceous rock fragments. The dominant mica is muscovite. Other micas are chlorite and biotite. Mica is generally present and is commonly coarse enough to be readily seen without magnification. Hopkins (1958) also reported the local occurrence of a green, microcrystalline, anisotropic mineral thought to be glauconite. The channel and sheet phases are petrographically similar with slightly less clay in the channel phase (Hopkins, 1958).

The channel phase is texturally quite distinct from the sheet phase. The sheet phase ranges from very fine- to fine-grained sandstone and averages fine-grained. The channel phase ranges from fine-grained to medium-grained sandstone and averages medium-grained. Grain size decreases upward in each channel-fill. The sandstone in the channel phase is also better sorted than that in the sheet phase. The channel phase is unconformable at its contact with underlying strata. The

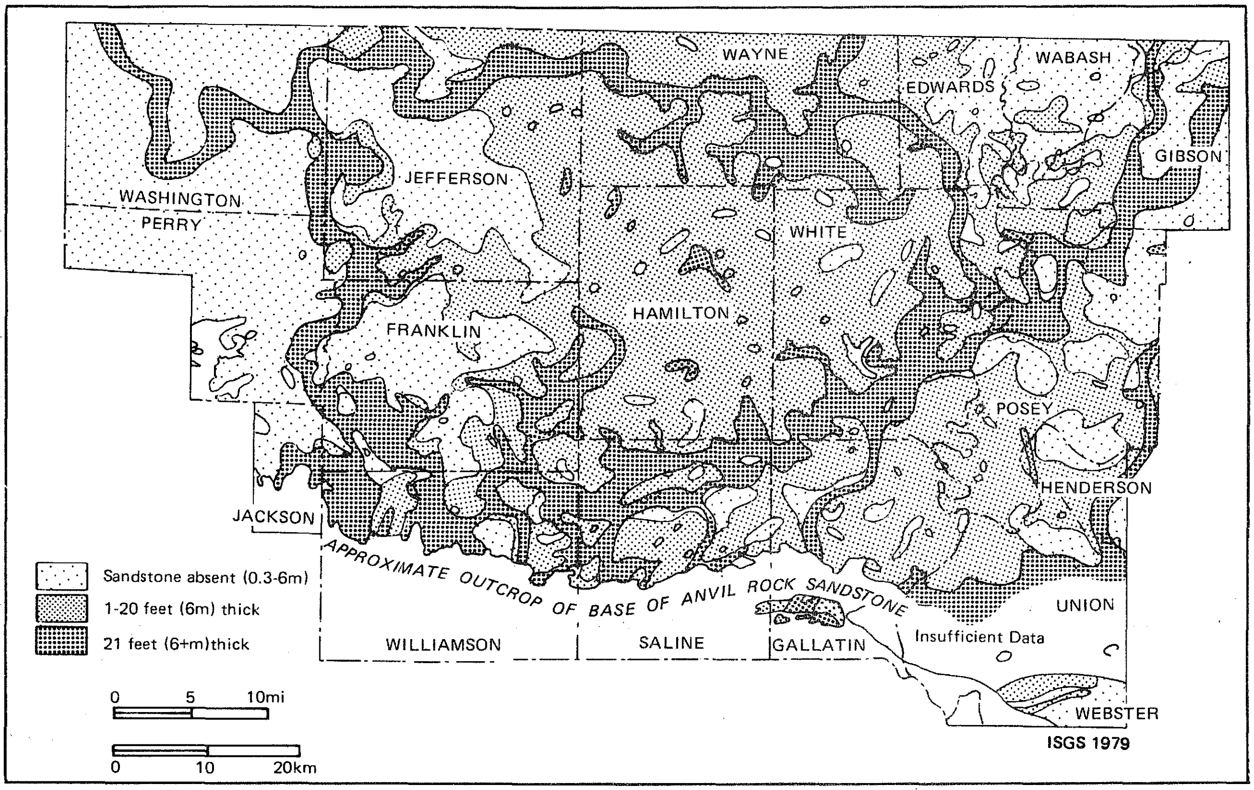


Figure IL-18. Generalized distribution and thickness of Anvil Rock Sandstone in southern Illinois, southwestern Indiana, and western Kentucky. (From Hopkins, 1958, with additional data in Eagle Valley compiled by Trask.)

sheet phase generally has gradational upper and lower contacts.

Hopkins (1958) gives the following interpretation for depositional environment of the Anvil Rock Sandstone. He thought that at least the lower part of the sheet phase was deposited first during a regression when sand brought to the nearshore area was spread laterally by weak currents. During the regression, minor channels extended over the coastal plain. At the period of maximum regression, extensive erosion occurred with development of the major channels and downcutting into underlying coal. Transgression following this stage of downcutting caused the channels to aggrade. The gradational contact with the overlying shale beneath the Bankston Fork Limestone is interpreted by Hopkins to indicate slight reworking or introduction of new sand during this later transgression.

At this time the coal being produced at Eagle Surface Mine of Peabody Coal Company is the Herrin (No. 6) Coal Member of the Carbondale Formation (equivalent to part of the Westphalian D in Western Europe). This coal seam accounted for about 70 percent of the 1977 coal production in Illinois; 25 percent came from the Springfield and Harrisburg (No. 5) Coal Members. The No. 6 Coal constitutes 42 percent of the total coal resources in the state. This coal occurs in and has been mined in all but the westernmost part of the Illinois Basin Coal Field. The No. 5 Coal also is present over a wide area of the state, and in this area it occurs commonly 90 to 145 feet (27 to 44 m) below the No. 6 Coal.

The No. 6 Coal at this mine is generally 43 to 45 inches (110 to 115 cm) thick, and usually it can be separated into three benches by two shale partings, each 0.75 to 1 inch (2 to 3 cm) thick. Commonly the upper parting is about 8 inches (20 cm) down from the top of the seam, and the lower one is about 28 inches (70 cm) below the upper parting. In certain local areas in this vicinity, the seam is split by a clastic wedge of sandy siltstone or mudstone commonly more than 2 feet thick, and the beds are complexly deformed.

The coal is predominantly bright clarain, containing numerous 0.1 to 0.15 inch (2 to 4 mm) layers of vitrain and thinner fusain and other duller layers. Pyrite is conspicuous as nodules along the bedding and along cleat surfaces representing 1 to 5 percent of the seam, depending on the location. The beds overlying the coal are typically gray or dark gray, thinly laminated shale (Anna Shale Member) except where they have been cut on and replaced by the Anvil Rock Sandstone.

Coal in Illinois is ranked as high-volatile bituminous in composition. Here in the Eagle Valley Syncline, the coal is of the highest rank of this group, high volatile A bituminous. Within a distance of 10 to 50 miles (16 to 80 km) from here, the coals are lower in rank, high volatile B bituminous; beyond, they grade

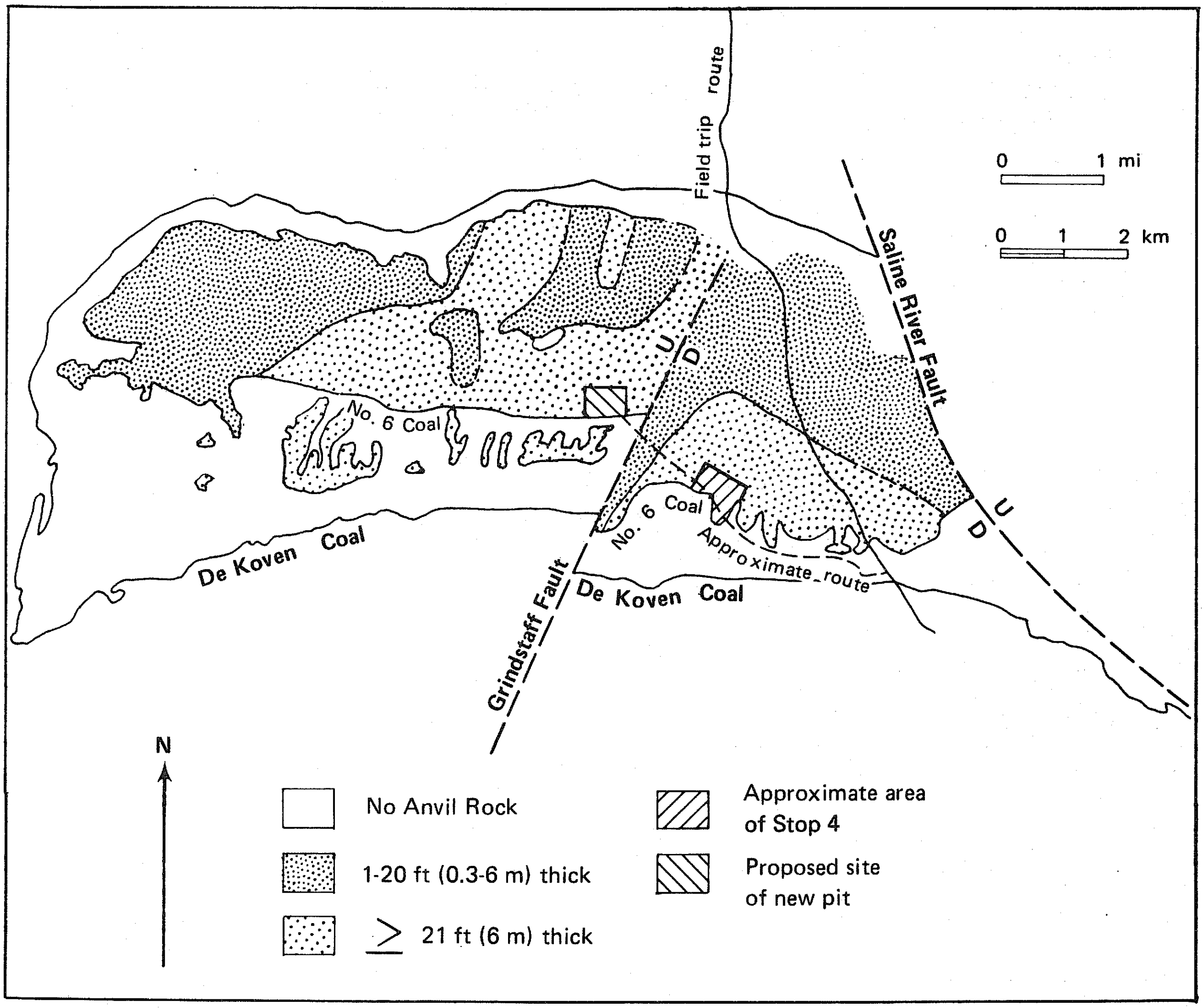


Figure IL-19. Extent and thickness of the Anvil Rock Sandstone Member in Eagle Valley Syncline.

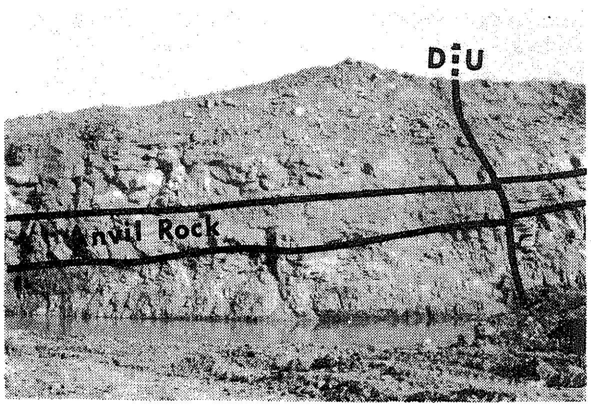


Figure IL-20. Channel phase, Anvil Rock Sandstone, high wall of Eagle Surface Mine. The Brereton Limestone has been locally removed by stream erosion and is replaced by channel-fill deposits of the Anvil Rock Sandstone. At other localities, channel-fill deposits locally replace the underlying Herrin (No. 6) Coal. A small fault (about 1 foot [0.3 m] displacement), which may be related to the nearby Grindstaff Fault (fig. IL-19), extends diagonally across the highwall.

lower to high volatile C bituminous over much of the northern and western areas of the Illinois Basin Coal Field.

Samples taken at the working face of this mine in July 1978 contained 38 to 41 percent volatile matter (dmmf), decreasing as the seam develops downward. The ash is consistently about 11 to 12 percent in the three benches.

39.9 Leave Stop 4.

40.4 Anvil Rock Sandstone Member in roadcut.

40.7 Bridge over Eagle Creek. Eagle Creek flows generally eastward on the south limb of the Eagle Valley Syncline and empties into the Saline River a short distance east (right) of the highway.

42.7 Approximate location of axis, Eagle Valley Syncline.

43.1 Four new houses, closely adjacent. Road curves to left (northwest).

44.1 Road rises on north limb of Eagle Valley Syncline; note broad southward dip slopes.

44.8 Route passes through area of nearly vertical

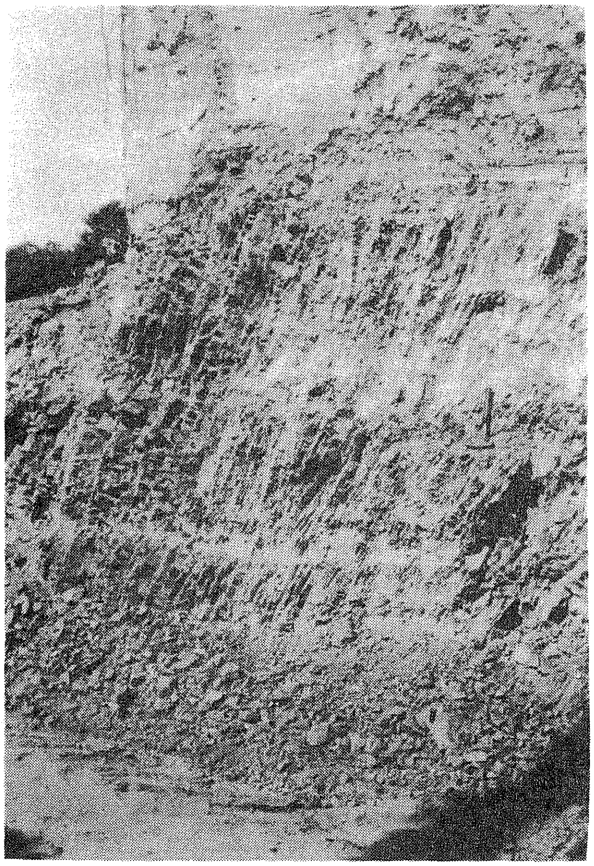


Figure IL-21. Near-vertical siltstone and shale of Caseyville Formation, Shawneetown Fault Zone on west side of new Illinois Route 1 roadcut. Bluff above bedrock surface is loess.

rocks of the Caseyville Formation (fig. IL-21). Major fault of the Shawneetown Fault Zone is located at base of ridge adjacent to bridge over Saline River. Area of intensely fractured and slickensided sandstone is located about 100 feet (30 m) to the left (west). North of the Shawneetown Fault, rocks of the Carbondale Formation are at the surface and dip at a low angle (about 1° or less) toward the northeast. These rocks appear to be almost totally unaffected by the complex structural deformation south of the Shawneetown Fault zone. The vertical displacement there is about 1,000 feet (305 m).

To the west (left), several saline springs are located along the fault zone (fig. IL-22). The brine evidently seeps to the surface within the fault zone from deeply buried strata that contain connate salt water.

45.7 Large white house on hill to left front (northwest) is known as "The Old Slave House" (fig. IL-23).

47.2 Historical marker (fig. IL-24). Memorial to General Michael K. Lawler.

47.5 Intersection at stop sign with new Illinois Route 13. Turn left (west).

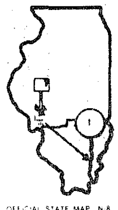
49.4 Bridge over North Fork of the Saline River.

50.3 Turn left (south) on Calhoun Street, Equality, Illinois. Equality was incorporated in 1872. Originally known as Gallatin City, its name was changed to Equality in honor of an old

Illinois State Historical Library

This mural depicting a salt mining operation is in Gallatin County Courthouse

Located: West side of Illinois 1, 2.4 miles south of the junction of Illinois 1 and 13 near Equality.



OFFICIAL STATE MAP N-8
GALLATIN COUNTY

THE UNITED STATES SALINES [EQUALITY]

Two salt springs in Gallatin County produced brine for one of the earliest salt works west of the Alleghenies. One spring is just southwest of Equality and the other is a short distance west of this site. The Indians made salt here long before the first settlers appeared. In 1803 the Indians ceded their "great salt spring" to the United States by treaty. Congress refused to sell the salt lands in the public domain but it did authorize the Secretary of the Treasury to lease them to individuals at a royalty. The leases required the holder to produce a certain quantity of salt each year or pay a penalty

Although the Northwest Ordinance prohibited slavery in this area, special territorial laws and constitutional provisions permitted exceptions at these salines. The lessees brought in Negroes as slaves or indentured servants and used them extensively in manufacturing salt. The census of 1820 for Gallatin County listed 239 slaves or servants.

In 1818, as part of the process of making a new state, Congress gave the salines to Illinois but forbade the sale of the land. The state continued to lease the springs and used the revenue to finance part of its operating expenses. Eventually Congress allowed the outright sale of the land. The commercial production of salt continued here until about 1873 when the low price for salt made the expense of extracting it from the brine prohibitive.

Figure IL-22. Historical marker and photograph depicting early salt-mining operations in southeastern Illinois. (Photograph courtesy of the Illinois State Historical Library. Marker and other information courtesy of Brevet Press, Inc.)

French fort. The old Turner Opera House in downtown Equality was built in 1899 and was a center of entertainment during the first quarter of this century.

50.8 City water tower; bear right around circle.

50.9 Turn right (south) on Calhoun Street.

51.1 Stop sign. Turn right (west) on Lane Street. Old Turner Opera House (Sallie's House of Plenty) on right.

51.4 Turn left (south) on Walnut Street.

51.9 Bridge over Saline River. Wildcat Hills (high ridge directly ahead) are formed by rocks in the steep northern limb of Eagle Valley Syncline. The north face of the ridge is a resequent fault-line scarp of the Shawneetown Fault Zone. Sandstone of the Caseyville Formation crops out on the ridge; rocks of the Chesterian Series (upper Mississippian) crop out along the lower slopes adjacent to the Shawneetown Fault Zone.

53.1 Red barn ahead on right. Turn right (west) on gravel road. Hills to right front are underlain by No. 5 and No. 6 Coals. The croplines of both coals have been surface mined. Fault-line scarp visible to left.

55.1 T-intersection. Turn right (west). Route parallels base of fault-line scarp and is located on

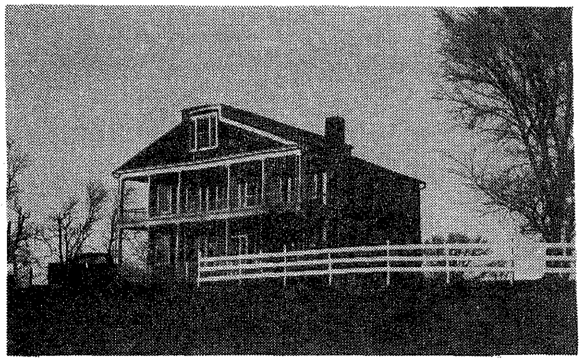


Figure IL-23. Old Slave House on Hickory Hill, Gallatin County, Illinois. Built for John Hart Crenshaw during the late 1830s, the building is steeped in folklore. It was reported to have been a link in the Underground Railroad through which escaped slaves reached the North prior to the Civil War. However, cramped quarters and shackles on the top floor are evidence that it may have been used for holding escaped slaves for subsequent resale to their owners. A third legend indicates that the top floor was used to house slaves who worked in the nearby salt-processing operations.

concealed steeply dipping strata.

55.8 Enter Saline County. Saline County, established in 1847, derived its name from the salt springs which abound in the area.

56.1 Intersection and site of abandoned small community of Horseshoe. Water-well drilled adjacent to intersection reportedly produced salt water from Shawneetown Fault Zone. Continue straight ahead.

56.2 Disembark buses on main road. Follow stop leaders around margin of ridge on farm road to vantage point in rock quarry for stop discussion. After discussion, time will be allowed to examine rocks of quarry site.

STOP 5 Shawneetown Fault Zone, north limb of Eagle Valley Syncline.

Leaders: H.-F. Krausse, James E. Palmer, and C. Brian Trask, Illinois State Geological Survey.

The abandoned quarry is about 250 feet (76 m) wide and 850 feet (259 m) long. It includes a total area of about 5 acres (12 hectares). Average strike of rock strata is about N 80° W, and dip is toward the south at about 60°. The rock strata seen here are part of the north limb of the Eagle Valley Syncline near a point where the syncline turns southwestward and terminates. This area is part of a large fault slice which is bounded on the north by a high angle reverse fault with vertical displacement of at least 3,500 feet (1,067 m) (fig. IL-25). A normal fault with vertical displacement of about 800 feet (244 m) is located about 0.5 mile south of the quarry. Rock strata within the slice dip southward at an average angle of about 35°.

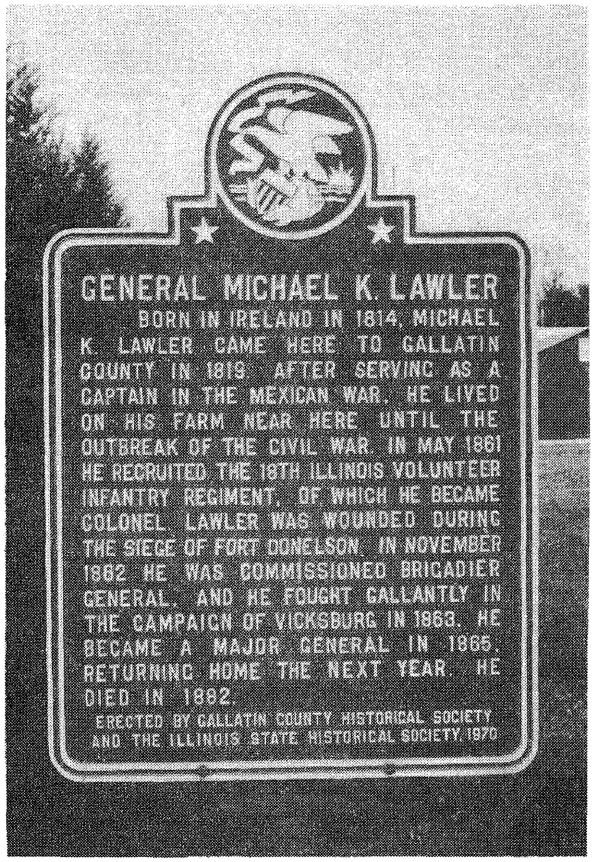


Figure IL-24. Historical marker, General Michael K. Lawler.

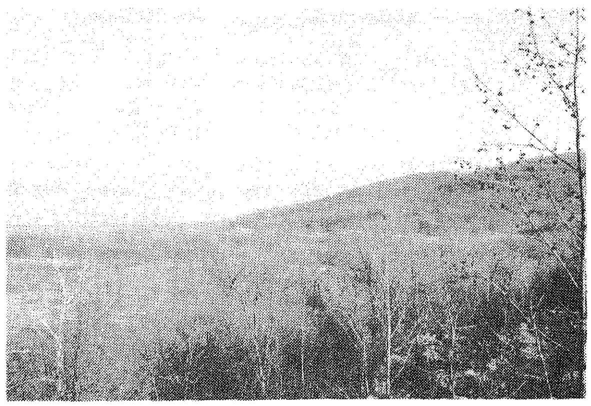


Figure IL-25. View east from abandoned quarry at Horseshoe. Resequent faultline scarp of the Shawneetown Fault Zone separates the hills to the south (right) from the plain to the north (left). Kentucky is visible on the horizon.

More than 200 feet (60 m) of partly silicious and calcareous shale and siltstone of the Fort Payne Formation of the Valmeyeran Series (middle Mississippian) is exposed at the quarry site. The Fort Payne Formation was deposited as an irregular tongue-shaped body in southern Illinois that partially filled a deep-water basin bordered by the foreset slopes of the Borden Siltstone delta to the north and west (Lineback, 1966). The

Ullin Limestone, which overlies the Fort Payne Formation, is not exposed here. Uppermost units of the New Albany Group (Mississippian, Devonian) are exposed in the extreme northwestern part of the quarry site. These units consist of black to dark gray carbonaceous shale which is intensely fractured and contains numerous partly phosphatic siltstone and claystone nodules.

Intense fracturing (fig. IL-26) is present in all units exposed at the quarry site. The most intensely deformed units are present near the eastern end of the quarry and about 100 feet (30 m) south of the access road (fig. IL-27). These crumpled and complexly deformed units consist of soft, somewhat brittle shale which failed under shearing stresses. These soft shale units lie between silicious siltstone and shale of the upper part of the Fort Payne Formation and thick units of the New Albany Group which deformed competently.

56.2 Board buses; continue west on gravel road.
57.4 Exposure of steeply dipping sandstone in fault zone, both sides of road.
58.7 Road on left to Sulphur Springs Baptist Church. Continue straight.
58.8 Turn right (north). As we proceed to the north away from Eagle Valley Syncline, we will be crossing silt and clay deposits of Pleistocene Lake Saline.
59.5 Large reinforced concrete bridge over the Saline River. The river flows to the right (east).
60.5 Road curves sharply to the right (east). Cast pile to left front after turn is from surface mining (Vinyard Mine) of No. 5A and No. 5 Coals.
60.8 Turn left (north).
61.1 Note house and new barn on left and surface mine (Vinyard Mine) on right.

Figure IL-26. Calcite-filled fractures in calcareous shale and siltstone of the Fort Payne Formation. Rocks strike approximately perpendicular to plane of photograph (N. 80° W.) and dip south (left) at about 60°.

Figure IL-27. Fort Payne Formation exposed in fault zone at Horseshoe Quarry. All units dip steeply to the south except for some units in the intensely deformed zone, which are overturned to the north. The highly sheared soft and somewhat brittle shale is exposed near center of photo.

Surface mining in this area removed three coals, Herrin (No. 6), Briar Hill (No. 5A), and Harrisburg (No. 5) Coals. The No. 6 Coal is in a highwall about 0.5 mile (0.8 km) to the right (east). The No. 5A Coal is about 16 inches (40 cm) thick and is exposed in the highwall immediately to the right of the road. The No. 5 Coal is concealed in the pit.

61.7 T-intersection. Turn right (east).

61.9 Road curves gently to the left (north) and crosses small creek tributary to Rocky Branch. Rocky Branch School (abandoned) and Rocky Branch Social Brethren Church on right.

62.3 Small mining operation ahead on right. Equality Mining Company is surface mining the Herrin (No. 6) Coal. Anvil Rock Sandstone is present in the highwall and was deposited variably on No. 6 coal, Anna Shale, and Brereton Limestone.

62.5 Intersection at stop sign with old Illinois Route 13. Continue straight (north).

62.8 Intersection at stop sign with new Illinois Route 13. Turn left (west).

At various times today, the field-trip route has crossed flat bottomlands underlain by deposits of late Pleistocene Lake Saline (fig. IL-28). During Wisconsinan glaciation, meltwater flowing down the Wabash and Ohio Rivers carried great volumes of outwash. This outwash alluviated the master valleys of the two rivers, damming the valleys of tributary streams not directly connected with the melting glaciers and creating slackwater lakes in their river basins. Lake Saline was one of these lakes (Frye et al., 1972).

Lake Saline was filled with water three times to levels ranging from 350 to 400 feet (107 to 122 m) above sea level. At the highest stage, it may have been connected with Pleistocene Lake Muddy to the west (Day 6, this field trip). Apparently the lake level fluctuated too rapidly to allow the formation of beaches and wave-cut cliffs. Loess-covered bedrock knobs without lake deposits identify the location of islands (fig. IL-29).

Sediment in the lake plain was brought in by meltwater from the glaciers. The finer material remained in suspension and was circulated through and deposited in the slackwater lake basin leaving as much as 150 feet (45 m) of sediment. The final phase of still-water lake deposition was interrupted by an erosive stage when the discharge of flood waters from glacial Lake Maumee in the Erie Basin to the northeast eroded some of the lake deposits in the Wabash Valley.

From this point to about 8 miles (13 km) west of Harrisburg, the field trip route will be located primarily on silt and clay deposits of Lake Saline with intermittent rises onto loess-covered bedrock knobs that formed islands in the lake.

64.1 The large complex of buildings at crest of hill on right (north) is Southeastern Illinois College. The hills visible to the left (south) are located at the western terminus of the Eagle Valley Syncline.

66.2 Cast piles about 1 mile (1.6 km) south (left) of road are from surface mine on the Harrisburg (No. 5) Coal.

67.8 Bridge over Middle Fork of the Saline River.

69.0 Harrisburg levee.

Harrisburg is susceptible to flooding from the Saline and Ohio Rivers. To protect the town during flooding, levees have been built in low areas between higher bedrock knobs to an elevation of 370 feet (113 m). Route 13 crosses over the levee, leaving the levee as a continuous wall under the highway. However, U.S. Route 45, to the northeast of Harrisburg, passes through the levee, leaving a break in the line of flood defense. During time of flooding, a gate in the levee at the U.S. Route 45 crossing is closed across the highway to maintain the continuity of the levee.

69.4 Enter Harrisburg (population 9,500). Wooden buildings to the right are the shops and warehouses of Sahara Coal Company. Harrisburg is the county seat of Saline County. It was settled by James Harris, a sawmill proprietor. It was first platted in 1853.

69.5 Intersection at stop light with U.S. 45. If alternate stop at Will Scarlet Mine is not made, continue straight on Illinois Route 13 and use alternate mileage no. 2 on p. 80. Otherwise, follow alternate mileage no. 1.

ALTERNATE MILEAGE NO. 1
(to reach Stop 6, optional)

0.0 Turn left (south) on U.S. 45.

4.6 Enter community of Ledford.

6.1 Cast piles to left (southeast) are from surface mining on Davis and De Koven Coals.

6.2 Enter Carrier Mills (population 2,000).

10.1 Cast piles of Will Scarlet Mine visible to left front.

11.0 Intersection. Haulage road, Will Scarlet Mine.

STOP 6 Will Scarlet Mine, Peabody Coal Company (optional stop).

Leaders: Russell R. Dutcher, Southern Illinois University at Carbondale; and Richard D. Harvey, James E. Palmer, and C. Brian Trask, Illinois State Geological Survey.

The highwall at the Will Scarlet Mine contains three coal beds which are overlain by dark gray to black silty shale and sandstone (figs. IL-30 and 31). The Davis Coal, about 3 feet (0.9 m) thick, is at the base of the pit and is separated from the overlying De Koven Coal by about 15 feet (4.5 m) of gray to black silty shale and fine-grained sandstone. The De Koven Coal, also about 3 feet (0.9 m) thick, is directly overlain by fine-grained sandstone about 25 feet (7.6 m) thick. The upper part of the sandstone grades laterally into dark gray shale. The uppermost

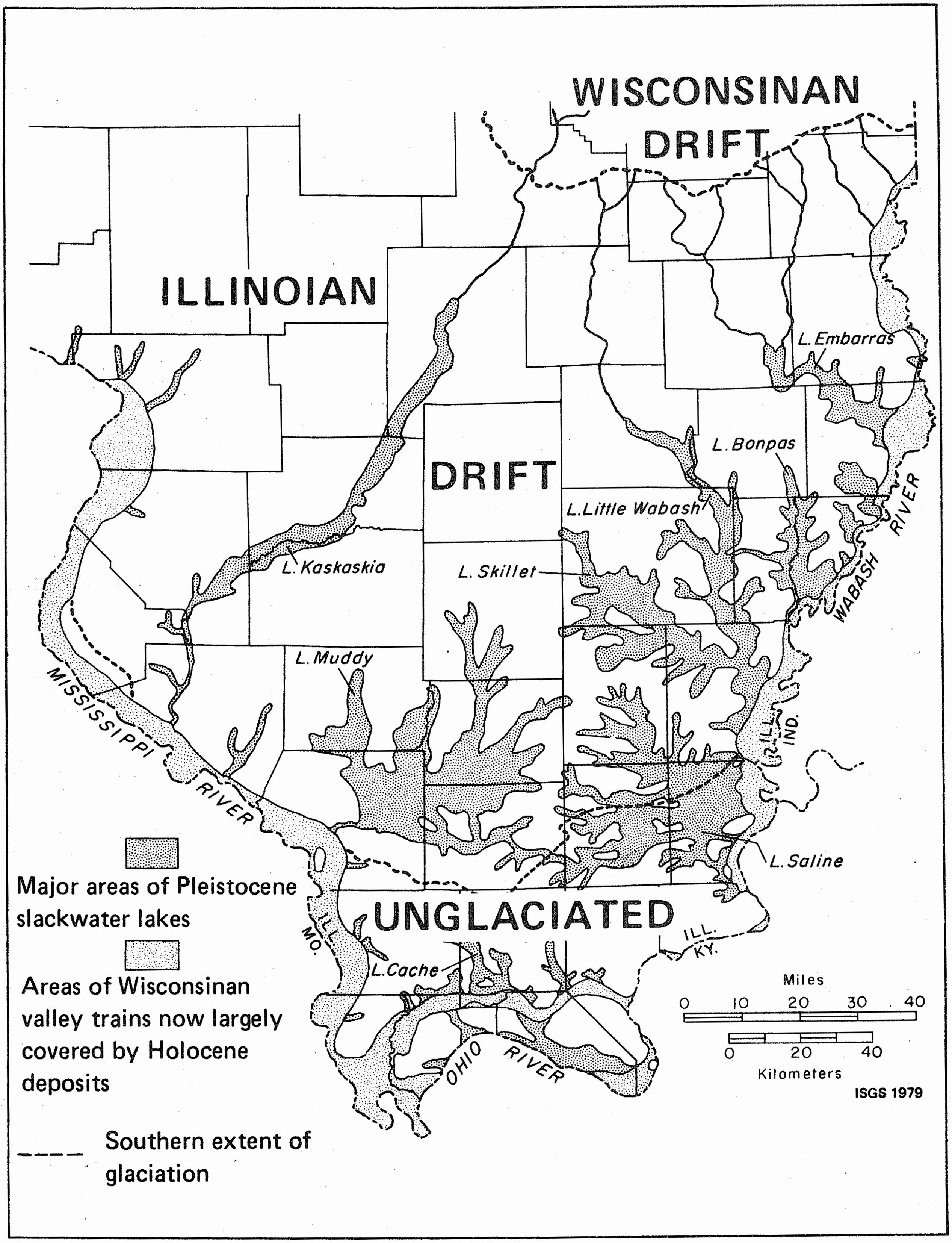


Figure IL-28. Pleistocene slack-water lakes of southern Illinois. (From Frye et al., 1972.)

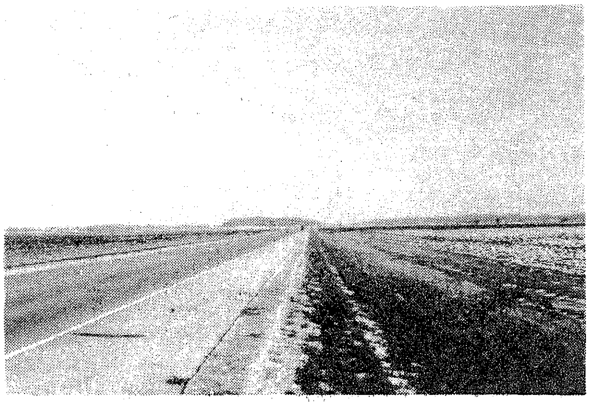


Figure IL-29. Illinois Route 1 east of Harrisburg, Illinois, looking east. Flat area in the foreground is underlain by silt and clay deposits of Pleistocene Lake Saline. The tree-covered hills in the background were islands in Lake Saline and are composed of bedrock overlain by wind-blown loess deposits.

coal is about one foot (0.3 m) thick and is known locally as the "De Koven rider." No detailed studies of this coal are available, but it may be correlative with the Seelyville Coal Member (III) of east-central Illinois and Indiana.

The Davis and De Koven Coals are located about 100 feet (30 m) below the upper boundary of the Spoon Formation and about 750 feet (230 m) above the base of the Pennsylvanian System. Coals of the underlying Abbott and Caseyville Formations are generally thin and lenticular and rarely contain marine limestones. These lower coals apparently were deposited in an alluvial plain or upper delta plain environment.

The first clearly recognizable development of regionally extensive marine limestones occurred with the deposition of the Curlew Limestone Member—about 175 feet (53 m) below the Davis Coal—which is widespread in southern Illinois and western Kentucky. The Curlew Limestone has been correlated with the Seville Limestone Member of northern Illinois, the Lower Mercer Limestone of Ohio and Pennsylvania, and the Verne Shaly Limestone Member of Michigan (Wanless, 1957).

With the development of regionally extensive marine and coastal plain environments, the vertical succession of strata became much more uniform. The De Koven Coal, for example, lies from 15 to 30 feet (4.5 to 9 m) above the Davis Coal and is uniformly present above it for a lateral distance of more than 100 miles (161 km).

Above the Davis and De Koven Coals, the vertical succession of strata becomes even more uniform, and some limestones and coals of the Kewanee Group (middle Pennsylvanian) extend, with certain variations and interruptions, essentially the full extent of the Illinois Basin. The unusually orderly sequence of strata,

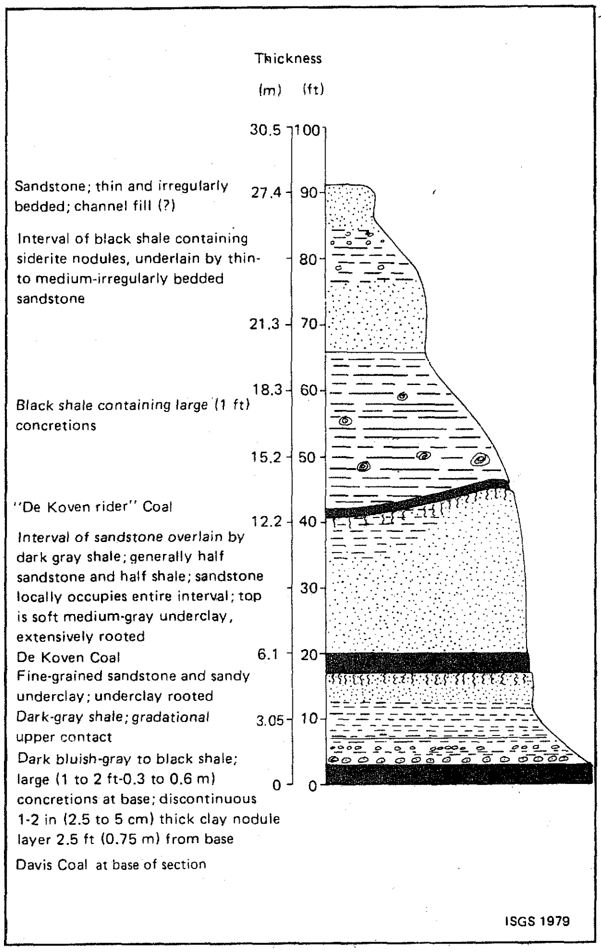


Figure IL-30. Columnar section of highwall at Will Scarlet Mine. Rider coal, near middle part of highwall, may be correlative with the Seelyville Coal of east-central Illinois and Indiana.

given the name "cyclothem" by Wanless and Weller (1932), was first recognized in western Illinois in rocks of the Kewanee Group.

11.0 Leave Will Scarlet Mine and proceed northeast on U.S. 45.
14.5 Enter Carrier Mills.
14.9 Intersection with County Road 9. Turn left (north). Follow County Road 9 through Carrier Mills.
15.0 Cross railroad tracks and turn left (west). Proceed one block to stop sign and turn right (north).
17.0 Stripping on right is in Davis and De Koven Coals.
18.9 Intersection with Illinois Route 13. Turn left (west). Omit alternate mileage No. 2 and turn to mileage 75.1.

ALTERNATE MILEAGE NO. 2

69.5 Intersection at stop light with U.S. 45. Continue straight (west) on Illinois Route 13.
72.9 Mine subsidence has occurred on both sides and under road. Mine No. 16, Sahara Coal Company, removed Harrisburg (No. 5) Coal at

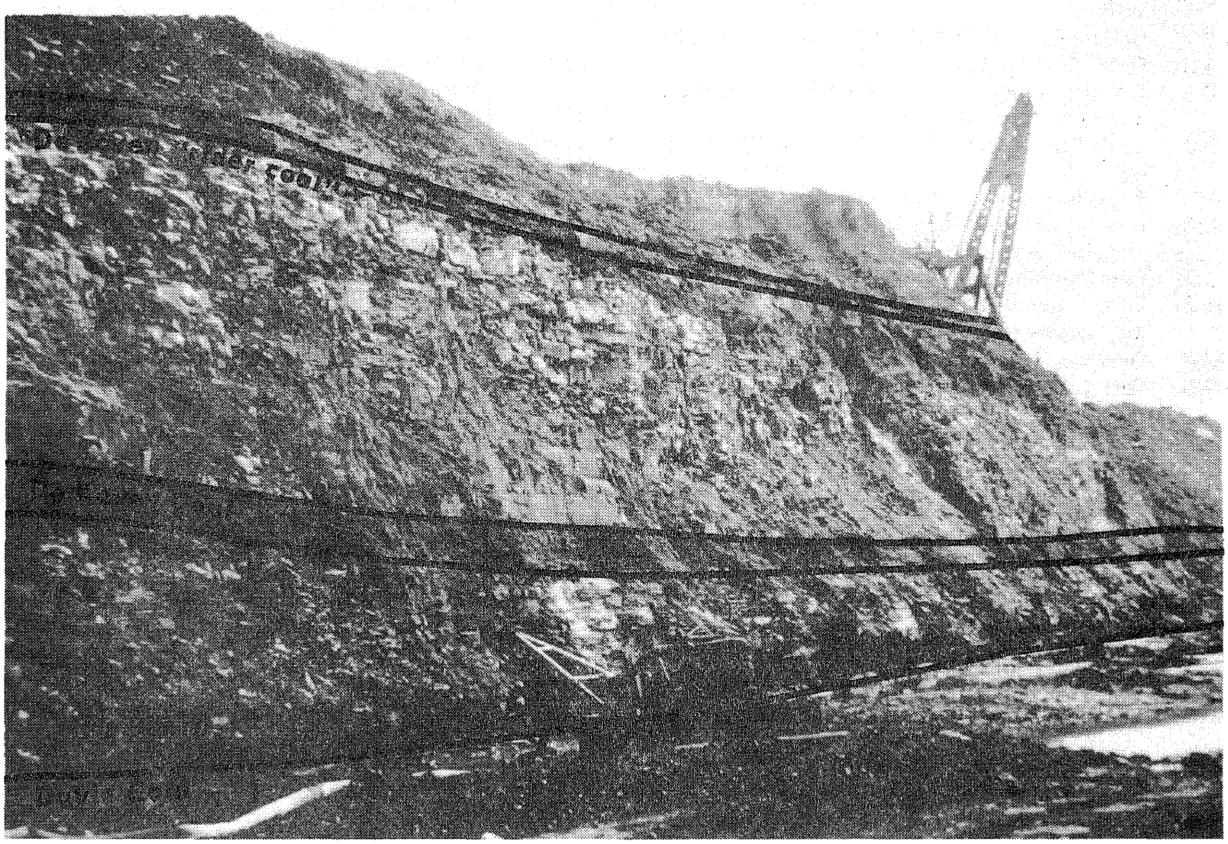


Figure IL-31. Highwall, Will Scarlet Mine. Davis Coal is exposed at the base of the pit, De Koven Coal is about 15 feet (4.5 m) above base of highwall, and 1-foot (0.3 m) coal rider is near the top of the highwall. Note: variation in thickness of interval between the De Koven and "De Koven rider" Coals apparently is due in part to the relatively greater compactibility of shale where the dominant lithology changes from sandstone to shale elsewhere in highwall.

a depth of about 225 feet (70 m) on the west side of a linear body of clastic sedimentary rocks filling the Galatia Channel (see Hopkins, Nance, and Treworgy, this Guidebook, part 2, p. 142). Approaching the channel, the miners encountered as much as 18 feet (5.5 m) of coal along the sides of the channel-fill. They mined only the lower 6 feet (1.8 m), as the remainder was too shaly to be of economic importance. In January 1972 the mine was abandoned because of collapsing roof. On November 13, 1977, a section of Illinois Route 13 and surrounding fields subsided as much as 3.5 feet (1 m) in an area approximately 600 feet (183 m) in diameter (fig. IL-32).

74.5 More mine subsidence at dip in road. Many irregularities in the highway are the result of mine subsidence.

75.1 Intersection with County Road 9 to Carrier Mills on left (south). Continue straight (west).

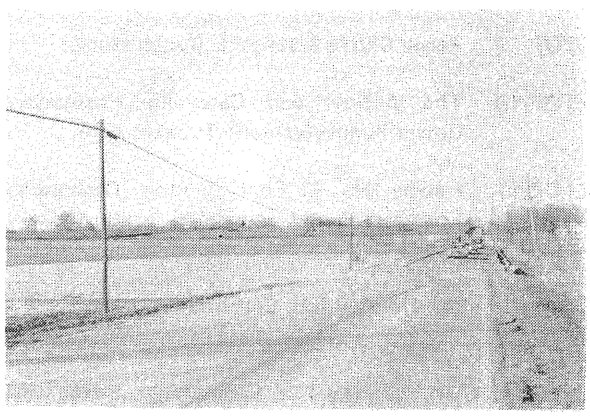


Figure IL-32. Subsidence damage to Illinois Route 13 and adjacent fields, west of Harrisburg, Illinois, above abandoned Mine No. 16, Sahara Coal Company. View to east. Road is being regraded, and ridges either side of cars are gravel.

75.1 Proceed west from Carrier Mills Road.

76.3 Coal conveyor belt over road. This belt transports coal from the mine to the loading area for Mines No. 20 and 21, Sahara Coal Company.

79.0 Intersection with haulage road of Delta Mine, AMAX Coal Company. Continue straight (west). Enter Williamson County.

79.7 Spring Grove Methodist Church and Cemetery on left.

79.8 Extensive surface mining both sides of road. The No. 6 Coal has been mined out on the left (south) side of the road, where Anvil rock Sandstone is extremely common in the highwall.

83.7 Delta Mine, AMAX Coal Company, on right.

85.0 Enter Crab Orchard.

86.6 Surface mining to right (north) of highway is on the No. 6 Coal.

87.2 Davis Prairie Crab Orchard Baptist Church on left.

87.7 Begin four-lane divided highway.

88.0 Intersection with Illinois Route 166. Continue straight (west).

90.2 End four-lane divided highway.

91.3 Enter Marion (population 12,900). Marion is the county seat of Williamson County.

93.9 Overpass, Interstate 57. Continue straight.

94.5 Cast piles to right (north) of road are from surface mines on the No. 6 Coal.

96.9 Williamson County Airport to right (north) of highway. Surface mining to northeast of airport is on the No. 5 Coal.

97.5 Intersection with Illinois Route 148. Continue straight (west).

102.6 Crab Orchard on right.

104.1 Crab Orchard Lake both sides of road.

106.2 Enter Jackson County. Jackson County was established January 10, 1816, and named for Andrew Jackson, President of the United States from 1829 to 1837.

108.6 Enter Carbondale (population 26,900). University Mall Shopping Center on left.

109.3 Turn right into Holiday Inn parking lot for overnight stop. End of fourth day.

DAY 5 South-central Illinois.

Trip leaders: George H. Fraunfelter, John E. Utgaard, and Charles F. Mansfield, Southern Illinois University at Carbondale; and John T. Popp, Illinois State Geological Survey.

Thursday, May 31, 1979

STOP 7. **Mississippian-Pennsylvanian Unconformity, U.S. Route 51.**

STOP 8. **Caseyville Formation (lower Pennsylvanian), Interstate 57.**

STOP 9. **Ferne Clyffe State Park (lunch stop).**

STOP 10. **The Abbott and Caseyville Formations (lower Pennsylvanian), Interstate 24.**

STOP 11. **Herrin (No. 6) Coal Member (Carbondale Formation) and associated strata at Delta Mine, AMAX Coal Company.**

Overnight stop, Holiday Inn, Carbondale.

0.0 Depart Holiday Inn, Carbondale; travel west on Main Street (Illinois Route 13). See figure IL-33 for a map of today's route.

0.7 Intersection, University Avenue (U.S. Route 51); turn left (south).

1.5 Campus of Southern Illinois University, Carbondale (right). SIU-C is a fully accredited university offering undergraduate and graduate degrees in many disciplines. The University has a full-time enrollment of about 22,000 students.

5.3 Signal light; intersection, U.S. Route 51; turn left (south).

Roadcuts along the next 2 miles of U.S. 51 expose Illinoian (Pleistocene) till beneath brownish Roxana Loess and buff-colored Peoria Loess. The road is located near the crest of a ridge which rises as much as 200 feet (61 m) above Drury Creek, a major stream to the east. Some valleys in this area may predate Illinoian glaciation, because they contain partly eroded valley-fill till deposits. In portions of the Shawnee Hills south of Carbondale, till is found more than 200 feet (61 m) above the lowlands to the north. The advance of glacial ice was stopped by the Shawnee Hills, but to the northwest between Big Muddy River and Mary's River, glaciers crossed the Shawnee Hills and entered the Mississippi River valley.

9.3 Bald Knob Cross on horizon to right (west). Bald Knob is about 1,030 feet (395 m) above sea level and is so named because its summit is devoid of trees.

10.2 Enter Union County.

10.5 Caseyville Formation (lower Pennsylvanian), in roadcut. Exposure consists of sandstone and claystone, about 75 feet (25 m) thick.

10.9 Caseyville Formation in roadcut, probably the Drury Shale Member. Section consists of fine-grained sandstone, crossbedded and ripple-bedded, containing a few burrows, and some load deformation features. Thickness is about 45 feet (13.7 m).

11.9 Unconformity separating Mississippian and Pennsylvanian Systems (concealed).

12.5 Kinkaid Limestone, Chesterian Series (upper Mississippian).

13.4 Small abandoned quarry (right) in Negli Creek Member of Kinkaid Limestone.

13.6 Disembark buses. Watch carefully for highway traffic.

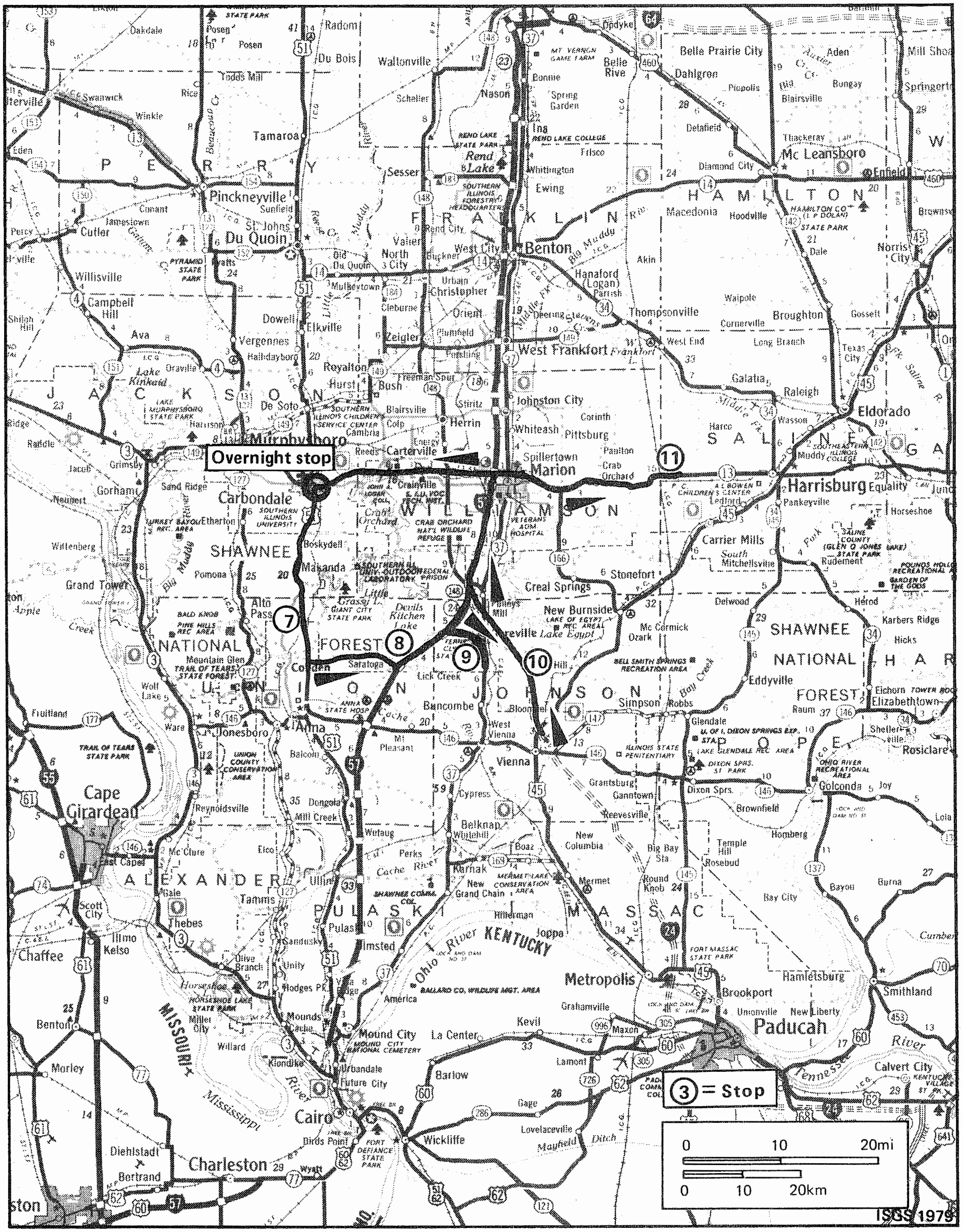


Figure IL-33. Field trip route for Illinois, Day 5, south-central Illinois.

STOP 7 Mississippian-Pennsylvanian Unconformity, U.S. Route 51.

Leaders: George H. Fraunfelter and John E. Utgaard, Southern Illinois University at Carbondale; Richard H. Howard and John T. Popp, Illinois State Geological Survey; and David Houseknecht, University of Missouri-Columbia.

The unconformity between the Chesterian (upper Mississippian) Kinkaid Limestone and the Caseyville Formation (lower Pennsylvanian) is unusually well-exposed (fig. IL-34). This outcrop may be compared with those seen at the Nolan Reservoir in Kentucky on Day 2. The roadcut is south of the principal outcrop belt of the Caseyville Formation. The Caseyville here is part of an outlier, which was apparently preserved due to deposition in a channel cut into Mississippian rocks.

Four distinct lithic and depositional units have been identified at this outcrop. Depositional environments for the units are discussed in the following paragraphs. Their lithologies are described and illustrated in figure IL-34.

UNIT 1. Gray, fossiliferous shale. The shale was apparently deposited on a shallow marine subtidal shelf where sediment transport was primarily by suspension, and sedimentation was very slow. Limestone detritus debris was winnowed by currents into small lenses in a quiet-water environment.

UNIT 2. Gray, thick-bedded limestone, very fossiliferous. Deposition was in a shallow subtidal marine environment where currents were strong enough, at times, to transport bedload sediment, as suggested by the fossils, texture, and sedimentary structures. Laminated structures in the upper part of the unit are diagenetic in origin and are convex upward into fractures filled with sparry calcite cement. Abundant vertical burrows in upper part of the lower limestone suggest a period of little or no sedimentation when an abundant infauna became established on the carbonate shelf.

UNIT 3. Quartzose sandstone, fine to coarse grained. The sandstone, which was the first unit of Pennsylvanian age to be deposited in this area, fills an erosional channel that removed part of the underlying limestone and shale. The channel lag deposits are characteristic of fluvial channels.

UNIT 4. Siltstone with shale interbeds. Deposition of this unit represents a transition from Unit 3. Roush and Ethridge (1973) believe Units 3 and 4 were deposited in an environment that was transitional between a migrating fluvial (distributary channel?) of Unit 3 and an estuarine environment of Unit 4.

13.6 Board buses; continue south on U.S. 51.

14.3 Degonia Sandstone (upper Mississippian), right. Interbedded sandstone and shale, about 2.5 feet (.74 m) thick, overlain by fine-grained, well sorted quartzose sandstone, about 10 feet (3 m) thick, that contains interbedded shale.

14.7 Clore Formation and the Degonia Sandstone (upper Mississippian), both sides of the highway. The Clore Formation consists of gray limestone (4 ft, 1.2 m), containing crinoids and brachiopods; gray to brown shale with carbonaceous fragments (4 ft) and yellow-brown mudstone with ironstone concretions at top (2 ft). The Degonia Sandstone, which is about 20 feet (6 m) thick, overlies the Clore Formation. It consists of a fine-grained, well sorted quartzose sandstone containing planar and trough cross-beds.

15.4 Lick Creek cutoff. Turn left.
Menard Limestone (Chesterian, upper Mississippian) on right (south). The Menard is a bluish-gray biomicrite with crionoid debris, infilled brachiopods, trepostome, fenestrate and rhomboporoid bryozoans, solitary corals, and gastropods.

15.5 Menard Limestone in creek bank, left.

15.6 Palestine Sandstone (upper Mississippian), left. Fine-grained, well-sorted quartzose sandstone, thin-bedded, jointed, and limonite-stained. Individual beds are irregular and one to three inches (2.5 to 7.6 cm) thick. Micro cross-laminations and asymmetrical current and interference ripples are present, especially in upper part.

16.1 Negli Creek Member of the Kinkaid Limestone and the Caseyville Formation crop out beyond water tower (left).

19.7 Turn left, cross bridge.

20.0 Caseyville Formation (sandstone and siltstone), left.

21.2 Note prominent Caseyville escarpment (left).

23.7 Stop sign, road intersection. Turn left.

24.5 Note sinkholes, right. Cave Hill Member, Kinkaid Limestone (left).

25.1 Junction, Lick Creek Road with Interstate 57. Enter northbound access road, Interstate 57. While crossing I-57, a highway roadcut in the Caseyville Formation can be seen about 1.4 miles (2.7 km) north. This exposure will be examined at Stop 8.

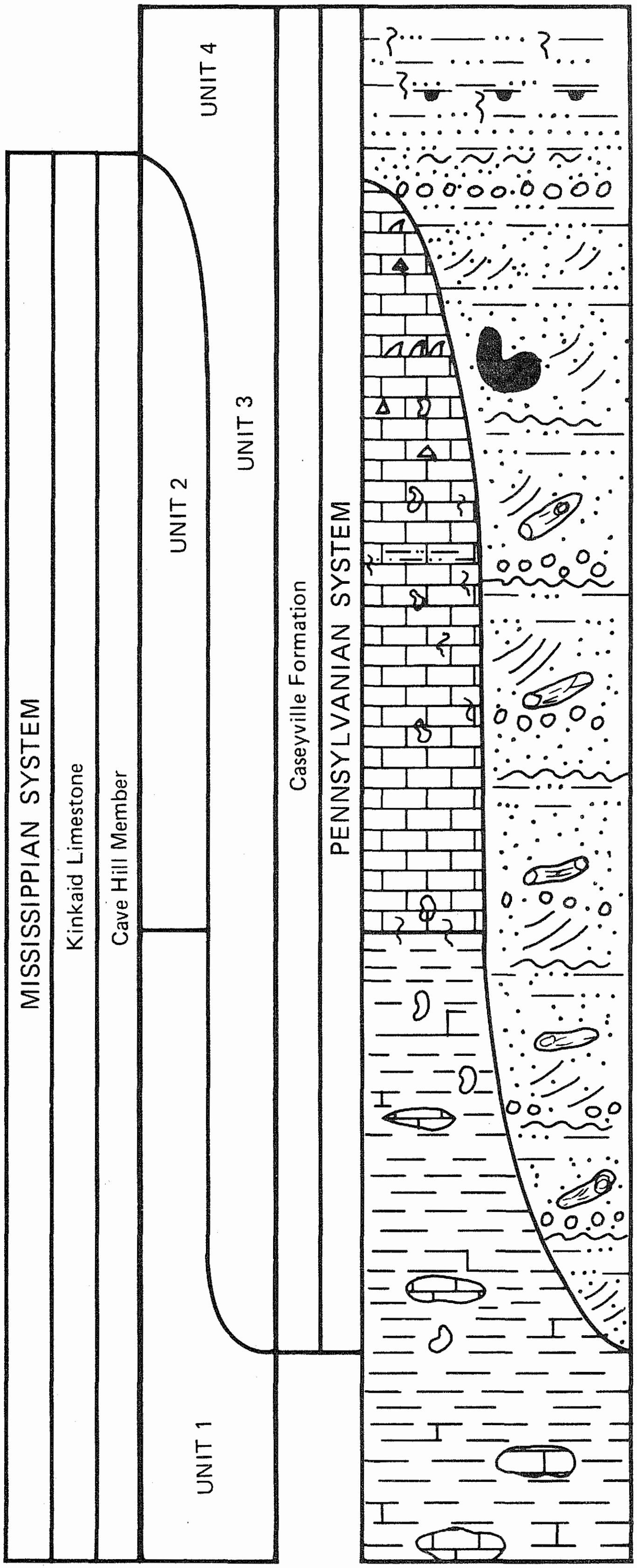
26.6 Negli Creek Member of the Kinkaid Limestone in roadcut (right).

STOP 8 Caseyville Formation (lower Pennsylvanian), Interstate 57.

Leaders: C. Allen Koeninger, Shell Oil Company; Charles F. Mansfield and John E. Utgaard, Southern Illinois University at Carbondale; and David Houseknecht, University of Missouri-Columbia.

The Caseyville Formation is exposed here, with exception of a covered interval about 30 feet (9 m) thick in the central part.

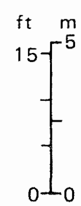
The stop consists of two roadcuts in the Caseyville Formation separated by a covered interval. The lower



UNIT 4. Lenticular and flaser-bedded siltstone with shale interbeds; units contain numerous small horizontal burrows and load features.

UNIT 3. Sandstone, quartzose, fine- to coarse-grained, cross-bedded; contains quartz and chert granules and pebbles. Repeated superimposed channel-fill deposits; individual channel fill consists of basal lag conglomerate containing clay pebbles, quartz and chert pebbles, and log casts (*Calamites* sp. and *Lepidodendron* sp.); overlain by medium- to coarse-grained sandstone with polymodal trough cross-beds. The uppermost unit is lenticular, flaser-bedded siltstone and shale containing leaf and twig impressions and abundant carbonaceous plant fragments. Grain size decreases upward within channel-fill deposit and horizontally toward the channel margins. Slump blocks as much as 5 feet in diameter occur along the north channel margin on the east side of the highway.

UNIT 2. Limestone, light gray, thick-bedded, very fossiliferous, consists of biomicrites and biosparites. Contains solitary corals, *Archimedes*, other fenestrate bryozoans, ramose and frondose bryozoans, brachiopods and gastropods. Trace fossils include vertical burrows as much as 12 inches long in upper part of lower limestone, and long branching horizontal burrows near base of lower limestone. Shale interbeds containing flame structures occur in upper limestone. Interbeds become more abundant and thicker toward the top. Upper limestone contains microtrough cross-beds and lenticular beds. Irregular chert-filled concretions present in the upper part of upper limestone. Sinkholes occur both east and west of roadcut.



UNIT 1. Shale, dark gray, finely laminated, very fossiliferous. Contains numerous thin to thick lenses of argillaceous, gray, biomicritic limestone. Shale contains *Archimedes, Fenestrella, Polypora,* crinoid debris, solitary corals, and brachiopods. Limestones abundantly fossiliferous; contain allochems of fenestrate, fistuliporoid, and trepostome bryozoans and brachiopods.

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Figure IL-34. Columnar section and description of rock units, Mississippian-Pennsylvanian Unconformity, U.S. Route 51 (Illinois Stop 7). (After Rousch and Ethridge, 1973.)

roadcut consists of about 170 feet (52 m) of sandstone and shale (Battery Rock Sandstone Member). The upper roadcut consists of about 105 feet (32 m) of sandstone and shale (Pounds Sandstone Member). Strata dip about 1° northward.

This roadcut was first described by Harris (1961); additional descriptions and environmental interpretation have been made (Simon and Hopkins, 1966; Gopinath, 1972; Roush, 1972; Ethridge et al., 1973; Ethridge and Fraunfelter, 1976; and Koeninger, 1978). Environmental interpretations presented here are based on work by Koeninger (1978); additional data are presented in Koeninger and Mansfield, this Guidebook, part 2, p. 76-81.

Strata here appear to have been deposited in a fluvial and marine deltaic environment. In contrast, units of the Caseyville Formation exposed to the east, Interstate 24 (Stop 10), appear to have been deposited in a predominantly fluvial and fluvial-deltaic environment. Koeninger and Mansfield (this Guidebook, part 2) have characterized the individual facies and facies correlations between Interstate 57 and Interstate 24.

The Caseyville Formation here was deposited by shifting distributaries on a lower delta plain, with several episodes of channel abandonment and reoccupation. Channel abandonment and filling resulted in slack-water environments in which tides and waves reworked previously deposited sand. Peat swamp conditions developed only once, which suggests that varying depositional conditions on the delta plain rarely permitted establishment of vegetation.

Caseyville Formation, Lower Roadcut, Interstate 57.

The section at Stop 8 consists of sandstone with interbedded conglomerate, siltstone and shale. Its total thickness is about 170 feet (52 m). The strata include interdistributary bay, deltaic lake, distributary/fluvial channel, abandoned channel, and marsh depositional facies.

The outcrop is divided into seven depositional units. Descriptions of the rock units are given in figure IL-35; inferred depositional environments for each unit are described in the following paragraphs.

UNIT 1 (at bottom of section). Sandstone and siltstone. Interdistributary bay-fill deposit; grades into overlying unit.

UNIT 2. Gray to black mudstone. Deltaic lake deposit. Upper part cut by distributary/fluvial channel.

UNIT 3. Sandstone and conglomerate. Distributary/fluvial channel-fill deposit. Becomes finer grained in upper part, suggesting that slack-water conditions developed as the channel was abandoned and filled.

UNIT 4. Shale with sandstone and siltstone. Slack-water deposits that were affected by wave and tidal currents. Upper part eroded by distributary/fluvial channel.

UNIT 5. Sandstone with conglomerate and shale. Distributary/fluvial channel-fill deposits. Grades upward to shale, as slack-water conditions developed.

UNIT 6. Shale with sandstone lenses. Marsh and interspersed overbank deposits. Upper part eroded by distributary/fluvial channel.

UNIT 7. Fine grained sandstone. Distributary/fluvial channel-fill deposits.

27.2 Board buses; depart Stop 8, Lower Roadcut.

27.9 Disembark buses; Stop 8, Upper Roadcut.

Caseyville Formation, Upper Roadcut, Interstate 57

The upper one-third of the Caseyville Formation (105 ft, 32 m) is exposed in the upper roadcut, which consists of sandstone with lesser amounts of conglomerate and siltstone (fig. IL-36). The outcrop is divided into three lithic units (fig. IL-37) which include abandoned channel, interdistributary bay, crevasse splay, and distributary/fluvial channel depositional facies, as described in the following paragraphs.

UNIT 1. Sandstone and shale. The lower part of Unit 1 was deposited in a tidally-influenced abandoned channel environment. Medium- to large-scale cross-beds in the middle part of Unit 1 suggest that an active channel subsequently reoccupied this area. Deposits of the upper part of Unit 1 suggest that a tidally influenced abandoned channel environment was re-established.

UNIT 2. Shale, siltstone, and sandstone. Unit 2 consists of interdistributary bay-fill deposits with crevasse splay deposits in the upper part.

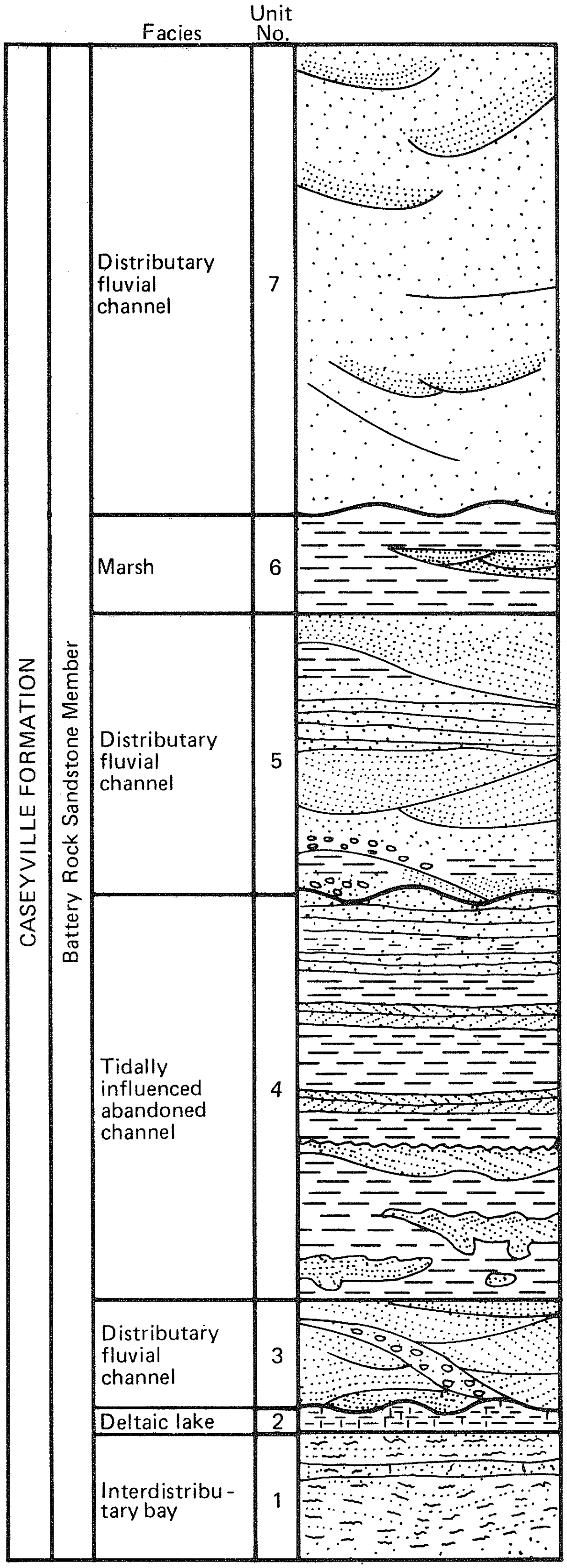
UNIT 3. Sandstone and siltstone. The nature and extent of cross-bedding in Unit 3 suggests that it was deposited as a fluvial/distributary channel deposit.

28.3 Board buses. Depart Stop 8, Upper Roadcut. Continue north on Interstate 57.

28.5 Goreville Exit. Leave I-57; stop sign. Turn right on Goreville Road. Sandstone, claystone, and shale of the Abbott Formation in both sides of Interstate 57 (thickness 25 ft, 7.6 m).

The Goreville road is located along the crest of the high escarpment that marks the Caseyville Formation cropline in southern Illinois. The lowlands (Lesser Shawnee Hills) to the south (right) are underlain by alternating sandstone, shale, and limestone beds of Chesterian (upper Mississippian) age.

Strata of the Caseyville Formation strike nearly eastward here, but underlying Chesterian (upper Mississippian) rocks strike southeastward. The difference in strike is due to regional warping of Mississippian rocks during



UNIT 7. Sandstone, white to light orange; light gray and orange with purple mottling where weathered; fine grained with individual grains subangular to subrounded. Sandstone is moderately sorted to well sorted and friable. Planar cross-bedding occurs on erosional surfaces; some units contain ripple and ripple-drift stratification. Paleocurrent direction toward northwest.

UNIT 6. Shale with sandstone lenses. Shale, brown to black, weathers gray with yellowish color due to sulfur content; partly carbonaceous, locally contains thin lenticular coal. Sandstone is white to light gray; yellow to black where weathered; fine- to medium-grained, with individual grains subangular to subrounded; thin bedded and partly cross-bedded. Sharp erosional contact with overlying sandstone.

UNIT 5. Sandstone with conglomerate and shale; sandstone, white to light gray, buff and brown where weathered, fine- to medium-grained; contains predominantly subrounded grains and moderately sorted to well sorted. The sandstone is cross-bedded but contains ripple-drift laminations and some horizontal beds. Conglomerate, dark reddish brown; contains quartz pebbles and clay chips. Occurs in trough sets of thin cross-bedded units and pinches out locally. Shale, very thin, missing locally. Paleocurrent directions trend both south-east and northeast. Gradational contact with overlying shale.

UNIT 4. Shale with sandstone and siltstone; shale, gray to black; sandstone and siltstone pink to orange, weathers tan and brown with purple mottling. Shale becomes silty toward top of unit and increases in silt content near sandstone lenses. Sandstone is lenticular; lenses are cross-bedded and occur as thin trough-sets of thin to laminar beds. Bottom sets of cross-beds are generally tangential to an erosional base, and topset cross-beds grade into asymmetrical ripple beds. Lenses contain ball-and-pillow structures. Paleocurrent directions dominantly north-northeast and also south-southeast. Sharp erosional contact with overlying sandstone, conglomerate, and shale.

UNIT 3. Sandstone and conglomerate, light gray to pink, weathers orange with purple mottling. Sandstone is fine- to medium-grained; conglomerate has quartz pebbles as much as 1.5 cm long and clay chips as much as 5 cm long. Sand grains are subangular to subrounded and are moderately sorted to well sorted. Sandstone contains load casts and discontinuous, thick, planar, high-angle cross-bedding with some thin low-angle trough-sets; thin bedded. Conglomerate is thin-bedded and discontinuous. Paleocurrent direction is toward south-east. Grades into overlying shale.

UNIT 2. Mudstone; gray to black, weathers dark gray with yellow banding due to oxidized pyrite; thin and discontinuous beds. Sharp erosional contact with overlying sandstone.

UNIT 1. Sandstone and siltstone, quartzose, gray to orange, weathers tan-orange with purple mottling. Silt and fine sand grains are subangular to subrounded; well-sorted to moderately well-sorted. Very thin to laminar, somewhat wavy beds with very abundant symmetrical ripples. Lenticular and ripple laminations are common; few ripple-drift laminations. Grades into overlying mudstone.

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Figure IL-35. Columnar section and description, Caseyville Formation, Lower Roadcut, Interstate 57 (Illinois Stop 8). (After Koeninger, 1978, and Koeninger and Mansfield, 1979.)

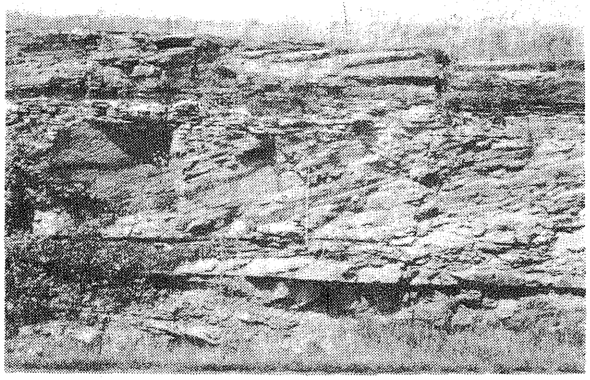


Figure IL-36. Large-scale planar cross-bedding in sandstone, upper part of Caseyville Formation (Upper Roadcut, Interstate 57, Illinois Stop 8). A well-defined erosional contact (just below base of measuring rod) separates cross-bedded sandstone (Unit 3 of fig. IL-37) from underlying sandstone and shale (Unit 2 of fig. IL-37). Measuring rod is 6 feet (1.8 m) long.

the hiatus following their deposition and preceeding deposition of Pennsylvanian strata. Much of the area of escarpments of the Caseyville Formation and the Lesser Shawnee Hills is included in the Shawnee National Forest. The alternating ridges and lowlands, bluffs, and overhangs are particularly scenic and have become popular areas for outdoor recreation.

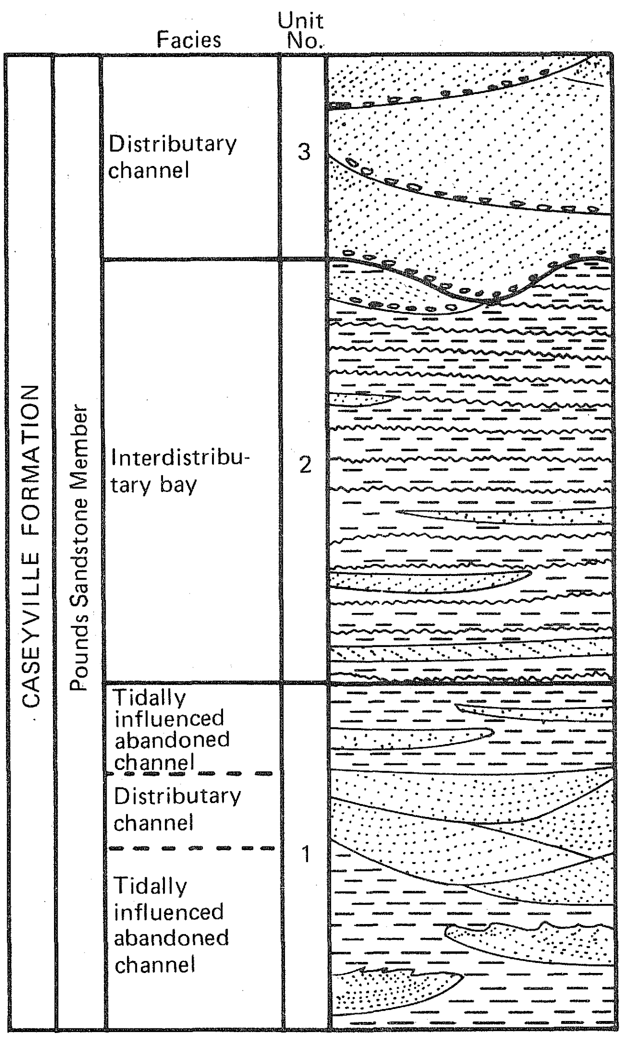
31.3 Goreville city limits. Named for an early settler, John Gore. Goreville advertises itself as the Crossroads of Southern Illinois, apparently due to its location near the intersection of Interstates 24 and 57.

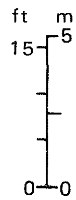
32.0 Stop sign. Illinois Route 37; turn right (south).

33.6 Entrance, Ferne Clyffe State Park; turn right (west).

34.2 Stop sign; turn left. Follow signs to picnic area.

35.4 Disembark buses.





UNIT 3. Sandstone and siltstone; sandstone, white; weathers tan and buff, fine- to medium-grained; grains are subrounded; large-scale planar cross-bedding dominant; some topset beds are gradational into ripple and ripple-laminated siltstone. Two sandstone-filled channels have eroded underlying siltstone and sandstone. Paleocurrent directions south-southeast.

UNIT 2. Shale and siltstone with sandstone; shale, light gray, weathers dark brown and black, silty. Sandstone, light purple, weathers brown or rusty purple; fine- to very fine-grained; grains are subangular to subrounded, cross-bedded and lenticular; asymmetrical ripple laminations common. Siltstone and shale, uniformly thin-bedded, ripple laminations common, generally asymmetrical. Paleocurrent direction to south and southeast. Sharp contact with overlying sandstone (fig. IL-36)

UNIT 1. Sandstone and shale; sandstone, white to orange, weathers dark orange and brown with purple mottling, fine-grained with grains subangular to subrounded. Quartz is dominant mineral. Shale, dark gray to black, weathers light gray and white, silty. The sandstone occurs as lenses filling channel scours in shale and as laterally persistent beds. Sandstone is cross-bedded; load features are common. Paleocurrent directions west-northwest and west. Gradational contact with overlying shale and siltstone.

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Figure IL-37. Columnar section and description, Caseyville Formation, Upper Roadcut, Interstate 57 (Illinois Stop 8). (After Koeninger, 1978, and Koeninger and Mansfield, 1979.)

STOP 9 Ferne Clyffe State Park (lunch stop).

Leader: Stanley E. Harris, Jr., Southern Illinois University at Carbondale.

Geology and ecology of Ferne Clyffe State Park

The cliffs surrounding the picnic area are the Pounds Member of the Caseyville Formation. Widely spaced orthogonal joint sets in the sandstone have allowed separation and collapse of many large blocks. North of the picnic area is a cove where collapse blocks have formed long narrow passageways adjacent to the cliff walls. The collapse blocks, especially on the north side and along the passageways, commonly are covered with moss, lichens, and liverworts, and support plants such as hydrangea and alumroot.

In the picnic area, the floors of the coves are essentially at the level of the Drury Shale Member. Shale of this member crops out west of the parking lot where the stream has undercut the sandstone. The shale underlies the lowland belt that extends westward. A path leads westward up the grassy slope to a great shelter bluff. Weak rock beneath the massive sandstone has been eroded slowly downslope, leaving the base of the sandstone unsupported. Subsequent collapse resulted in a great arching roof that extends several meters under the bluff. Such shelter bluffs are common throughout the Shawnee Hills.

35.4 Board buses. Return to park entrance.
37.3 Illinois Route 37. Turn left. Retrace route to Interstate 57 on Goreville Road.
42.3 Junction with Interstate 57; enter northbound access road.
45.3 Sandstone, Abbott Formation, thickness about 14 feet (4.3 m). Medium-grained sandstone, trough cross-bedded; grades into micaceous siltstone, thin bedded to ripple bedded.
46.0 Junction, I-57 and I-24; proceed east on I-24.
48.2 Sandstone and shale, Abbott Formation, thickness about 36 feet (11 m). Medium grained, white to buff ripple-bedded sandstone, about 14 feet (4.3 m) thick, occurs in upper part of the outcrop. Contact with underlying trough cross-bedded sandstone is sharp. Gray shale as much as 4 feet (1.2 m) thick locally occurs as channel fill beneath the upper sandstone. Medium- to fine-grained sandstone containing low angle trough cross-bedding and ripple bedding occurs in the lower 18 feet (5.5 m) of exposure (fig. IL-38).
54.4 Sandstone and shale, Abbott Formation, thickness about 30 feet (9 m).
55.3 Grindstaff Sandstone Member, Abbott Formation. Thickness about 80 feet (24 m).
56.1 Abbott and Caseyville Formations.

STOP 10 The Abbott and Caseyville Formations (lower Pennsylvanian), Interstate 24.

Leaders: C. Allen Koeninger, Shell Oil Company; Charles F. Mansfield, Southern Illinois University at Carbondale; and John T. Popp and Russell A. Peppers, Illinois State Geological Survey.

Stop 10 consists of two roadcuts in the Abbott and Caseyville Formations which may be compared with exposures seen earlier on the fieldtrip. The roadcuts are separated by a covered interval. The upper roadcut consists of about 92 feet (28 m) of sandstones, shale, and coal (Grindstaff Sandstone and Reynoldsburg Coal Members of the Abbott Formation, and the Pounds Sandstone Member of the Caseyville Formation). The lower roadcut consists of about 170 feet (52 m) of sandstones and shales (Battery Rock Sandstone Member of the Caseyville Formation).

Descriptions and environmental interpretations of these strata were first made by Ethridge et al. in 1973. The interpretations presented here are based on work by Koeninger (1978), and additional discussion is presented in Koeninger and Mansfield, this Guidebook, part 2. The strata exposed at Stop 9 are predominantly fluvial and fluvial-deltaic in origin whereas strata at Stop 8 of Day 5 are fluvial-deltaic to marginal marine in origin. The strata at Stop 9 appear to have been deposited in a deltaic environment dominated by zones of shifting distributary-fluvial channels with little or no marine influence. The absence of apparent marine strata and the presence of numerous nonmarine strata (coal and gray shales) suggest that the rocks were deposited in an upper delta-plain environment.

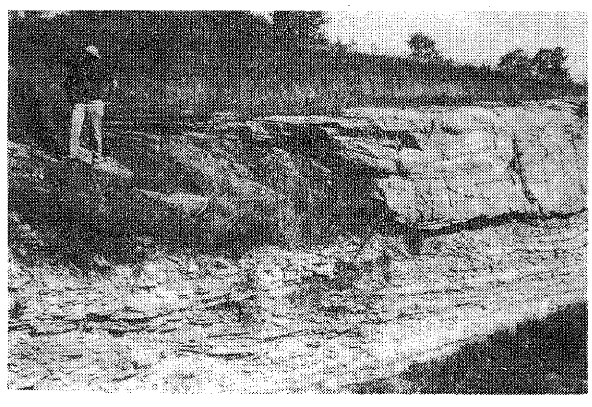


Figure IL-38. Trough cross-bedding in sandstone of the Abbott Formation. The upper thick-bedded sandstone is medium-grained and contains channel lag deposits on lower scour surfaces. A sharp erosional contact occurs at the base. Basal fine-grained shaly sandstone contains low angle trough cross-beds. View is to the east.

Abbott and Caseyville formations, Upper Roadcut, Interstate 24

Strata exposed here are divided into five distinct depositional units (fig. IL-39). The strata include the following depositional facies: channel/point bar, peat swamp, interdistributary bay, distributary channel or crevasse splay.

The type location of the Reynoldsburg Coal Member is about 6 miles (9.5 km) east of Stop 10 near the small town of Reynoldsburg. The coal is known to occur only in a relatively small area in the central part of the outcrop belt of southern Illinois (Hopkins and Simon, 1975). The coal, which is as much as 3 feet (0.9 m) thick, varies locally in thickness. The coal has been mined near Reynoldsburg.

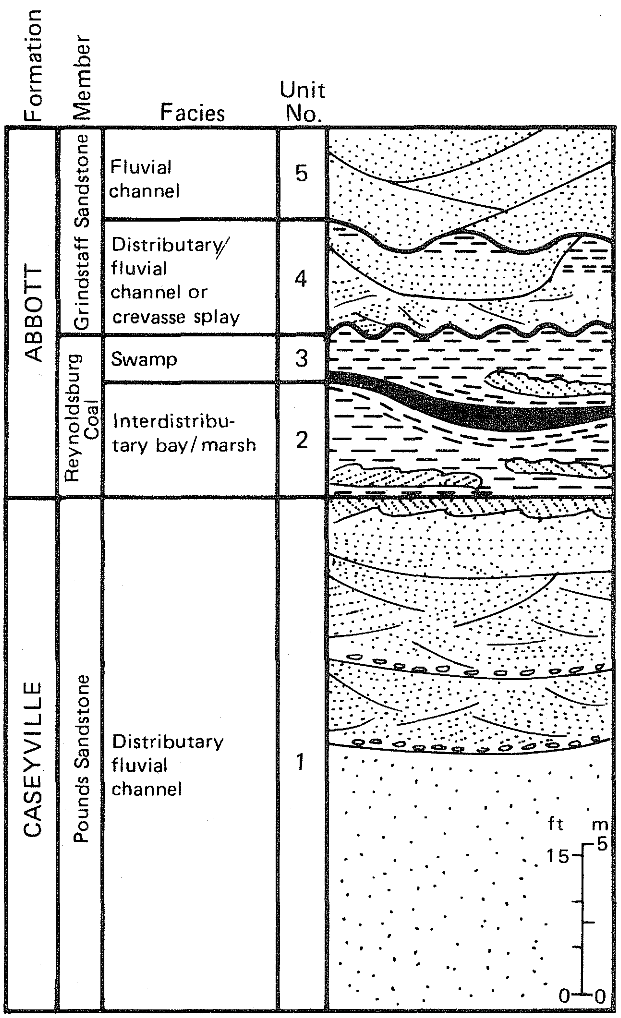
Two sandstone dikes are present in the Reynoldsburg Coal in the exposure on the east side of I-24 (fig. IL-40). Sandstone dikes occur rarely in coalbeds, and their origin is not completely understood. The dikes consist of sandstone similar to that directly overlying the coal, and the dikes pinch out downward toward the base of the coal. The dikes probably were emplaced as intrusions of sand from the overlying sandstone during compaction of the unconsolidated sediments.

Caseyville Formation, Lower Roadcut, Interstate 24

The section exposed here is 170 feet (52 m) thick and consists of sandstone with lesser amounts of conglomerate, siltstone, and shale. The strata include the following depositional facies: channel/point bar, upper point bar/floodplain, interdistributary bay, distributary channel, and abandoned channel.

The outcrop has been divided into five depositional units. Descriptions of the rock units are listed in figure IL-41; inferred depositional environments are described in the following paragraphs.

UNIT 1. Sandstone and conglomerate. Fluvial/distributary channel. Thickness of deposit and channel scours suggest that a meandering stream persisted in this area.



UNIT 5. Sandstone, white, weathers buff with iron-oxide staining, fine-grained to very fine-grained, grains are subangular to subrounded, well-sorted. Quartz is the dominant mineral; oxidized clay chips common. Unit is both planar cross-bedded with asymmetrical, low-amplitude ripples where sorting is poor, and structureless where sorting is good. Paleocurrent directions south-southwest.

UNIT 4. Sandstone and siltstone; sandstone, dark brown, weathers deep purple, fine- to medium-grained, subrounded grains, abundant quartz; some oxidized clay chips and wood fragment casts. Sandstone occurs as thick to thin lenses which have filled scours in siltstone. Siltstone, white, weathers light gray, fine-grained, silty, parts easily along bedding planes; thin- to very thin-bedded; deposits draped over sandstone lenses. Ripple lamination common. Paleocurrent directions west-southwest. Contact with overlying sandstone is sharp.

UNIT 3. Coal (Reynoldsburg Coal Member), shale, and siltstone. Unit 3 fills paleotopographic depressions and is scoured by Unit 4; thickness is variable. The coal is bright banded and as much as 27 inches (70 cm) thick; partly stained yellow. Shale, black, carbonaceous, thin-bedded. Siltstone, dark brown, weathers rusty brown, grains subangular; siltstone occurs in very thin lenses which are rippled and which cut into the underlying shale and grade into the overlying shale. Sharp contact with overlying sandstone and siltstone.

UNIT 2. Siltstone and shale; siltstone, light brown, weathers rusty brown and orange, subangular grains. Shale, gray, slightly silty, carbonaceous, thin-bedded to laminar. Siltstone is thin-bedded, ripple-bedded, and missing locally; fills an irregular eroded surface on underlying shale and grades into the overlying shale. Sharp contact with overlying shale and coal.

UNIT 1. Sandstone; white to pink, weathers rusty tan and buff, purple mottling, with red iron-oxide on bedding planes; fine-grained, grains are subrounded, sorting is fair to good. Quartz is the dominant mineral; contains few clay chips. Lower part of unit appears structureless due to good sorting of constituent grains; upper part contains planar and trough cross-beds. Paleocurrent directions south-southeast. Gradational contact with overlying siltstone and shale.

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Figure IL-39. Columnar section and description of units, Caseyville and Abbott Formations, Upper Roadcut, Interstate 24, (Illinois Stop 10). (After Koeninger, 1978, and Koeninger and Mansfield, 1979.)

UNIT 2. Sandstone, siltstone, and shale. An interdistributary bay environment, which was periodically interrupted by fluvial overbank deposits. Deposits were subject to periodic subareal erosions followed by marsh development. Upper part scoured by fluvial/distributary channels.
UNIT 3. Sandstone. Fluvial/distributary deposits, which are extensively cross-bedded.
UNIT 4. Sandstone, siltstone, and shale. Abandoned distributary channel fill, marsh deposits.
UNIT 5. Sandstone. Abandoned distributary channel fill.

The repeated occurrence of distributary channel and channel-fill deposits separated by interdistributary bay and overbank deposits suggests continued deposition and shifting of distributaries on a delta plain.

58.3 Depart Stop 10, lower roadcut. Continue south on I-24. Note terra rosa residual soil on Chesterian limestones, roadway median.
59.4 Vienna Exit, leave I-24. Stop sign, Illinois Route 146. Turn left. The Menard Limestone exposed here contains greenish-gray, micaceous shale and siltstone (11 ft thickness, or 3.4 m) overlying fossiliferous limestone (1 ft, 3 m).
60.1 Enter westbound access road, I-24.
62.4 to 63.6 Large roadcut, Abbott and Caseyville Formations, located about 0.25 mile (0.5 km) east of Stop 10.
72.5 Enter Williamson County. Till exposed here marks the southernmost advance of Illinoian (Pleistocene) glaciation in this area.
73.4 Junction, Interstates 24 and 57; proceed north on I-57.
74.6 Note sandstone of the Abbott Formation at Illinois Route 148 overpass. About 12 feet (3.7 m) of medium grained, light gray sandstone are exposed here. The sandstone is thin bedded and cross-bedded with some ripple bedding.

Visible to the east is stack of the Marion Plant, a coal-fired power plant operated by Southern Illinois Power Cooperative at Lake of Egypt. This plant used about 370,000 tons of 3.5 percent sulfur coal in 1976. Its generating capacity is 99 megawatts.
81.3 Palzo Sandstone Member of the Spoon Formation. Medium-grained, light gray, cross-bedded sandstone (17 feet or 5.1 m thick). Sandstones in individual cross-bed troughs become finer upward and have channel lag deposits at their base. This sandstone overlies the Davis and De Koven Coal Members.
82.1 Veterans Administration Hospital, right (east).
83.0 DeYoung Street Exit and junction with Illinois Route 13; take east exit to Marion and Harrisburg.

North of the highway interchange is crop line of the Herrin (No. 6) Coal Member (Carbondale Formation) which has been surface mined in this area. From this point northward, I-57 has very few roadcut exposures of the Pennsylvanian System. A thick mantle of

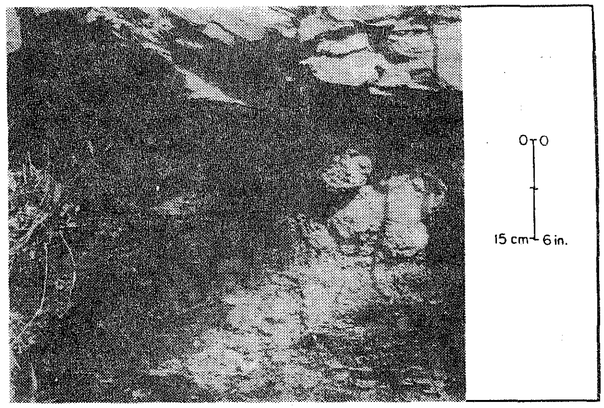


Figure IL-40. Sandstone dike in the Reynoldsburg Coal Member at Illinois Stop 10, Upper Roadcut. (Scale to the right of the dike is in inches and centimeters.) The dike apparently was derived from the overlying sandstone due to filling of an initially small depression at the top of the coal, and subsequent penetration into the coal. The dike tapers downward but entirely crosses the coal. Coal is approximately 1.5 feet thick.

loess, till, and outwash, for the most part, obscures all bedrock.

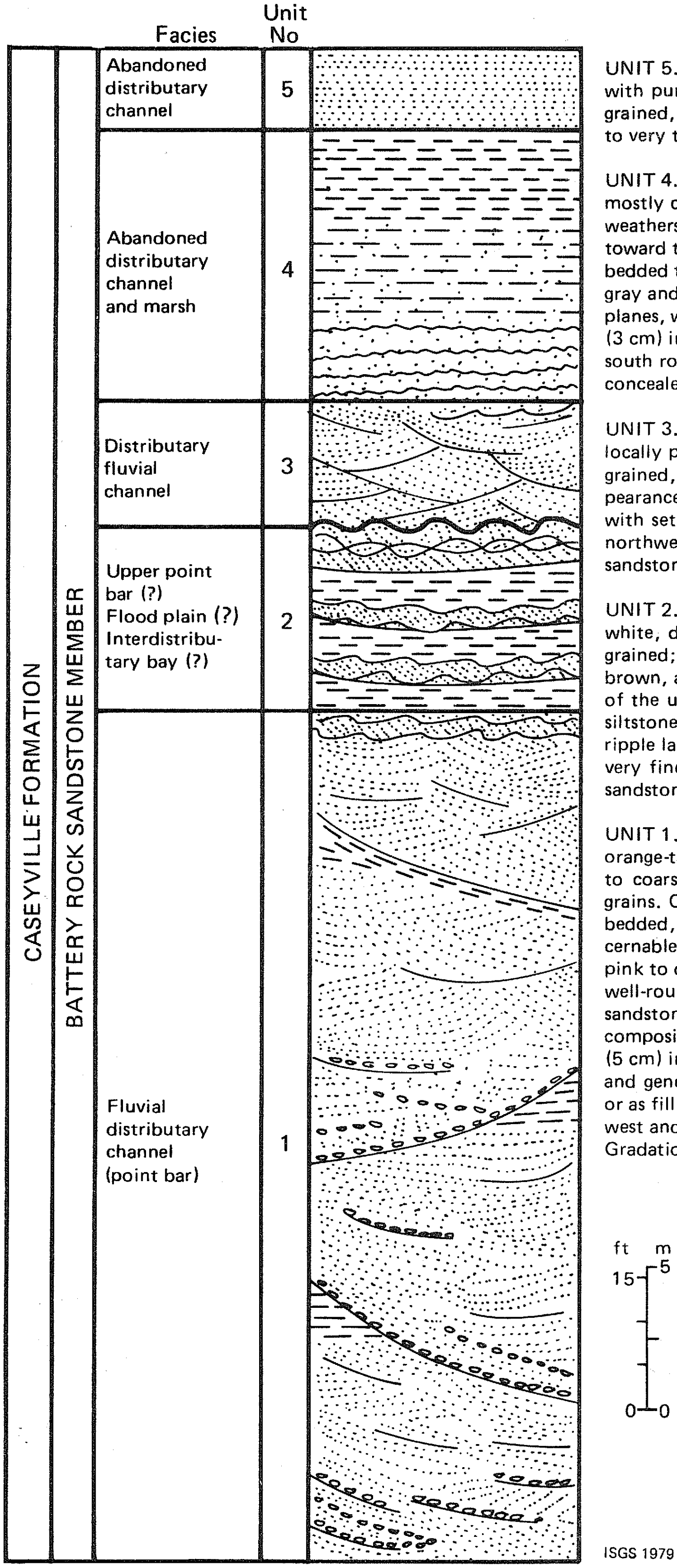
Enter city of Marion. Continue east on Illinois 13. Marion, the county seat of Williamson County, has a population of about 13,000.
84.6 Junction, Illinois Route 37; continue east.
89.2 Junction, Illinois Route 166; continue east.
91.5 Enter community of Crab Orchard.
92.9 To the north (left) is the active pit of the Delta Mine, AMAX Coal Company, which is a surface mine in the Herrin (No. 6) Coal Member. Northwest of the Delta Mine, Morris Coal, Inc., operates an underground mine in the Harrisburg (No. 5) Coal, which lies about 70 feet below the No. 6 Coal in this area.

Meadowlark Farms, Inc., a division of AMAX Coal Company, raises grain, hay, and livestock on reclaimed land here. In 1977, 78 acres (32 hectares) were mined, and an additional 78 acres (32 hectares) were graded and seeded in the reclamation process.

STOP 11. Herrin (No. 6) Coal Member (Carbondale Formation) and associated strata at Delta Mine, AMAX Coal Company.

Leaders: John E. Utgaard, Southern Illinois University at Carbondale; and Russell J. Jacobson, Illinois State Geological Survey.

Surface-mining operations began here in 1934 in an area south of Illinois Route 13. Mining began north of Route 13 in 1946 (fig. IL-42). The AMAX Coal Company expects to continue operations here for 20



UNIT 5. Sandstone, light gray, deeply weathered; rusty orange with purple mottling on weathered surfaces, fine- to medium-grained, friable, grains subangular to subrounded; bedding is thin to very thin. Contains a few low amplitude symmetrical ripples.

UNIT 4. Sandstone, siltstone and shale, deeply weathered; mostly covered by vegetation. Sandstone and siltstone, light tan, weathers dark orange, very fine-grained, silty; becomes finer toward top of unit; grains are subangular to subrounded; thin-bedded to laminated. Few low amplitude ripples present. Shale, gray and brown, weathers dark brown, carbonaceous on bedding planes, with abundant iron oxide concretions as much as 1¼ inch (3 cm) in diameter. Thin, discontinuous coal (12 in. or 30 cm) in south roadcut. May be the Gentry Coal Member. Upper contact is concealed.

UNIT 3. Sandstone, gray-white, orange where weathered, locally purple along joints and bedding planes, medium- to fine-grained, grains are subrounded to subangular; arkosic in appearance; poorly indurated. Unit contains trough cross-bedding with sets filling scours in underlying sets. Paleocurrent trend northwest and southwest. Gradational contact with overlying sandstone and siltstone.

UNIT 2. Sandstone, siltstone, and shale; sandstone is purplish white, dark orange and purple where weathered, very fine-grained; grains are subrounded to subangular. Shale, gray, tan, brown, and gray where weathered; banded in upper one-third of the unit; slightly silty. Shale grades laterally into lenticular siltstone. Sandstone, thin- to thick-bedded, ripple-bedded to ripple laminated, with some fine-grained scours into underlying very fine-grained beds. Sharp erosional contact with overlying sandstone.

UNIT 1. Sandstone and conglomerate, white and light pink, orange-tan with purple and red zones where weathered, medium- to coarse-grained, becomes finer in upper part, subrounded grains. Quartz is dominant mineral. Sandstone, planar cross-bedded, but with trough cross-bedding in channel fill. No discernable structure in some units. Conglomerate, white and light pink to dark tan-brown and reddish where weathered, consists of well-rounded, polished, oblate to spheroidal quartz pebbles in sandstone matrix. Matrix is similar to adjacent sandstone beds in composition and texture. Quartz pebbles as much as 2 inch (5 cm) in diameter. Conglomerate is thin- to very thin-bedded and generally occurs as elongate lenses along bedding planes or as fill in channels and scours. Paleocurrent direction northwest and southwest. Trend of two channels is west-southwest. Gradational contact with overlying shale.

Figure IL-41. Columnar section and description of units, Caseyville Formation, Lower Roadcut, Interstate 24 (Illinois Stop 10). (After Koeninger, 1978, and Koeninger and Mansfield, 1979.)

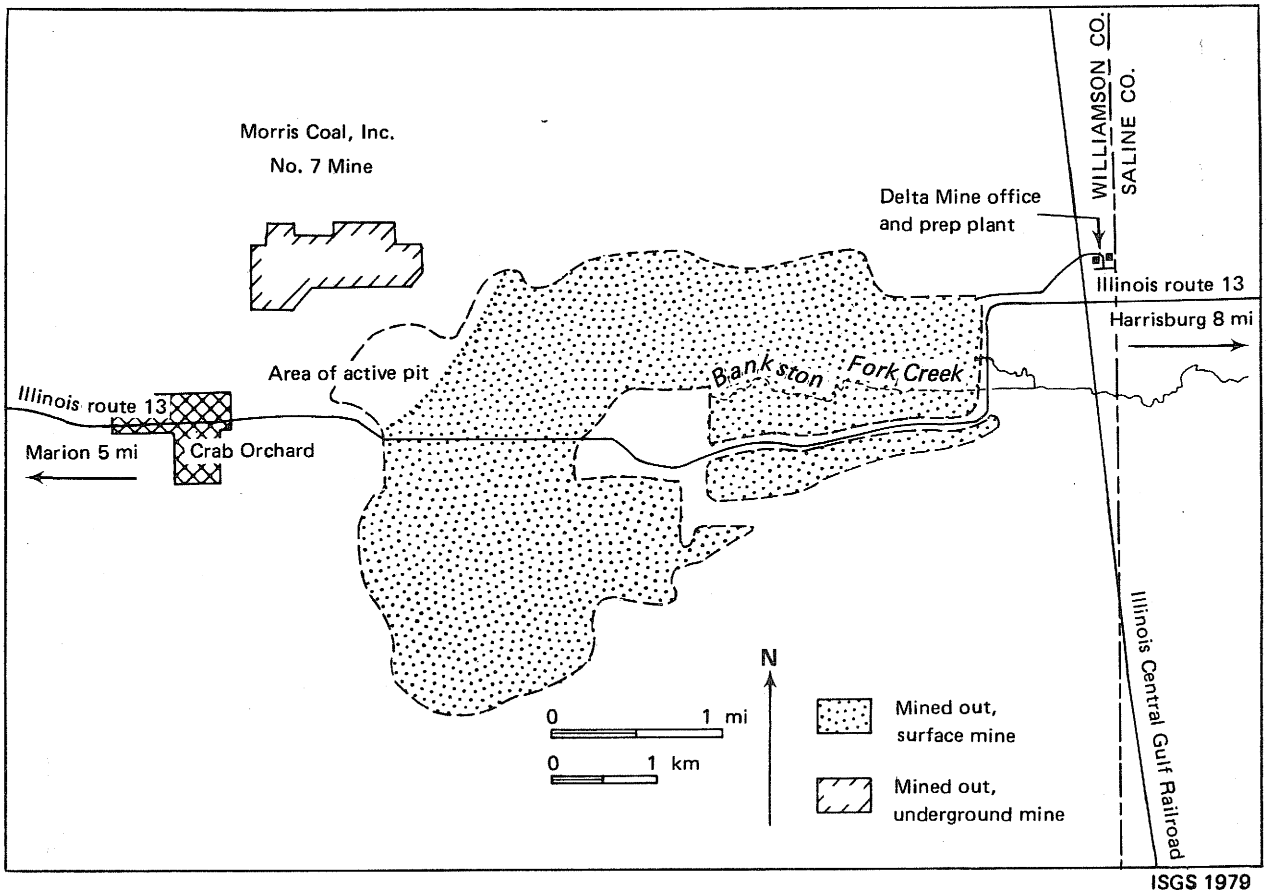


Figure IL-42. Location map, Delta Mine, AMAX Coal Company, Williamson County, Illinois.

years and to mine a total of 6,000 acres (2,430 hectares). Coal production in 1977 was 453,795 tons (411,683 MT) prior to a major expansion program which is now underway. Construction of a new dragline is expected to triple production capabilities. At Delta Mine the Herrin (No. 6) Coal is approximately 60 inches (152 cm) thick and lies beneath approximately 115 feet (35 m) of overburden in the present area of operation.

Rock strata exposed in the mine include units extending from the underclay beneath the Herrin (No. 6) Coal to and including the Bankston Fork Limestone Member (fig. IL-43). These units have been described by Hopkins (1958) and by Utgaard and Givens (1973). Many of the stratigraphic units in the Delta Mine are considerably variable in thickness and lithology, and several units are absent where mining operations are in progress in the northwest part of the mine. Utgaard (this Guidebook, part 2, p. 86-92) has described rock strata at the Delta Mine. His descriptions and environmental interpretations are summarized in the following paragraphs.

UNIT 1. Underclay, gray to greenish-gray, soft, rooted. Served as soil for initial development of coal-forming peat swamp.

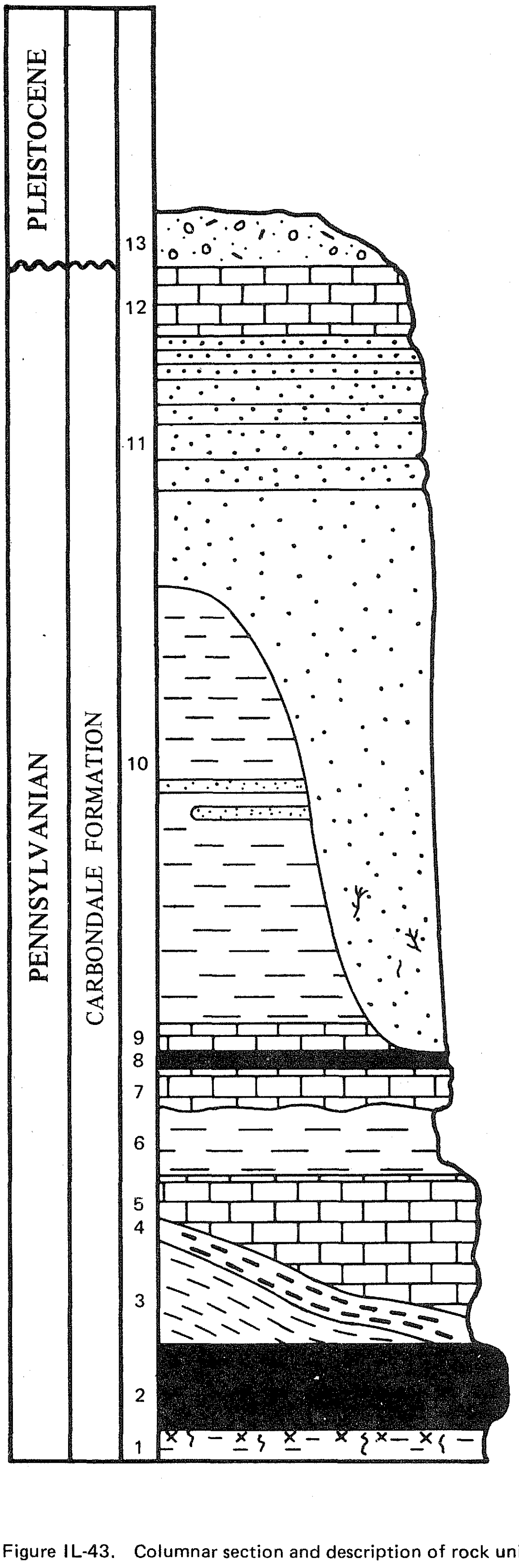
UNIT 2. Herrin (No. 6) Coal. Contains one or more clay or shale partings. Developed within a widespread system of peat swamps on a low, broad deltaic plain.

UNIT 3. Energy Shale Member. Gray shale. Some deposits appear to have formed in sites of local deposition, such as inlet channels where aerated marine waters invaded the coal swamps. About 25 miles (43 km) to the west this unit apparently consists of overbank and crevasse splay deposits of the Walshville channel (Palmer, Jacobson, and Trask, this Guidebook, part 2, p. 92-102.)

UNIT 4. Anna Shale Member. Dark gray to black carbonaceous shale. Probably represents incursions of aerated marine waters onto peat swamp. Highly carbonaecous black mud was deposited over both peat and gray shale lenses. Waters apparently approached normal salinity near end of Anna Shale deposition. A floating mat of vegetation may have prevented oxidation of organic matter.

UNIT 5. Brereton Limestone Member. Gray, fine-grained fossiliferous limestone. Offshore, shallow marine deposition. Lithic variations probably reflect variations in water agitation and deposition of detrital clay, with resultant changes in colonization of the bottom.

UNIT 6. Unnamed shale member. Dark gray, fossil-



13. Glacial drift. Undifferentiated, green clay with plant remains and yellow-brown, fine-grained loess. Erosional unconformity separates drift and loess from the Bankston Fork Limestone.

12. Bankston Fork Limestone Member. Limestone, light to medium gray, finely crystalline, argillaceous, contains marine fossils.

11. Anvil Rock Sandstone Member. Sandstone, quartzitic, light gray to brown, very fine to medium grained, micaceous, argillaceous, and carbonaceous. The sheet phase, which overlies the Lawson Shale Member, contains shale interbeds, a sparse fauna of bivalves, burrows, and abundant plant fragments. The channel phase, which locally cuts down to the Jamestown Coal Member at Delta Mine, displays large-scale cross-beds, becomes finer grained upward, and contains coal and plant fragments.

10. Lawson Shale Member. Shale, medium gray, micaceous, silty, interbedded lenticular siltstone beds with microcross laminations and thin sandstone beds filling channels. Contains plant fragments and horizontal and vertical dwelling burrows, feeding burrows, and trails. Absent where removed by Anvil Rock Sandstone.

9. Conant Limestone Member. Limestone, medium to dark gray, argillaceous, fossiliferous; contains a diverse offshore marine fauna (including sponges, corals, bryozoans, brachiopods, bivalves, gastropods, edrioasteroids, and crinoids) and some plant debris. Absent where removed by Anvil Rock Sandstone.
8. Jamestown Coal Member. Coal, bright banded, thin.
7. Unnamed limestone member. Limestone, dark gray, argillaceous, and fossiliferous. Contains a diverse, offshore marine fauna (sponges, corals, bryozoans, brachiopods, bivalves, gastropods, and crinoids) and in situ *Stigmaria*. Amount of detrital clay increases northward, and the unit is locally absent.
6. Unnamed shale member. Shale, dark gray, calcareous, fossiliferous. Contains a diverse offshore marine fauna (including fusulinids, corals, bryozoans, brachiopods, crinoids, and echinoids). Unit thins and becomes more argillaceous northward and may be absent in the pit.
5. Brereton Limestone Member. Limestone, micritic, gray, dense, fossiliferous, and/or argillaceous. Contains a diverse, offshore, shallow marine fauna (including fusulinids, other foraminifera, sponges, corals, bryozoans, brachiopods, bivalves, and crinoids), and some plant fragments.
4. Anna Shale Member. Shale, dark gray to grayish black, with sheety fissility. Highly carbonaceous and contains a sparse brackish to marine fauna (including conodonts, shark teeth, fish spines, *Dunbarella,* and *Orbiculoidea*) and driftwood fragments.
3. Energy Shale Member. Shale, soft, gray, contains plant fragments and a sparse marine fauna (bivalves, cephalopods, and brachiopods). Locally a thin (4 to 5 inches), thin-bedded dark gray shale is present at the base.
2. Herrin (No. 6) Coal Member. Coal, bright banded, can contain several clay partings, one of which is the prominent "blue band" in the lower part of the coal. Locally contains coal balls.
1. Underclay. Clay, soft, gray to greenish-gray, rooted.

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Figure IL-43. Columnar section and description of rock units, Delta Mine (Stop 11). (After Utgaard, 1979.)

iferous shale. May represent in part fairly rapid deposition of detrital clay in turbid water. Influx of clastics apparently slowed during deposition of upper part, with establishment of a diverse, level-bottom community.

UNIT 7. Unnamed limestone member. Appears to be a facies of the upper part of the underlying unnamed shale member (Unit 6). Was periodically affected by stronger current or wave action, as evidenced by local patches of better sorted crinoid debris. In situ *Stigmaria* roots with attached rootlets indicate this argillaceous marine carbonate served as the growth surface for plants that produced the Jamestown Coal.

UNIT 8. Jamestown Coal Member. In situ plant material that accumulated in a swamp developed on Unnamed Limestone Member (Unit 7).

UNIT 9. Conant Limestone Member. Gray, fossiliferous limestone. Striking similarities between assemblages and the fossil community in this limestone and that of Units 6 and 7 suggest that marine conditions were essentially similar immediately before and after deposition of the Jamestown Coal and permitted reestablishment of essentially the same, recurrent community in the Conant Limestone Member.

UNIT 10. Lawson Shale Member. Gray, micaceous carbonaceous shale. Contains mostly trace fossils, including horizontal and vertical dwelling burrows. Interpreted as either prodelta or interdistributary bay deposit.

UNIT 11. Anvil Rock Sandstone Member. Medium- to very fine-grained, micaceous quartz sandstone. Consists of distributary channels, delta front sands, and interdistributary bay deposits. Represents the constructional phase of a broad delta.

UNIT 12. Bankston Fork Limestone Member. Not studied at Delta Mine. Elsewhere the Bankston Fork Limestone contains a shallow water open marine fauna similar to those in the Brereton and Conant Limestones.

92.9 Depart AMAX Delta Mine. Return to Illinois Route 13; turn right (west). Retrace route to Marion.

110.1 Enter Marion. Continue west on Illinois 13 through Marion.

116.8 Junction with Illinois Route 148; continue west on Illinois 13.

120.4 Enter Crainville.

121.0 Enter Carterville. Carterville is named for Leban Carter who arrived from Tennessee in 1864 and sank a coal shaft just east of town. The town was incorporated in 1872 and today has a population of about 3,000.

123.2 Crab Orchard Lake and Crab Orchard National Wildlife Refuge.

Crab Orchard Lake and its associated wildlife refuge were completed in 1940 by the Works Progress Administration and the Soil Conservation Service of the U.S. Government. The lake and refuge were begun as work relief-flood control projects. Crab Orchard Lake covers about 7,000 acres (2,830 hectares) and provides outdoor recreation for the area. The wildlife refuge includes 43,000 acres (17,400 hectares) and serves as a winter refuge for Canadian geese and other migratory birds which feed on about 6,000 acres (2,430 hectares) of cropland. Last fall and winter, hunters in southern Illinois counties were allowed to shoot 40,000 geese. With close management and restricted hunting, the flock has grown from approximately 200,000 geese to nearly 500,000 during the last 10 years.

125.2 Jackson County Line.

127.2 Enter Carbondale.

128.0 End of Day 5. Overnight stop, Holiday Inn, Carbondale.

DAY 6 Carbondale, Illinois, to southwestern Illinois area.

Trip leaders: Stanley E. Harris, Jr., and John E. Utgaard, Southern Illinois University at Carbondale; and Russell J. Jacobson and Richard D. Harvey, Illinois State Geological Survey.

Friday, June 1, 1979

STOP 12. **Channel fill and associated deposits of the Walshville channel and Anvil Rock channel. channel.**

STOP 13. **View of Mississippi River floodplain and Fountain Bluff (optional stop).**

STOP 14. **Sedimentary features of the Caseyville Formation, Kinkaid Lake Spillway.**

STOP 15. **Upper Desmoinesian strata, Burning Star No. 4 Mine.**

STOP 16. **Reclamation practices, Captain Mine, Southwestern Illinois Coal Company.**

End of field trip.

0.0 Board buses, Holiday Inn parking lot. Turn right (west) on Illinois Route 13. See figure IL-44 for a map of today's route.

0.7 Junction of Illinois Route 13 with U.S. Route 51, turn right (north) on U.S. 51.

1.3 For the next several miles, the field trip route crosses slackwater deposits of Pleistocene Lake Muddy. These deposits are similar in origin and lithology to those discussed on Day 4 for Pleistocene Lake Saline (see fig. IL-28, Day 4).

4.8 Bridge, Big Muddy River.

6.7 De Soto, Illinois, population about 1,000. De Soto is one of many communities in Illinois established on the route of the Illinois Central Railroad following its construction in the mid-19th century. It was named in honor of the Spaniard Hernando de Soto, one of the early explorers of the Gulf Coast of the United States.

7.1 Junction, Illinois Route 149; turn right (east).

10.0 Entrance road, Burning Star No. 5 Mine, Consolidation Coal Company; turn left (north).

STOP 12 Channel fill and associated deposits of the Walshville channel and an Anvil Rock channel.

Leaders: Russell J. Jacobson, Illinois State Geological Survey; and John E. Utgaard and Marc Deshowitz, Southern Illinois University at Carbondale.

General geologic setting

A large, linear body of sandstone and associated deposits extend from Shelby County about 150 miles (240 km) north on a somewhat meandering course through southwestern Illinois to this location, where the body is truncated by modern erosion at the cropline of the Herrin (no. 6) Coal Member (fig. IL-45). The sandstone was deposited by a river that flowed through the peat swamp of the Herrin Coal. Due to its effect upon deposition of the Herrin Coal and mining conditions (Nelson, this Guidebook, part 2, p. 151-158), deposits of this river have been intensively studied at the horizon of the Herrin Coal, where the channel is called the Walshville channel. Studies by Palmer, Jacobson, and Trask (this Guidebook, part 2, p. 92-102) indicate that sandstone filling the channel at this horizon is, in many areas, part of a succession of multistory or "stacked" sandstones which are locally as much as 300 feet (90 m) thick. The river that produced this thick body of sandstone appears to have been disrupted by shallow marine transgressions several times but successively reestablished itself in the same general area, apparently due to persistent differential subsidence. The multistory sandstone body is informally referred to as the "Highland fluvial complex."

The Burning Star No. 5 Mine is situated on the east flank of the channel-fill sequence (fig. IL-46). A cross section (A-A′) of the Walshville channel and associated deposits was compiled from coal test data (fig. IL-47). Drill holes 7, 8, 9, and 10, as sequentially numbered from left to right, are located directly in the sandstones and sandy siltstones which fill the Walshville channel. A channel margin overbank facies locally interrupted deposition of peat, producing thick splits in the Herrin Coal (drill holes 5 and 6, fig. IL-47). This split becomes much thinner farther to the west where it is also reached in drill holes 2, 3, and 4. No splits are identified in drill holes east of the channel, but thick deposits of the Energy Shale Member overlie the Herrin Coal. These appear to have been largely deposited in a crevasse splay.

At this stop an opportunity is offered to inspect the channel margin facies of the Walshville channel in an area where the closest approach yet to the channel by surface-mining operations has occurred. Although the margin of thick channel-fill deposits lies about 5,000 feet west of the highwall at this stop (fig. IL-46), mineable coal deposits terminate a short distance west of this pit due to coal splits and cut-outs.

Deposits from two major stream channels are present in the Burning Star No. 5 Mine area. Much of the lower part of the highwall, including all strata directly overlying the Herrin Coal, were derived from the Walshville channel. The sandstone that forms the upper part of the highwall is believed to have been deposited in an Anvil Rock channel as discussed on Day 4.

Stratigraphy and depositional environments of the Energy Shale Member

Overbank, crevasse splay, and splay margin deposits associated with the Walshville channel have been collectively given the name Energy Shale Member. Two major facies of the Energy Shale are recognized in the western one-quarter of the highwall at the Burning Star No. 5 Mine—splay channel-fill and splay margin facies. The western part of this highwall contains mainly splay channel-fill facies consisting of sandstone, siltstone, and silty shale, with lag deposits of siltstone pebble conglomerates which grade laterally and vertically into channel-fill sandstones (fig. IL-48).

A splay-margin facies consisting largely of shale is present to the east. This facies is replaced in the western half by the splay/channel-fill facies.

These deposits are overlain by point-bar deposits of medium- to coarse-grained sandstone of the Anvil Rock Sandstone Member (fig. IL-49). The Anvil Rock Sandstone is separated from the underlying Energy Shale by a marine gray shale which rests unconformably on an iron-stained corrosion surface developed on the underlying Energy Shale.

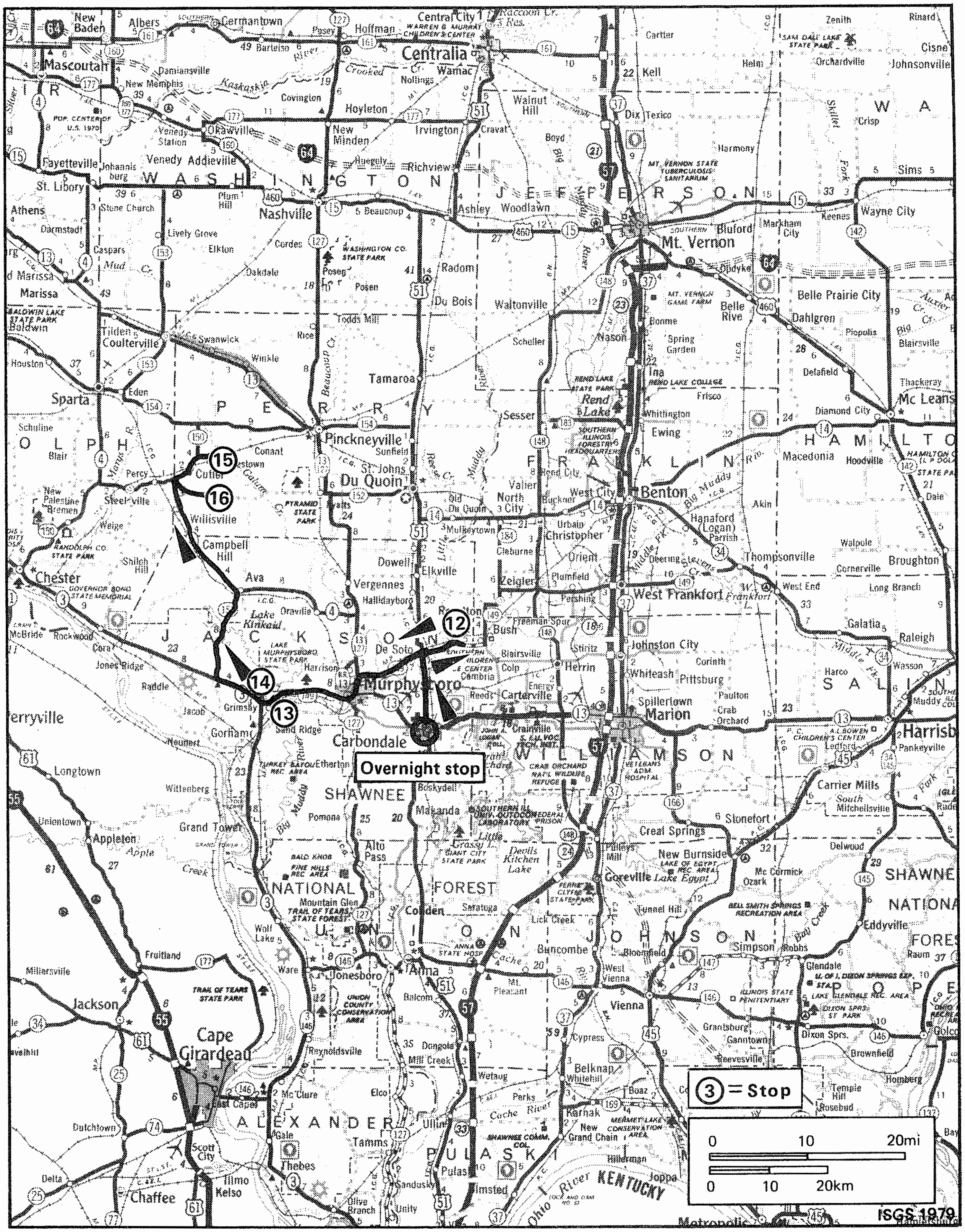

Figure IL-44. Field trip route for Illinois, Day 6, from Carbondale, Illinois, to southwestern Illinois area.

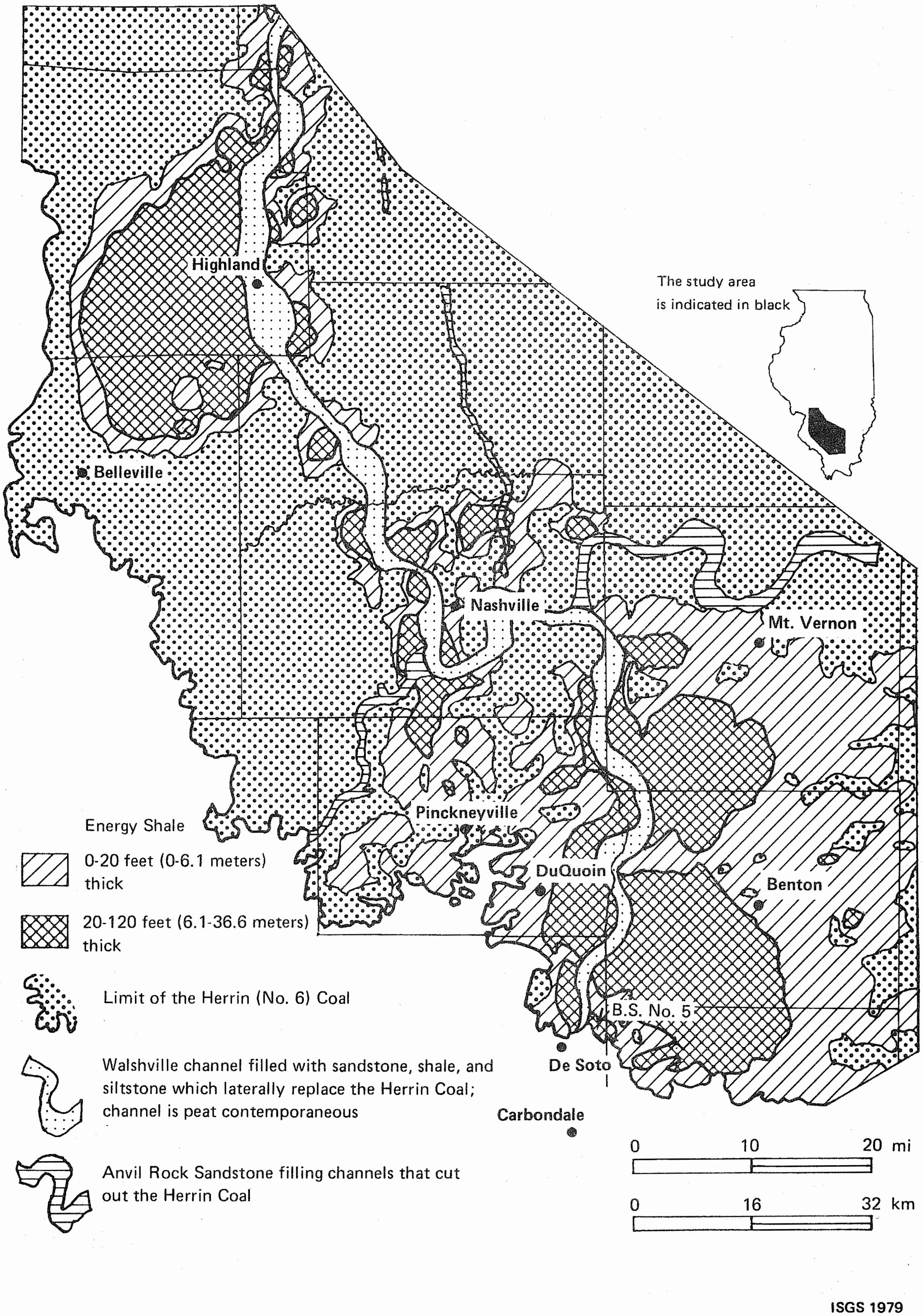

Figure IL-45. Distribution of the Walshville channel and Energy Shale and outcrop of the Herrin (No. 6) Coal in southwestern and western Illinois. (From Krausse et al., 1978.)

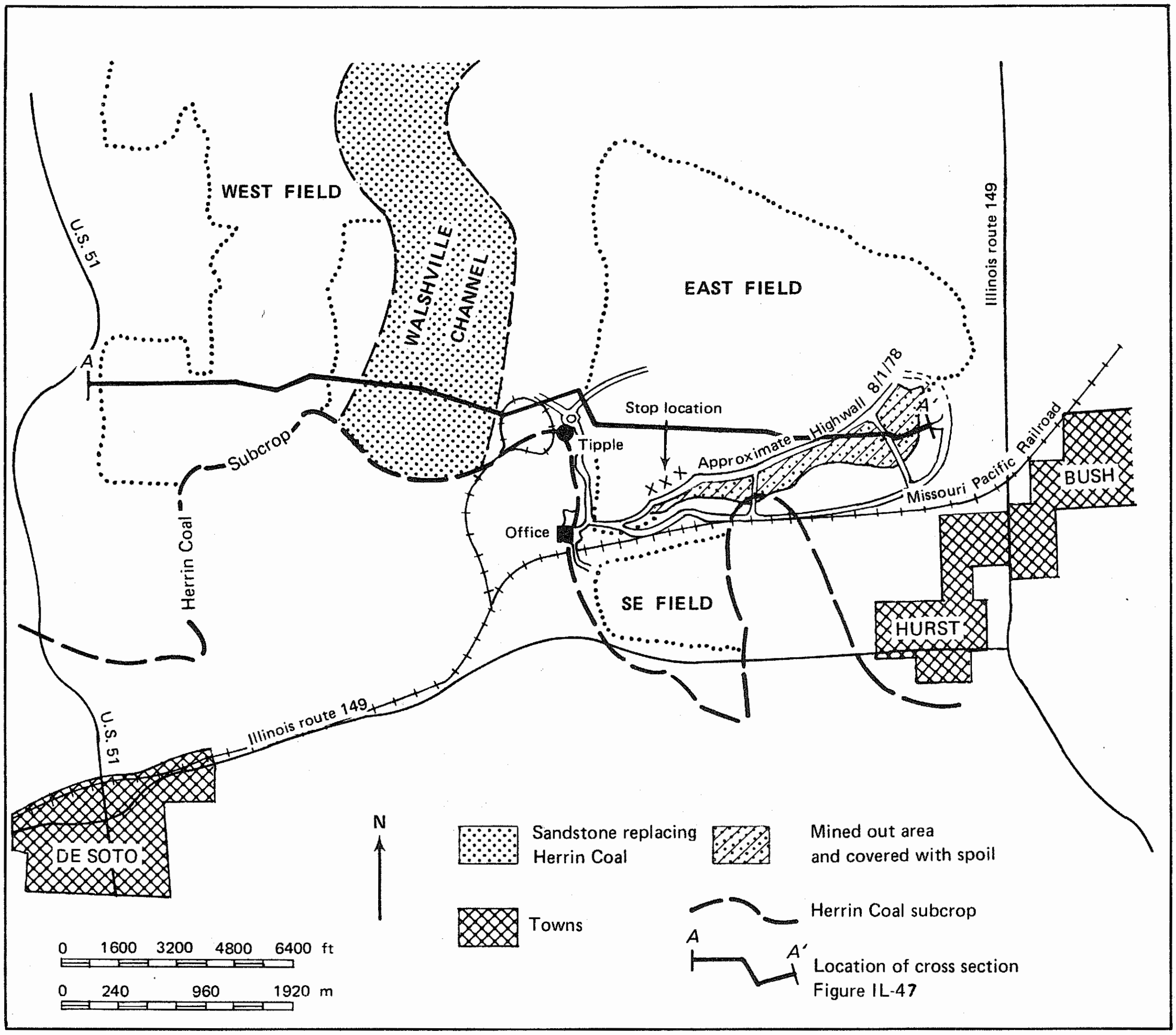

Figure IL-46. Burning Star No. 5 Mine, Consolidation Coal Company.

An interpretative model of depositional conditions (fig. IL-50) that may have existed in the Burning Star No. 5 Mine Area immediately prior to burial of the Herrin Coal depicts the relationship of channel fill, natural levee, splay-channel fill, and splay-margin facies to the peat swamp from which the Herrin Coal was formed.

Sedimentary features, detailed lithologic descriptions, and fossil remains through which these facies have been distinguished are listed in table IL-1 with details of inferred depositional environments.

10.0 Board buses, depart Stop 12, Burning Star No. 5 Mine. Turn right (west) on Illinois Route 149.

13.0 Enter De Soto. Junction with U.S. Route 51. Cross Route 51; continue straight (southwest) on Illinois 149.

17.1 Beaucoup Creek.

19.3 Junction, Illinois Routes 13 and 127. Turn left (south). Continue on Illinois 149.

19.9 Enter Murphysboro, population about 10,000. Immediately south of Murphysboro, one of the first major coal mines in Illinois was opened in the early part of the 19th century in the Murphysboro Coal Member of the Spoon Formation. Coal was shipped down the Big Muddy and Mississippi Rivers to points as far south as New Orleans. Major mining continued in the Murphysboro Coal until 1943.

20.2 Junction, Illinois Routes 13 and 149. Turn right (west) on Illinois 149 toward downtown Murphysboro.

23.3 Lake Murphysboro State Park on right (north).

25.1 Beehive-shaped charcoal ovens on left mark site of abandoned community of Brownsville, which was the early county seat of Jackson County.

27.0 Abbott Formation partly exposed here on

Table IL-1. Description of strata exposed in West End of Burning Star No. 5 Mine (East Pit) and inferred depositional history

Stratigraphic Unit	Description	Paleontology of units	Inferred depositional environment
ANVIL ROCK SANDSTONE MEMBER (0-48 ft, 0-14.4 m thick)	Sandstone, light gray to tan moderate yellow (5Y 7/6) when weathered; medium to coarse grained, friable, quartz-rich arenite; occurs as a channel fill deposit with tangential units in the lower portion that are internally trough cross-bedded and rise towards the margins in the upper half where they become largely horizontal but are still internally trough to planar cross-bedded. A basal lag consisting of clay pebbles, log casts, and coalified plant debris is present.	Plant debris, mostly coalified plant fragments and stems and log casts	This unit was deposited in point bars that filled a laterally migrating river channel that was part of the complicated Anvil Rock distributary system which prograded into the region from the east. The lower part of the sandstone deposit has large scale point bar accretion units whose tagential forset bedding was deposited in the edges of the active channel. The horizontally bedded units in the upper part of the deposit most likely represent the upper portions of the point bars which formed away from the edge of the active channel.
UNNAMED SHALE MEMBER (0-3 ft, 0-1 m thick)	Shale, present in a localized area beneath the margins of the Anvil Rock Sandstone. Dark gray (N3) to grayish black (N2), rests unconformably on an iron-stained corrosion surface, coating the underlying Energy. It has a weathered, unconformable contact with overlying Anvil Rock. Contains marine fossils, particularly in the base where they occur as a broken weathered hash.	Bryozoa-unidentified fragments of fenestrate Brachipoda Inarticulata *Lingula carbonaria* *Orbiculoidea missouriensis* Articulata *Composita* spp. *Crurythyris planoconvexa* Mollusca Bivalvia *Aviculopecten* spp. Gastropoda-unidentified forms Cephalopoda-unidentified fragments Chordata Pisces *Petrodus* spp. (shark dermicles miscellaneous fish teeth, spines, scales, and bone debris. Flora-carbonaceous plant fragments and coaly stringers.	A period of nondeposition and weathering is indicated by the corrosion surface on the Energy Shale below this unit. Eventually marine waters were able to cover the exposed splay depositing this shale in a shallow marine environment. The initial onlapping of marine waters onto the splay is recorded at the base of this shale where a broken highly weathered fossil breccia from marine organisms was deposited on the weathered Energy Shale surface. The shale deposited in this shallow marine environment may represent the initial influx of clastics into this area from a delta system to the east. Later progradation of this system over this region is represented by the Anvil Rock Sandstone that unconformably overlies this shale.
SPLAY CHANNEL-FILL FACIES (0-35 ft, 0-9 m thick)	(1) Sandstone and siltstone channel fill: Sandstone grading upward into siltstones. The sandstones are fine grained, medium dark gray (N4), and weather grayish yellow (5Y 8/4); quartz rich with angular quartz grains; abundant carbonaceous plant fragments. Clay pebbles, siderite pebbles, and log casts comprise a basal lag in some channel fills. Thin siltstone and shale partings are common. Siltstones are thin bedded, quartz-rich; with shale interbeds, load structures, and abundant plant fragments; and often are horizontally to ripple cross-laminated with clay drapes.	Plant debris, mostly coalified plant fragments and stem and log casts, with a few concretions containing plant compressions.	The sandstone and siltstone channel fill, and interbedded silty shales and sandstones of the Energy observed in the facies in the west half of this stop are interpreted to be splay distributary channel-fill deposits. The cut-and-fill relationships of the various units, and the various sedimentary structures observed, are all typical of channel-fill deposits. The channel-fill deposits observed here represent the complex, branching and laterally migrating splay distributary channels. These distributaries probably changed location during each successive flood, creating the complex cut-and-fill relationships characteristic of this facies. The varied lithology of fine- to medium-grained sandstone, interbedded sandstone and silty shale, and siltstone illustrates the varying amounts of sediment load during each depositional episode.

Table IL-1. *Continued*

Stratigraphic Unit	Description	Paleontology of units	Inferred depositional environment
SPLAY CHANNEL-FILL FACIES	(2) Sandstone and silty shale channel fill: Several channel fills with scoured bases contain a chaotic mixture of small sandstone and silty shale and siltstone clasts (fig. IL-48). Sandstones are medium grained, medium gray (N5) to weathered light gray (N7) or moderate yellow-brown (10YR 5/4), poorly sorted, micaceous quartz rich, with abundant plant fragments and silty shale pebbles. The beds are not continuous. The silty shale appears to be squeezed between the sandstone bodies, and soft sediment folding is evident. The chaotic nature of the bedding in these channel fills possibly represents rapid slumping of what was probably more regularly interbedded rippled sandstones and silty shales. (3) Interbedded silty shale and sandstone: Sandstones, 5 to 8 inches thick, medium gray (N5), tan to yellow when weathered, fine grained, quartz rich, poorly sorted and silty with concretions containing plant fragments. Sandstones contain numerous microcross laminations, asymmetrical ripples and climbing ripples. Flaser bedding is common. The silty shale interbeds are medium gray; weather brownish gray; and contain abundant, fine-grained carbonaceous plant fragments. Flame structures and convoluted bedding are found in this unit.		
SPLAY MARGIN FACIES (0-30 ft, 0-9 m thick)	Medium dark gray shale: This unit is medium dark gray (N4) to dark gray (N3), thinly laminated with abundant carbonized plant compressions and zones of abundant small to large sideritic concretions which contain well preserved plant fossils. Numerous coal stringers are present and several coal beds, 2 to 17 inches thick, split off from the Herrin (No. 6) Coal Member and ride up toward the west within the Energy Shale Member. Locally the shales are silty and contain small-scale cross laminations and ripple marks. Unit is 0 to 30 feet.	FLORA Lycopsida *Lepidodendron* spp. *Lepidophylloides laricinus* Sphenopsida *Calamites* spp. c.f. *carinatus* *Annularia stellata* Fern-Like Foliage *Pecopteris* spp. c.f. *lamuriana* c.f. *daubreii* c.f. *psuedovestita* c.f. *miltoni* Pteridospermophyta *Neuropteris* spp. c.f. *anomala* c.f. *scheuchzeri* c.f. *heterophylla* *Odontopteris* spp. c.f. *aequalis* *Alethopteris* spp. c.f. *serli* FAUNA Arthropoda, Crustacea, Branchipoda *Leaia tricarinata*	The medium to dark gray shale observed in the east half of the stop highwall represents distal crevasse splay deposits away from the coarser, splay distributary deposits, grading into the swamp and interdistributary bay. These finer clastics are typical deposits of splay margins and illustrate a reduced sediment load of the splay system at its margins due to the reduced current velocity and distance from the crevasse. The thin coal splits and stringers of the upper part of the Herrin (No. 6) Coal Member which interfinger with this facies indicate that the splay was spreading outward into the Herrin peat swamp. After each successive deposition of sediments along the splay margin, the Herrin peat swamp would reestablish itself on the splay margin. This process continued throughout the deposition of the shale preserved under the Anvil Rock channel, as is evidenced by coal partings near the top. The thin laminations, fine grain size, lack of sedimentary structures, and excellent preservation of delicate plants suggest deposition of part of the medium dark gray shale in quiet waters, possibly in an interdistributary bay.

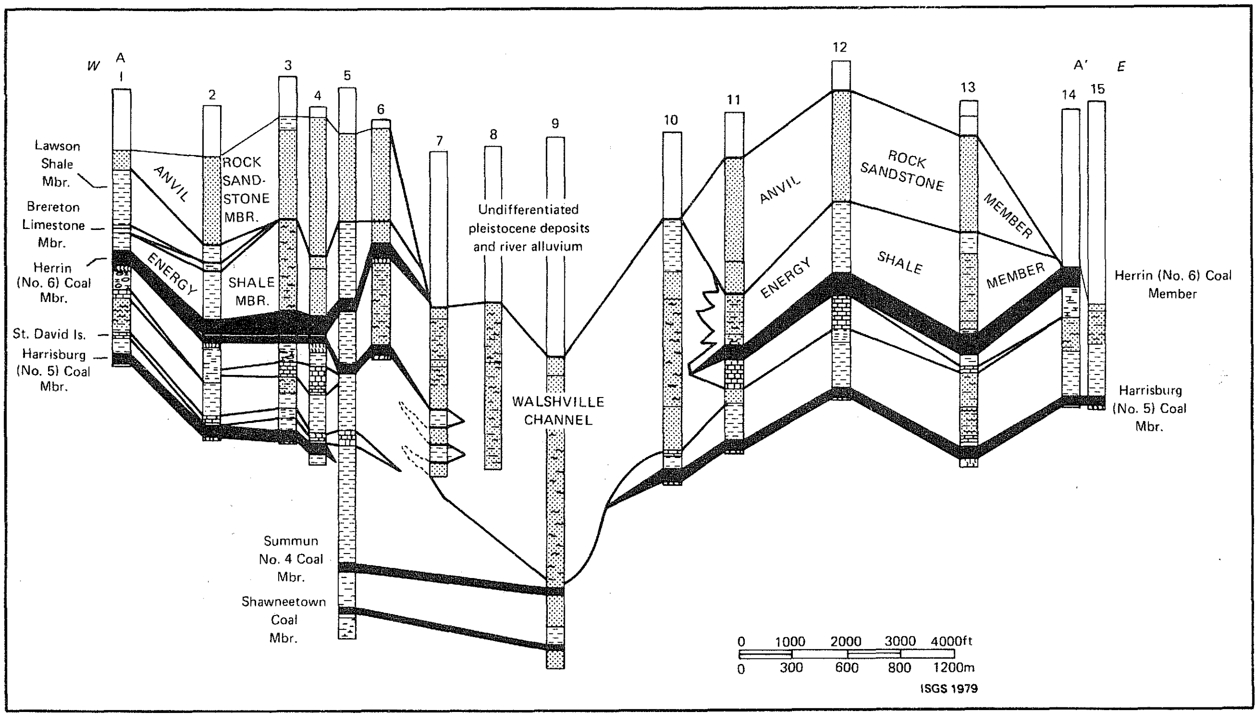

Figure IL-47. East-west cross section through Burning Star No. 5 Mine. (From Dutcher, Dutcher, and Hopkins, 1977; interpretations and correlations by R. J. Jacobson, 1979.)

both sides of highway for a distance of about one mile. Sandstone is generally dark reddish brown and thin bedded.

27.3 Pounds Sandstone Member, Caseyville Formation, roadcut on left side of road. Sandstone is yellowish-brown to buff; basal part is massive and cross-bedded with several channel scours; sandstone becomes thin bedded in upper part. Total thickness of section is about 8 feet (2.4 m).

STOP 13 View of Mississippi River floodplain and Fountain Bluff (optional stop).

Leaders: Stanley E. Harris, Jr., Southern Illinois University at Carbondale; and Russell J. Jacobson, Illinois State Geological Survey.

Fountain Bluff consists of northward dipping, thick bedded sandstone of the Caseyville Formation. Limestone and sandstone of the Chesterian Series (upper Mississippian) crop out at the south end. The bluff is bounded on the south by the Ste. Genevieve Fault Zone, which consists of high angle normal and reverse faults, with the southwest block upthrown (see Krausse and Treworgy, this Guidebook, part 2, p. 115-120). The valley between this location and Fountain Bluff was formerly the main valley of the Mississippi River. It is much wider than the valley to the west of Fountain Bluff and bedrock is overlain by as much as 200 feet (60 m) of alluvium and glacial outwash, which consists mainly of sand and gravel.

28.8 Gravel road (right) to Kinkaid Lake. Turn right (north).

29.4 Pleistocene loess (windblown silt) deposits, as much as 15 feet thick, exposed adjacent to road.

29.7 Caseyville Formation crops out adjacent to road; total thickness is about 40 feet (12.1 m).

30.3 Road to parking lot at base of spillway. Turn right.

30.4 Disembark buses. Follow stop leaders to spillway of Kinkaid Lake.

STOP 14 Sedimentary features of the Caseyville Formation, Kinkaid Lake Spillway.

Leaders: Russell J. Jacobson, Illinois State Geological Survey; David Houseknecht, University of Missouri-Columbia; and George H. Fraunfelter, Southern Illinois University at Carbondale.

General geologic and regional setting

The spillway at Kinkaid Lake is located in the upper part of the Caseyville Formation. Excellent exposures of sedimentary features of the formation may be observed directly on both sides of the spillway. The Drury Shale and Pounds Sandstone Members are exposed adjacent to Kinkaid Creek from the dam southward to Big Muddy River. At most exposures, the Caseyville is largely sandstone with some mudstone and siltstone. In this area, the Drury Shale Member consists of shale and thin-bedded, quartzose sandstone and lies between the Battery Rock and Pounds Sandstone Members (Pickard, 1963, p. 28). In areas of outcrop, the Drury Shale generally forms a slope beneath the bluff-forming Pounds Sandstone. The Pounds Sandstone, where exposed in this area, is fine to coarse grained, thin to thick bedded, cross-bedded, ripple marked, ferruginous, and locally conglomeratic.

The Caseyville Formation at Kinkaid Lake Spillway

Approximately 80 feet (24 m) of the Caseyville Formation is exposed in the spillway (fig. IL-51). Stratigraphic relationships of units of the Caseyville Formation and general lithologies are illustrated in figure IL-51 (modified from Leming, 1973; Leming

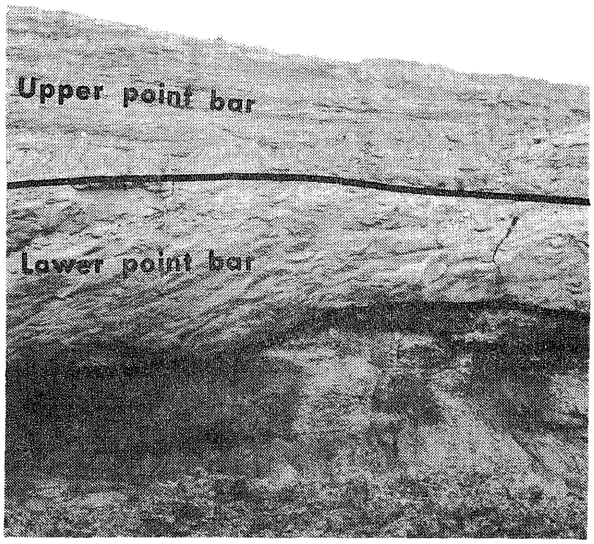

Figure IL-49. Point bar deposits of the Anvil Rock Sandstone Member (above) and splay margin gray shale of the Energy Shale Member (below). Erosion prior to deposition of the Anvil Rock Sandstone has cut into deposits associated with the older Walshville channel. The upper part of the Anvil Rock Sandstone consists of nearly horizontally-bedded strata. The lower part consists of large-scale point-bar accretion units. Both the upper and lower parts are internally trough cross-bedded. *Location:* east end of highwall, East Field, Burning Star No. 5 Mine.

Figure IL-48. ← Lag deposits of siltstone pebble conglomerates in splay channel-fill facies of the Energy Shale Member. Top: pebble conglomerate fills channel cut into underlying sandstone. Center: pebble conglomerate grades laterally into sandstone lens that has undergone less compaction. Bottom: detail of pebble conglomerate exposed along bedding plane. Individual clay pebbles are tabular, rounded to subrounded, and commonly sideritic. Located at west end of highwall near access ramp, East Field, Burning Star No. 5 Mine.

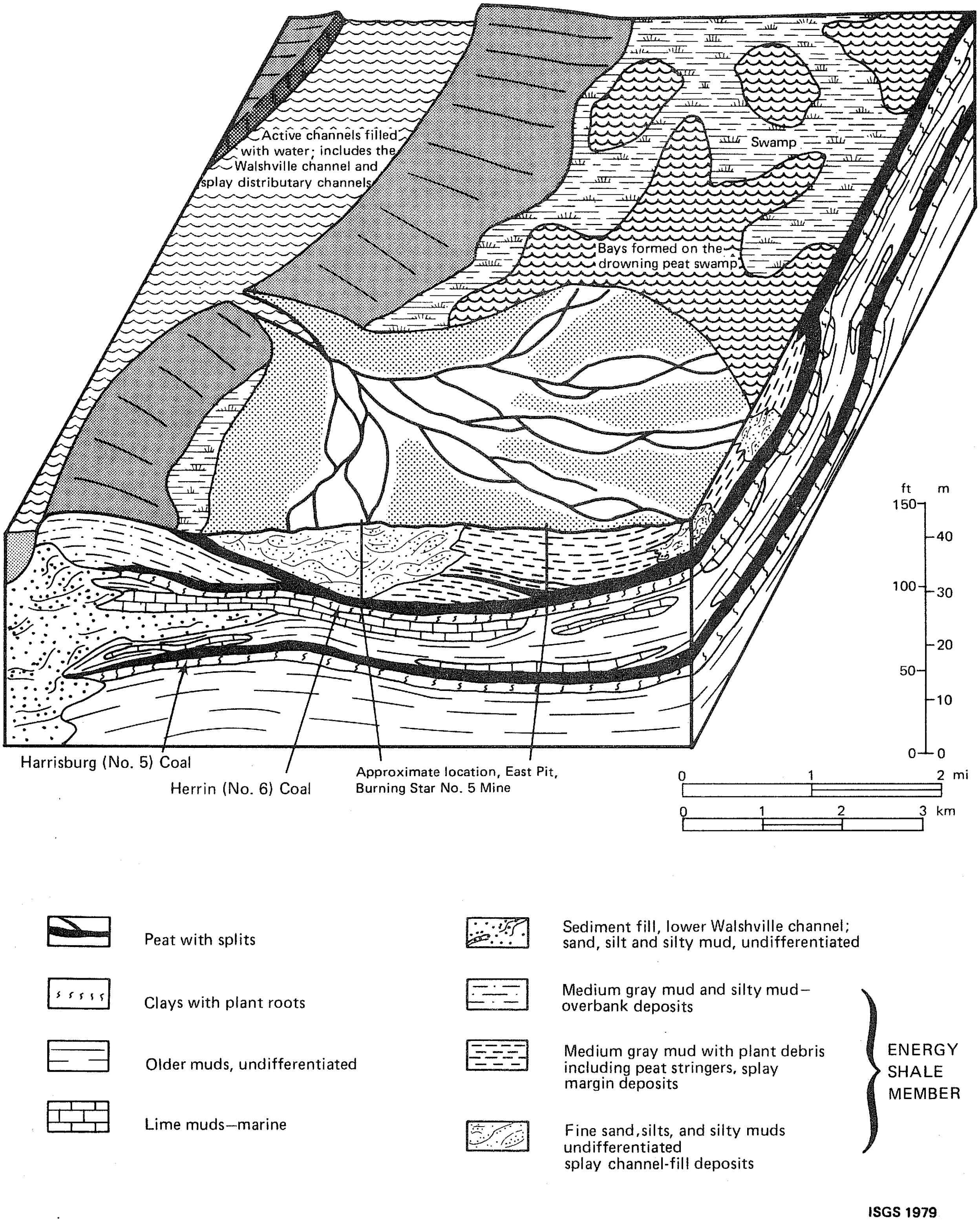

Figure IL-50. Model of the depositional environments and geology, East Field Area 6, Burning Star No. 5 Mine, near time of termination of peat accumulation, Herrin Coal swamp. (Based on local geology; after model of Baganz, Horne, and Ferm, 1975; and Coleman, 1976, fig. 35.)

and Ethridge, 1976). Lithologic and sedimentary features, paleocurrent characteristics, and inferred depositional environments of the units are presented in table IL-2.

The lower half of the spillway exposure consists of the Drury Shale Member, which is about 45 feet (13.5 m) thick. The Drury Shale Member is massive cross-bedded sandstone in the lower part, thin-bedded sandstone and siltstone in the middle, and shale with sandstone interbeds in the upper part (Units 1, 2, and 3, fig. IL-51, and table IL-2). These units contain abundant current ripples and cross-bedding (figs. IL-52 and 53). The Pounds Sandstone Member of the Caseyville Formation, which is approximately 40 feet (12 m) thick, overlies the Drury Member in the upper part of the spillway exposure. The Pounds Member consists of about 20 feet (6 m) of thick, cross-bedded sandstone (fig. IL-54), overlain by 4 feet (1.2 m) of siltstone, sandstone, shale, and claystone. This is overlain by about 13 feet (4 m) of massive, cross-bedded sandstone (Units 4, 5, and 6, fig. IL-55 and table IL-2). Sedimentary features common in Units 4, 5, and 6 (table IL-2) are abundant current ripples (fig. IL-55), load structures, and trough cross-beds. Interpretations of depositional environments for each of the units of the spillway cut are given in table IL-2.

The most abundant sedimentary structures are cross-bedding and current ripples. The structures present in the spillway represent almost the full spectrum of both bedding surface structures and stratification features developed under lower flow regime conditions (i.e., those rivers or streams in which the resistance to flow is large and the sediment transport is relatively small) (Middleton, 1965, p. 36). They generally produce dunes with superimposed ripples as the dominant bed form. Exposures at the spillway provide a rare opportunity to observe these structures in three dimensions.

30.4 Board buses. Depart Kinkaid Lake Spillway.
32.0 Junction, Illinois Route 149; turn right (west) on Illinois 149.
32.4 Field trip route crosses a remnant of a braided Mississippi River terrace at this location.
32.8 Intersection, Illinois Routes 149 and 3. Turn right (west) on Illinois 3. Sand pit and screening plant are straight ahead at junction. The sand is a deposit of the braided terrace deposits. Excavations have reached weathered glacial till, which may be Illinoian (Pleistocene) in age. Lignitic coal fragments which may have been carried from the western plains by the Missouri River are also abundant in the sand pit.
33.8 Narrow valley through which the Mississippi River flows between Fountain Bluff and the Ozark Bluffs of Missouri can be seen to left (south) at this point. For the next 3.5 miles (5.6 km), sandstone of the Caseyville Formation caps bluffs to the right beneath a cover-

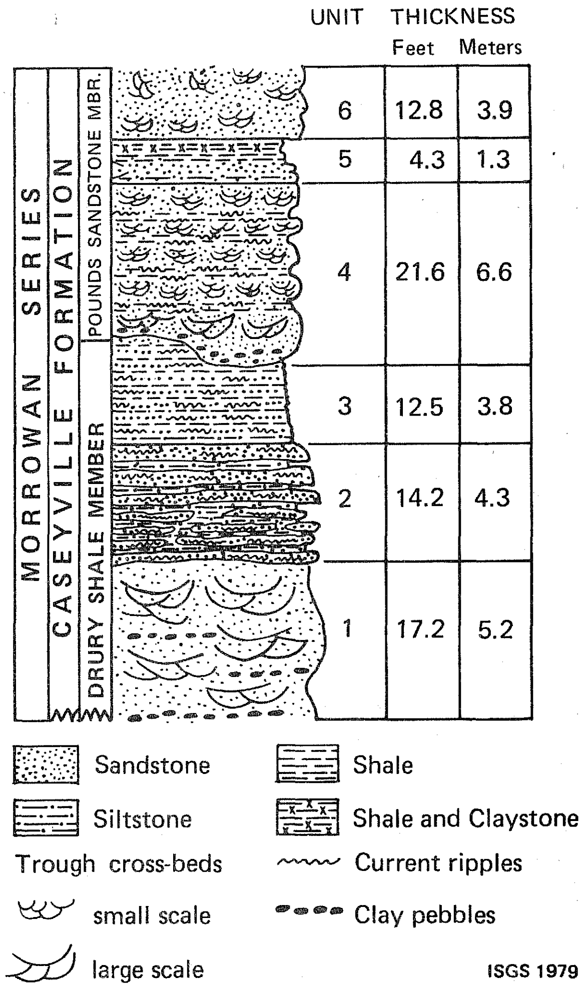

Figure IL-51. Measured section, Drury Shale and Pounds Sandstone Members, Kinkaid Lake spillway. (Modified from Leming, 1973; Leming and Ethridge, 1976.)

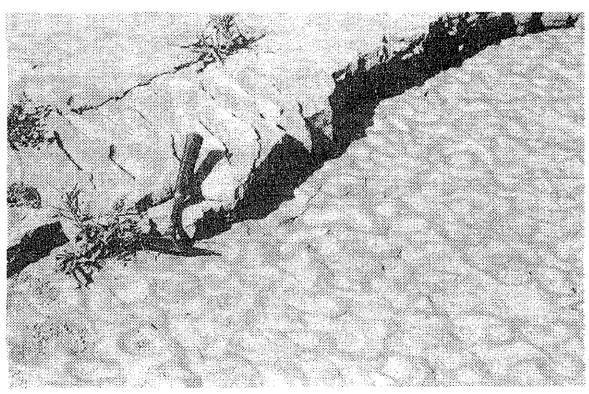

Figure IL-52. Asymmetrical (upper left) and linguloid (lower right) current ripples, Caseyville Formation (Unit 2 of fig. IL-51). Location: near center of Kinkaid Lake spillway.

Table IL-2. Characteristics and inferred depositional environments of genetic units exposed in Kinkaid Lake Spillway

Lithology	Sedimentary features	Paleocurrent characteristics	Inferred depositional environment
UNIT 6 Sandstone, quartzose, fine to medium grained, buff to brown, contains zones of clay pebbles, lenses of mudstone and siltstone	Conformable lower surface, small scale trough cross-bedding, wood casts, carbonaceous plant fragments	Bimodal-bipolar, north and south	Distributary mouth bar
UNIT 5 Claystone-mudstone, brown (70 cm)			Abandoned distributary channel
Shale, gray (30 cm)	Parallel laminations, plant fragments		
Sandstone, quartzose, fine grained, tan, thin zone of clay pebbles (15 cm)			
Siltstone, quartzose, tight gray, contains interbeds of shale	Ripples (probably of swash origin), load structures, horizontal burrows		
UNIT 4 Sandstone, quartzose, fine to medium grained, reddish-brown, iron stained, clay pebbles at base, interbeds of light gray siltstone and gray shale	Erosional lower surface, thick trough cross-bed sets with current ripples on foresets	Unimodal, north	Active distributary channel
UNIT 3 Shale, gray; interbeds of fine grained, well sorted quartzose sandstone (more numerous near base of unit)	Carbonaceous plant fragments in shale, linguoid ripples on sandstone interbeds		Open interdistributary bay
UNIT 2 Sandstone, quartzose, very fine to fine grained, tan, interbeds of white siltstone and gray shale	Conformable lower surface, tabular beds of rippled sandstone		Crevasse splay into open bay or (less likely) delta front marginal sheet or distal bar sands
UNIT 1 Sandstone, quartzose, medium grained, brown, iron stained, zones of clay pebbles	Lower surface not exposed, large scale trough cross-bed sets with sinuous-crested and linguoid current ripples on foresets, wood casts common	Unimodal, north	Active distributary channel

(Source: Leming, 1973, 1976, with modifications)

ing of loess. Rocks of the Mississippian System are locally exposed at the base of the bluffs. Present in ascending order are the Clore Formation, Degonia Sandstone, and Kinkaid Limestone of the Chesterian Series (upper Mississippian). Outcrop areas of the Degonia Sandstone commonly contain slumped blocks of sandstone; the Kinkaid Limestone and Clore Formation are commonly obscured by vegetation and loose rock debris.

37.3 Intersection, Illinois Routes 3 and 151. Turn right. Proceed northward on Illinois 151. Reenter Shawnee National Forest. Note the Hopewellian Indian mound on left adjacent to Illinois 3 (fig. IL-56). Many mounds such as this one were built in this area by Indians of the Hopewellian Culture (300 B.C. to 400 A.D.)

41.5 Crossing Kinkaid Lake.

43.1 Outcrop, both sides of road. Thin-bedded, dark gray shale and siltstone of the Abbott Formation.

45.0 Enter Ava, Illinois.

45.3 Junction, Illinois Routes 151 and 4. Turn left. Proceed northwest on Illinois 4.

48.3 Top of hill. Tipple and stripping shovel of the Leahy Mine (AMAX Coal Company) may be visible to right in distance. This mine is operating in both the Herrin (No. 6) and Harrisburg (No. 5) Coal Members of the Carbondale Formation.

48.8 Enter Campbell Hill, Illinois.

49.7 A now abandoned mine of the Campbell Hill Coal Company was located in junkyard on right. Several underground coal mines in this

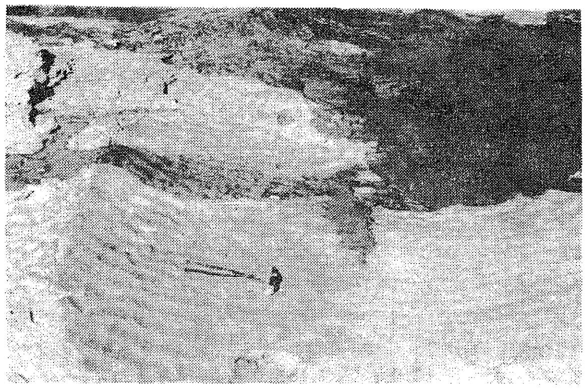

Figure IL-53. Large shallow trough scour with current ripples. Interference ripples are also common. Caseyville Formation (Unit 2 of fig. IL-51). Location: near center of Kinkaid Lake spillway.

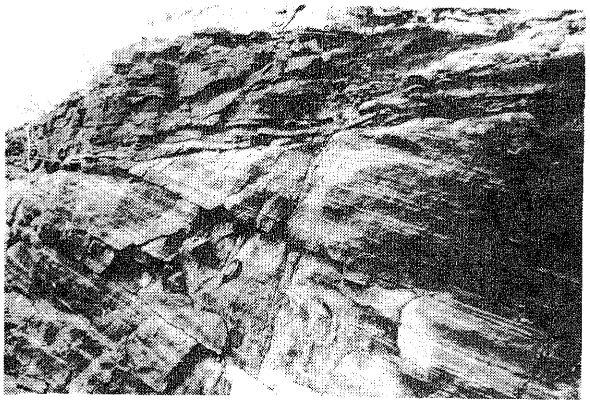

Figure IL-54. Thickly bedded sandstone containing large-scale cross-beds, overlain by horizontal, thin, ripple-laminated sandstone. Scale is indicated by camera lens cap near center of photograph. Caseyville Formation (Unit 4 of fig. IL-51). Location: upper part of Lake Kinkaid spillway, west wall.

Figure IL-55. Current ripples, Caseyville Formation, Kinkaid Lake Spillway (Unit 4 of fig. IL-51). Location: central part of Kinkaid Lake spillway floor.

vicinity operated in the "Campbell Hill Coal" which is about 4 feet (1.2 m) thick and is at a depth of about 50 feet (15 m). The Campbell Hill Coal is in the Spoon Formation and may be correlative with the Wise Ridge Coal Member.

51.0 Enter Perry County. Settlers came to Perry County as early as 1799 from Kentucky, Tennessee, and Virginia. The county, founded in 1827, was named after Oliver Hazard Perry, a U.S. Navy Commodore who became famous as a commander of the fleet during the Battle of Lake Erie in 1813. Coal mining is the most important industry in the county. In 1977, about nine and one-half million tons of coal were produced from five mines in Perry County, which was the highest level of production for any county in Illinois.

52.3 Roadcut, both sides of road. Peoria (Pleistocene) Loess.

52.4 Roadcut. Peoria (Pleistocene) Loess, left. Entrance to the Leahy Strip Mine of AMAX Coal Company (right). Spoil piles and the abandoned last cut in pit to north of the access road are part of the Captain Mine, Southwestern Illinois Coal Company, which is operating a short distance to the northeast.

53.2 Enter community of Willisville. The Willis Coal Company operated two now abandoned deep mines here in the Herrin (No. 6) Coal at an average depth of 75 feet (22.5 m).

55.2 Lunch stop—Scuttle Inn.

55.2 Depart Scuttle Inn. Continue northward on Illinois Route 4.

57.4 Junction, Illinois Routes 4 and 150. Turn right (northeast) on 150.

58.8 Enter Cutler, Illinois. Cutler was established in 1873 as a post office for the Chester and Tamaroa Coal and Railroad Company.

59.2 Access road. Turn right.

60.2 Enter Burning Star No. 4 Mine, Consolidation Coal Company.

Figure IL-56. Indian mound, Hopewellian Culture (300 B.C. to 400 A.D.), near intersection of Illinois Routes 3 and 151, Jackson County.

STOP 15 Upper Desmoinesian Strata, Burning Star No. 4 Mine.

Leaders: John E. Utgaard, Southern Illinois University; and Russell J. Jacobson, James E. Palmer, and Richard D. Harvey, Illinois State Geological Survey.

General geologic setting

Desmoinesian strata of the upper part of the Carbondale Formation and of the lower part of the Modesto Formation are exposed in the pit of the Burning Star No. 4 Mine.

The pit trends generally northeastward (fig. IL-57). The strata exposed in the pit dip gently to the northeast at the rate of about 20 to 30 feet per mile. The pit is operated at the southern end of a small dome. Bell, Ball, and McCabe (1931) show that this dome plunges to the south, west, and northeast from its center located at Jamestown. Dutcher, Dutcher, and Hopkins (1977) reported changes in stratigraphy related to this structure; these include thinning and wedging out of the Danville (No. 7) Coal Member, thinning of the Herrin (No. 6) and Harrisburg (No. 5) Coal Members, and the presence of coal balls along the east flank of the structure.

Rock strata that extend from the Harrisburg (No. 5) Coal Member of the Carbondale Formation to the Piasa Limestone Member of the Modesto Formation are exposed in the highwall. Some Pennsylvanian strata have been removed by erosion in the valley of Galum Creek. In the center of the valley, all strata that overlie the Harrisburg (No. 5) Coal have been removed.

This stop will be made in the southwestern part of the mine where the most complete section is present. The stratigraphic section in the southwestern part of the mine is presented in figure IL-58. The units are also listed in table IL-3, where lithology and paleontology are described.

Stratigraphy of highwall in southwestern portion of mine

Four coals exposed in the highwall in the southwest portion of the pit are, in ascending order, the Harrisburg (No. 5), Herrin (No. 6), Jamestown, and Danville (No. 7) Coal Members of the Carbondale Formation. The Herrin (No. 6) Coal contains a 1- to 2-inch (2- to 5-cm) claystone parting in its lower part called the "blue band," which is also present in the Herrin Coal at Eagle Surface Mine and Delta Mine in Illinois, and in the Kentucky No. 11 Coal (Herrin Coal of Illinois) at the Homestead Mine (Kentucky Stop 3).

Six limestones (Units 4, 6, 11, 15, 17, and 21, fig. IL-58 and table IL-3) and four calcareous shale (Units 5, 12, 14, and 16, fig. IL-58 and table IL-3) containing abundant marine fossils are present in the highwall. These units constitute about 60 percent of the rocks exposed in the highwall at Burning Star No. 4 Mine. Three carbonaceous black shales (Units 3, 10, and 20, fig. IL-58 and table IL-3) overlie the thicker coals and contain a marginally marine fauna.

The Energy Shale Member (Unit 9, fig. IL-58 and table IL-3) consists of small localized pods of dark gray, slightly silty shale which occur between the overlying black Anna Shale and the underlying Herrin Coal. These pods contain a marine fauna consisting largely of the pectinoid bivalve *Dunbarella.*

Thick underclays containing *Stigmaria* occur beneath all exposed coals (Units 1, 7, 18, fig. IL-58) except the Jamestown Coal.

In some areas of the Burning Star No. 4 Mine, the Jamestown Coal rests directly on a marine calcareous shale (Unit 12). In other areas it overlies a 3- to 5-inch (8- to 13-cm) thick, carbonaceous, shaly limestone, which in succession overlies black carbonaceous shale, 1 to 2 inches (2 to 5 cm) thick. The limestone contains a fauna of ostracodes (abundant), with calcareous worm tubes. The black shale contains a fauna similar to that of the black shales that overlie the thicker coals.

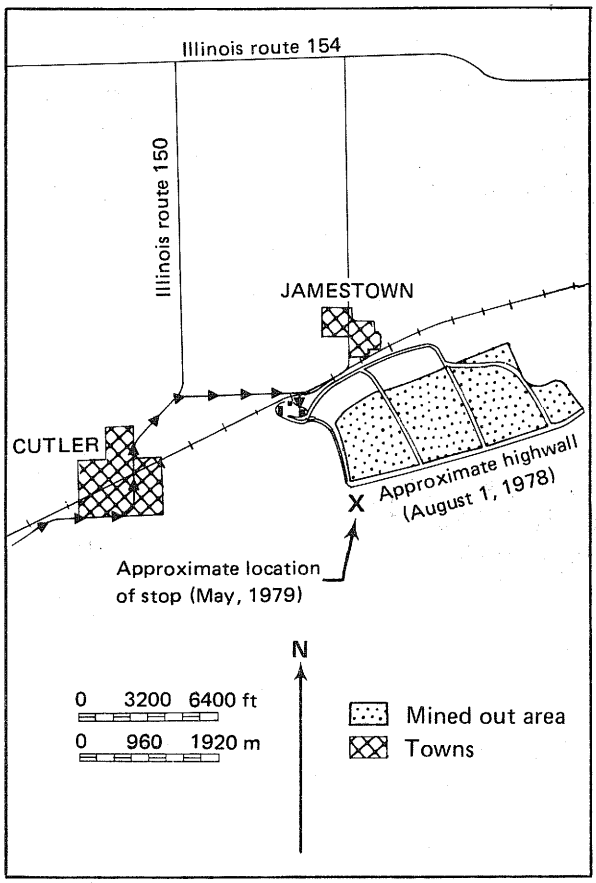

Figure IL-57. Burning Star No. 4 Mine, Consolidation Coal Company.

Inferred depositional history

In a study of the strata above the Herrin Coal in southwestern Illinois, Palmer, Jacobson, and Trask (this Guidebook, part 2, p. 92-102) indicate that marine strata above the Herrin Coal were deposited in a shallow shelf environment during several shallow marine transgressions. The black shales overlying the Danville and Herrin Coals are lagoonal, brackish-water deposits that record transition from fresh- and brackish-water environments of the coal swamps to open marine environments in which the overlying limestones were deposited. The Herrin and Danville Coals and their associated underclays are products of the extensive lower delta and coastal plain peat swamps. The Jamestown Coal was formed in a coastal plain swamp which was of relatively short duration and contained numerous brackish to possibly fresh-water lagoons and lakes in which a prolific community of ostracodes and other organisms thrived. The strata below the underclay of the Herrin probably represent a lower delta to coastal plain swamp (Units 1 and 2), transitional marine (Unite 3), open shallow marine (Unit 4), shallow marine with terrestrial clastic input (Unit 5), and shallow open marine (Unit 6).

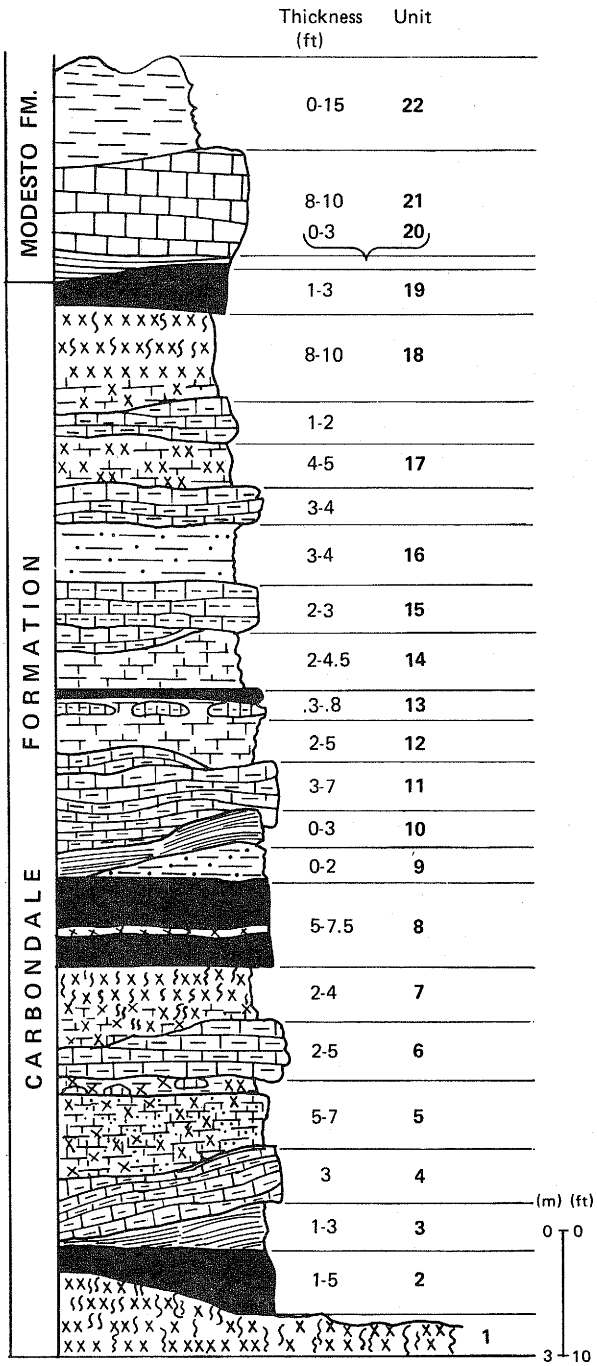

Figure IL-58. Generalized geologic column, Burning Star No. 4 Mine. See table 3 for explanation of numbers.

60.2 Depart Burning Star No. 4 Mine. Proceed west on mine road.
61.2 Junction, mine road with Illinois Route 150. Turn left (south).
61.6 Enter Cutler, Illinois.
63.1 Junction, Illinois Routes 150 and 4. Turn left (south) on Illinois 4.
64.2 Scuttle Inn, right. County road, left. Turn left (east) on county road.
67.2 Washing plant and tipple, Captain Mine, left.
68.9 Entrance, Captain Mine, Southwestern Illinois Coal Company.

STOP 16 Reclamation practices, Captain Mine, Southwestern Illinois Coal Company.

Leaders: Robert Holloway and other personnel of Southwestern Illinois Coal Company; Russell R. Dutcher, Southern Illinois University; and Russell J. Jacobson, Illinois State Geological Survey.

General geology, Captain Mine

Rock units exposed at the Captain Mine include strata extending from the Harrisburg (No. 5) Coal to the Bankston Fork Limestone Member, which is located above the Herrin (No. 6) Coal. Pleistocene glacial till and outwash deposits overlie the No. 6 Coal in many parts of the mine, and the No. 6 Coal also is locally missing.

Reclamation practices at Captain Mine, Southwestern Illinois Coal Company

At the Captain Mine, the recently acquired 1000 MX Bucket Wheel Excavator operates in advance of a Marion 6360 stripping shovel, removing topsoil from areas to be mined. This topsoil is then transported over a conveyor belt, about 2 miles long, which deposits it on previously mined land.

Table IL-3. Lithology and paleontology of strata, Burning Star No. 4 Mine, Jamestown, Illinois

	Unit	Lithology	Fauna and flora
22	unnamed shale	shale, multicolored, greenish, bluish gray, orange-yellow to reddish, well laminated, weathered and eroded in upper portion	scattered plant debris and coaly stringers
21	Piasa Limestone Member	limestone, medium to light gray, fine grained, dense, hard, thick bedded, very fossiliferous	mostly unidentifiable brachiopod and crinoid debris together with abundant whole specimens of *Phricodothyris perplexa*
20	unnamed black shale	shale, black, carbonaceous, slaty	pyritized plant fragments and coaly stringers
19	Danville (No. 7) Coal Member	coal, normal bright banded	
18	unnamed claystone and shaly claystone sequence	shaly claystone, medium greenish gray; grades upward to claystone, medium gray; unit is weakly laminated, massive especially in upper portion; lower shaly claystone calcareous containing numerous small limestone pellets	upper claystone—rooted—*Stigmaria*; lower shaly claystone—algal limestone nodules
17	Bankston Fork Limestone	upper limestone, light, brownish-tan to greenish gray mottled, fine grained, thick bedded, fossiliferous	ostracodes—*Geisina, Macrocypris* and *Coryellites* sp., calcareous worm tubes—*Spirorbis* sp., common plant roots—*Stigmaria*
		shaly claystone, medium greenish to gray to greenish or gray mottled, calcareous; thin and irregularly laminated; contains numerous small gray limestone nodules	algal limestone nodules
		basal limestone, light brown to light greenish tan, fine grained, thick bedded, fossiliferous	mostly brachiopod and crinoid debris; contains abundant whole specimens of brachiopod *Mesolobus mesolobus*
16	Lawson Shale Member	shale, medium to medium dark gray, silty; well laminated in lower 2-3 feet; grades upward to mottled light greenish to medium gray shale upper 1-2 feet	upper: barren except at upper contact with Bankston Fork Limestone—contains brachiopods *Mesolobus mesolobus* and *Linoproductus* sp.
			lower: silty shale—burrows, pyritized plant fragments, bivalve *Dunbarella rectalaterarea,* brachiopods—*Lingula* carbonaria, gastropods—*Donaldina robusta, Euphemites carbonaria,* Bryozoan *Stenopora* sp., Ostracode—*Coryellites* sp.
15	Conant Limestone Member	limestone, medium dark gray, argillaceous, hard, fine grained, thick bedded, fossiliferous	Brachiopods—*Linoproductus prattenianus, Antiquatonia portlockianus, Mesolobus mesolobus, Composita* sp., calcareous foraminifera—*Ammodiscus* and *Serpulopsis* sp., Ostracodes—*Geisina warthini, Macrocypris* sp., *Bardia* sp., crinoid debris
14	unnamed calcareous shale	shale, medium to medium dark gray, calcareous, well laminated, firm, fossiliferous	brachiopods—*Mesolobus mesolobus, Linoproductus prattenianus, Antiquatonia portlockianus,* crinoid fragments, calcareous foraminifera—*Ammodiscus* and *Serpulopsis* sp.
13	Jamestown Coal Member	coal, thin, normal bright banded	
		limestone, dark gray to black, biomicrite to biosparite, thinly laminated, shale and carbonaceous debris	ostracodes—*Geisina* sp., and other unidentified forms; calcareous worm tubes—*Spirorbis* sp., phosphatic fish debris
		shale, dark gray to black, calcareous, fossiliferous	bivalve—*Myalina wyomingensis* gastropod—*Knightites montifortianus* brachiopod—*Lingula carbonaria*

Table IL-3. *Continued*

	Unit	Lithology	Fauna and flora
12	unnamed calcareous shale	shale, medium to dark gray, calcareous, slightly silty, well laminated, fossiliferous	brachiopods—*Linoproductus prattenianus Lingula carbonaria,* calcareous foraminifera—*Ammodiscus* sp., ostracode—*Bardia* sp., gastropods *Donaldina robusta Euphemites carbonarius*
11	Brereton Limestone Member	limestone, medium to dark gray, argillaceous, fine grained, hard, dense, thick bedded, very fossiliferous	brachiopods—*Mesolobus mesolobus* and other fragments, calcareous foraminifera—*Ammodiscus* sp., *Fusulina illinoisensis,* abundant crinoid fragments
10	Anna Shale Member	shale, black, carbonaceous, fissile, hard with phosphatic bands and lenses, some coal stringers	*Dunbarella rectalaterarea*—bivalve, *Orbiculoidea missouriensis* and *Lingula carbonaria*—inarticulate brachiopods, contains *Crurithyris planoconvexa* in bioturbated zone at top contact with overlying Brereton, phosphatic fish debris
9	Energy Shale Member	shale, medium to dark gray, thinly laminated, occurs in lenticular pods	pyritized bivalve debris mostly *Dunbarella rectalaterarea,* carbonaceous plant fragments
8	Herrin (No. 6) Coal Member	coal, normal bright banded; contains a persistent 1-2 inch claystone parting near middle; commonly called "blue band"	
7	unnamed claystone	Claystone, medium greenish gray, massive, weakly bedded, slickensided throughout	abundant *Stigmaria*
6	unnamed limestone, possible correlative of Higgensville in Missouri	limestone, hard, dense; consists of light brownish tan, fine-grained, irregular, churned bands and clots in a clayey, greenish gray bioclastic limestone matrix	crinoid and brachiopod debris, *Stigmaria*
5	unnamed calcareous shaly claystone and siltstone	shaly claystone, medium to brownish gray, silty and calcareous in lower 4-6 feet, grades to noncalcareous medium greenish gray claystone in upper 1½ feet, thinly bedded with limestone nodules along bedding planes; scattered pods of fine-grained micaceous, dark gray sandstone in lower 4 feet	burrows, algal limestone nodules
4	St. David Limestone Member	limestone, medium to greenish gray; very argillaceous, bioclastic, in upper half to an argillaceous, bioclastic micrite in lower half	broken brachiopod and crinoid debris
3	unnamed black shale above Harrisburg (No. 5) Coal	shale, black, carbonaceous, fissile, with phosphatic bands and lenses, fossiliferous	*Orbiculoidea missouriensis*—brachiopod, pyritized bivalve fragments, phosphatic fish debris
2	Harrisburg (No. 5) Coal Member	coal, normal bright banded	
1	unnamed claystone below No. 5 Coal	claystone, medium greenish gray, massive, weakly bedded, slickensided; only upper portion exposed on pit floor	*Stigmaria*

Important geographical data related to reclamation of the area to be mined are recorded during preliminary studies. As the coal is uncovered, large overburden piles or "spoil banks" are left behind by the Marion 6360 and the Bucyrus-Erie 2570 walking dragline. Subsequently, grading equipment smooths out the tops of spoil banks to match as closely as possible the original surface topography prior to mining. Finally, a covering of topsoil is spread over the graded land.

The land is then seeded with special grasses or with trees indigenous to the area, and sometimes fishing lakes are created. In some areas, the land is reclaimed for grazing, and various types of cattle are raised. In addition, corn, wheat, hay, sorghum, and honey are produced on the reclaimed land. This program was begun by Southwestern Illinois Coal Company in 1936 at the nearby Streamline Mine, and reclamation work was begun immediately at Captain Mine when it opened in 1964.

End of field trip.

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