Illinois Basin Consortium

Illinois State Geological Survey
Indiana Geological Survey
Kentucky Geological Survey

Toward a More Uniform Stratigraphic Nomenclature for Rock Units (Formations and Groups) of the Pennsylvanian System in the Illinois Basin

Illinois Basin Consortium Study 5

By The Tri-State Committee on Correlation
of the Pennsylvanian System in the Illinois Basin

Participating organizations:

Illinois State Geological Survey
Natural Resources Building
615 East Peabody Drive
Champaign, IL 61820-6964
(217) 333-4747

Indiana Geological Survey
611 North Walnut Grove
Indiana University
Bloomington, IN 47405-2208
(812) 855-7636

Kentucky Geological Survey
228 Mining and Mineral Resources Building
University of Kentucky
Lexington, KY 40506-0107
(859) 257-5500

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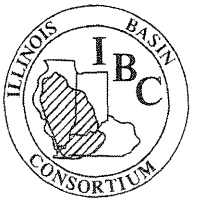

A Joint Project of the
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PREFACE

The Tri-State Committee on Correlation of the Pennsylvanian System in the Illinois Basin (Tri-State Committee) was formed in 1979 to resolve correlation problems in the Pennsylvanian System across the basin and to try to standardize stratigraphic terminology for the Pennsylvanian System. Originally the group consisted of members from the state geological surveys of Illinois, Indiana, and Kentucky. In 1989 the committee was expanded to include geologists from universities and coal companies involved in research on the Pennsylvanian System. The concept of cooperative basinwide geologic research begun by the Tri-State Correlation Committee has been continued and expanded by the current day Illinois Basin Consortium (IBC). The IBC is composed of the Illinois State Geological Survey, the Indiana Geological Survey, and the Kentucky Geological Survey.

The Tri-State Committee's initial efforts were focused on correlating key beds in the middle and upper parts of the Pennsylvanian System and on establishing a common nomenclature for these beds (Jacobson and others, 1985). This report presents the results of the committee's efforts to unify nomenclature for formations and groups based in part on these key beds, as well as on vertical lithological changes in the lower part of the Pennsylvanian (namely, the Raccoon Creek Group).

The members of the Tri-State Committee who contributed to this study include: R. J. Jacobson, W. J. Nelson, H. H. Damberger, C. P. Weibel, and R. A. Peppers of the Illinois State Geological Survey; W. A. Hasenmueller, N. R. Hasenmueller, D. L. Eggert, and C. H. Ault of the Indiana Geological Survey; S. F. Greb and D. A. Williams of the Kentucky Geological Survey; M. E. Hopkins; H. Lamkin, Jr.; and R. L. Langenheim of the University of Illinois. S. F. Greb, N. R. Hasenmueller, W. A. Hasenmueller, R. J. Jacobson, C. P. Weibel, and D. A. Williams compiled and modified the draft of the manuscript.

TOWARD A MORE UNIFORM STRATIGRAPHIC NOMENCLATURE FOR ROCK UNITS (FORMATIONS AND GROUPS) OF THE PENNSYLVANIAN SYSTEM IN THE ILLINOIS BASIN

By The Tri-State Committee on Correlation
of the Pennsylvanian System in the Illinois Basin

ABSTRACT

The Tri-State Committee on Correlation of the Pennsylvanian System in the Illinois Basin proposes revisions in Pennsylvanian nomenclature. Formation and group boundaries are moved to horizons marked by either distinct lithologic changes or by key beds.

In the proposed classification, the basal Raccoon Creek Group is underlain by an unconformity on rocks ranging in age from Ordovician to Mississippian. The group extends upward to the base of the Seelyville Coal Member or Davis Coal Member/bed[1] of the Carbondale Group/Formation. In Illinois and Kentucky, the Raccoon Creek Group comprises the Caseyville and Tradewater Formations. In Indiana, where the boundary between the Caseyville and Tradewater Formations is not recognized, the Raccoon Creek Group is divided, in ascending order, into the Mansfield, Brazil, and Staunton Formations. The Carbondale Group/Formation and overlying McLeansboro Group are accepted basinwide. The boundary between the Carbondale and the McLeansboro is placed at the base of the Providence (Brereton) Limestone Member of the Shelburn Formation in Kentucky and Illinois and the top of the Danville Coal Member of the Carbondale Group in Indiana. The McLeansboro Group comprises the Shelburn, Patoka, Bond, and Mattoon Formations and the boundaries of all but the base of the Shelburn are placed at common horizons in all three states.

Although many of the Pennsylvanian formation and group boundaries and unit names have been unified as a result of the Tri-State Committee's work, significant differences in geology and in the mapped continuity of key beds have made it impossible at this time to unify formation and group names throughout the basin. However, the standardization achieved thus far represents progress. This standardized nomenclature will improve communication among geologists and the coal mining industry working in the Pennsylvanian System; many geologists and companies operate in two or three states of the Illinois Basin.

INTRODUCTION

Stratigraphic nomenclature of Pennsylvanian formations and groups in the Illinois Basin has differed significantly for Illinois, Indiana, and Kentucky (fig. 1). For example, of 17 formation names used in the basin, only four (Caseyville, Carbondale, Bond, and Mattoon) were used in more than one state. Although the name "Carbondale" was used in all three states, it was ranked as a formation in Kentucky and Illinois and as a group in Indiana, and the boundaries were different in all three states (fig. 1). In addition, only one of the five group names was used in more than one of the states (fig. 1).

Correlation problems still exist and prevent basinwide adoption of some units and formation boundaries where defining lithologies or key beds are not recognized as being continuous; such correlation and mapping problems are discussed and are considered topics of future research. In the meantime, adoption of the new nomenclature will improve communication and foster future cooperative studies among the three state geological surveys, industry, and academia.

NEW NOMENCLATURE FOR FORMATIONS AND GROUPS OF THE PENNSYLVANIAN SYSTEM

The Tri-State Committee's principal objective in this report is to identify basinwide formations and groups of the Pennsylvanian System and establish common names and boundaries insofar as possible. No new stratigraphic names are introduced; the proposed classification builds on previously defined rock-units. The definitions of some rock-units have been amended to place boundaries at horizons of more distinct vertical lithologic change or at key beds considered by this committee to be regionally extensive.

[1]The Seelyville is ranked as a member in both Illinois and Indiana; the Davis is considered a member in Illinois but a bed without formal status in Kentucky, thus Davis Coal Member in Illinois, Davis coal bed in Kentucky. The "slash" symbol (/) is used to indicate change in rank between states, and parentheses are used to indicate stratigraphic equivalence.

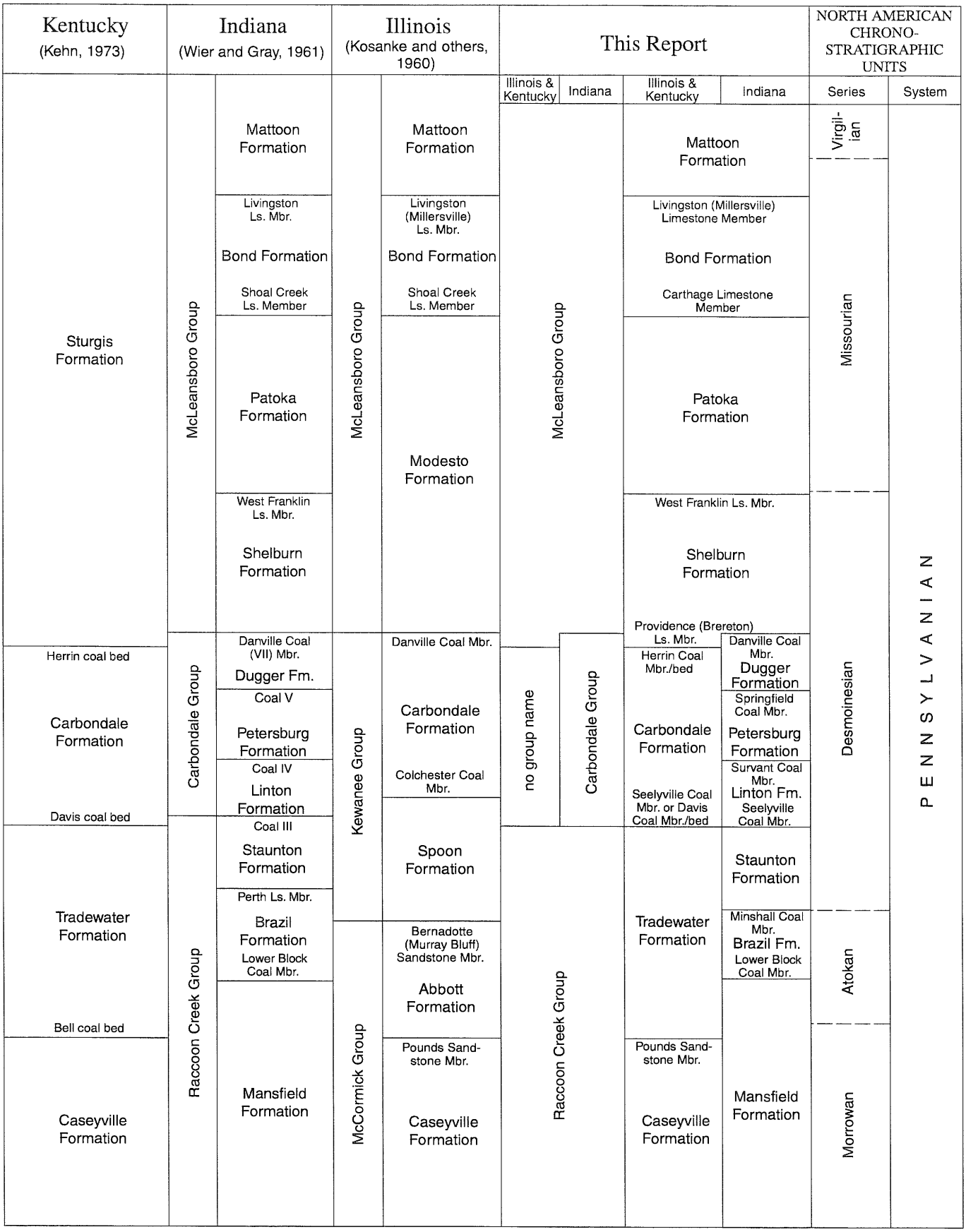

Figure 1. Previous and newly adopted Pennsylvanian nomenclature for Kentucky, Indiana, and Illinois.

The new nomenclature for the Pennsylvanian System is, in ascending order: 1) the Raccoon Creek Group, made up of the Caseyville and Tradewater Formations in Kentucky and Illinois and the Mansfield, Brazil, and Staunton Formations in Indiana, 2) the Carbondale Formation in Illinois and Kentucky, and the Carbondale Group, comprising the Linton, Petersburg, and Dugger Formations in Indiana, and 3) the McLeansboro Group, comprised of the Shelburn, Patoka, Bond, and Mattoon Formations (fig. 1) in all three states.

RACCOON CREEK GROUP

Definition and Justification

The Raccoon Creek Group, as herein revised, is extended to Illinois and Kentucky where it comprises two formations, the Caseyville and Tradewater. In Indiana the group is made up of three formations, the Mansfield, Brazil, and Staunton (fig. 1). The Raccoon Creek consists mostly of shales, siltstones and sandstones, and minor coals, limestones, and conglomerates. The group extends from the unconformity at the base of the Pennsylvanian System to the base of the Seelyville Coal Member or Davis Coal Member/bed[2] of the Carbondale Group/Formation.

The sub-Pennsylvanian unconformity at the base of the Raccoon Creek Group marks the division between the Kaskaskia and Absaroka cratonic sequences (Sloss and others, 1949; Sloss, 1963) and has been mapped across the basin (Siever, 1951; Wanless, 1955; Bristol and Howard, 1971; Davis and others, 1974; Droste and Keller, 1989; Greb, 1989a; Keller, 1990). The base of the Seelyville Coal Member or Davis Coal Member/bed at the top of the Raccoon Creek Group is the first horizon that can be consistently mapped in parts of all three states above the sub-Pennsylvanian unconformity. The lithology of the Raccoon Creek Group varies markedly, both laterally and vertically, between the unconformity and the Seelyville or Davis.

The group name previously used in Illinois for most of this interval is the McCormick Group (Kosanke and others, 1960) (fig. 1). The McCormick Group is of doubtful validity because recent mapping in the type area of the Abbott Formation (Jacobson, 1992) demonstrates that the Abbott cannot be differentiated consistently from the overlying Spoon Formation (Kewanee Group) of Kosanke and others (1960). The name "Raccoon Creek" of Indiana is a suitable replacement for the interval of the McCormick and the lower part of the Kewanee Group in Illinois because the Seelyville Coal Member or Davis Coal Member/bed is more traceable regionally than the Murray Bluff and Bernadotte Sandstone Members of the Abbott Formation, which marked the top of the McCormick Group. Lithologic cyclicity is well developed above this coal and poorly developed to nonexistent below. In Kentucky, the introduction of the name "Raccoon Creek" as a group comprising the Caseyville and Tradewater Formations provides a useful term in areas where these formations are undifferentiated.

So far none of the key beds that define the Mansfield, Brazil, and Staunton Formations in Indiana, or the lithologies that separate the Caseyville and Tradewater Formations in Kentucky and Illinois are known to be regionally extensive. Therefore, the only key beds currently recognized by the committee are the bounding units of the Raccoon Creek Group.

Wier (1961, 1965) designated a type area for the Raccoon Creek Group that consists of exposures along Raccoon Creek in the southern part of Parke County, Indiana, in T. 14 N., R. 6, 7, and 8 W., and T. 15 N., R. 8 W. The type area was studied and mapped by Hutchison (1976) and Friedman (1989). Hutchison (1976, p. 26–27, p. 52–57) designated core from Indiana Geological Survey drill hole SDH-31 in the NENE sec. 3, T. 14 N., R. 7 W., and a composite section of core from SDH-30 and SDH-174 in the SESW sec. 31, T. 15 N., R. 6 W., as reference sections for the lower part of the Raccoon Creek Group, that is, for the Mansfield Formation. Friedman's location 13 (SDH-33) is a continuous core spanning the interval from the top of the Raccoon Creek down to the upper part of the Mansfield. These four drill holes are located within or close to the type area designated by Wier (1961) and include sufficient stratigraphic overlap to permit confident correlation of key beds. The four cores identified above are herein designated as reference cores for the Raccoon Creek in Indiana with the amendment that the Seelyville Coal Member is placed in the Carbondale. A split of each core is archived in the Indiana Geological Survey's Core Library.

Historical Perspective

The first published use of the term "Raccoon Creek Group" (pl. 1) in Indiana was on the stratigraphic column that accompanies the geologic map of the Indianapolis 1° X 2° Quadrangle (Wier and Gray, 1961). The term "Raccoon Creek" has continued to be used in Indiana (Wier, 1970b, 1986c).

Strata equivalent to the Raccoon Creek Group in Illinois (fig. 1, pl. 1) were previously included in the McCormick Group and the lower part of the Kewanee Group as defined by Kosanke and others (1960). The names "McCormick Group"

[2] In Illinois and Indiana most coal seams are classified stratigraphically as members, while the Kentucky Geological Survey follows the U.S. Geological Survey practice of not recognizing coal seams as formal stratigraphic units, thus the term "beds."

and "Kewanee Group" are herein abandoned. Prior to the report by Kosanke and others (1960) the only group designation applied to this part of the section in Illinois was the elevation of the Tradewater and Caseyville Formations to group rank by Wanless (1938) and Weller (1940) (pl. 1).

In the past, this interval of strata was known as the Pottsville Group (Lee, 1916) in western Kentucky. The Pottsville Group of Lee (1916) differed from the Raccoon Creek Group only in the exclusion of the underclay of the Seelyville Coal Member or Davis Coal Member/bed. The usage of the name "Pottsville" has lapsed in recent years.

CASEYVILLE FORMATION

Definition and Justification

The Caseyville Formation in Illinois and Kentucky includes strata from the base of the Pennsylvanian System to the top of the uppermost quartz arenite containing quartz pebbles. Along the outcrop in southeastern to southern Illinois, this sandstone forms distinct bluffs and appears to be continuous. In these areas it has been mapped as the Pounds Sandstone Member, but current work in progress indicates that it does not form a continuous unit throughout southern Illinois. The type section proposed by Lee (1916) incorporates outcrops between Gentry('s) Landing and the Saline River along the Ohio River in Hardin County, Illinois. Similar strata are locally conspicuous in the basal Pennsylvanian of Indiana, but the relationship of these rocks in Indiana with the Caseyville in the southern part of the basin in Illinois and Kentucky is poorly understood. In Indiana the name "Mansfield Formation" is retained for the rocks extending from the base of the Pennsylvanian System to the base of the Lower Block Coal Member of the Brazil Formation (Hutchison and Hasenmueller, 1986b).

Historical Perspective

The term "Caseyville conglomerate" (pl. 1) was first used by Owen (1856) in western Kentucky. Glenn (1912a) gave formational status to the Caseyville and described the unit as the cliff-forming conglomeratic sandstones between the base of the Pennsylvanian and the coal measures (Tradewater and younger formations). Lee (1916) renamed the formation the "Caseyville Sandstone," noting that the unit contains less conglomerate than sandstone. Lee defined it as "all the beds from the top of the sparsely pebbly sandstone exposed at Caseyville to the base of the Pennsylvanian series." He also designated and described the type section of the Caseyville Formation near Caseyville in Hardin County, Illinois (Lee, 1916).

Caseyville-equivalent strata in southern Illinois have been called the "Lower Coal Measures" (Worthen, 1875) and simply "Lower Pennsylvanian" (Weller, 1906). DeWolf (1910) placed Caseyville-equivalent strata in Illinois into the Pottsville Formation (pl. 1) on the basis of a belief that the strata were equivalent to Pottsville strata of the Appalachian area. This belief was also held by Lee (1916) for equivalent strata in western Kentucky. Butts (1925) adopted Lee's (1916) use of the term "Caseyville Formation" in southern Illinois, but the name "Pottsville Formation" prevailed in Illinois literature for many years (Lamar, 1925; Wanless, 1929, 1931).

Weller (1940) abandoned the use of the name "Pottsville" in Illinois in favor of the name "Caseyville" (pl. 1). Weller's use of the term "Caseyville" was based on an unpublished study by Wanless (1938) that suggested adopting the Caseyville as a formational name because of uncertainties in the correlation of key boundary beds for the Pottsville Formation of the Appalachians. In revisions of Wanless's unpublished manuscript in 1939 and 1951, the Caseyville was designated as "Sandstone" and then again as "Group," following the policy of the Illinois State Geological Survey in each of the years that the manuscript was revised.

Wanless (1938) differentiated several cyclothems as members in the Caseyville Formation. Because these cyclothems were considered "fundamental" units of Pennsylvanian rocks, Willman and others (1958, p. 10) noted that they were raised to formation status by Weller (1940), paralleling the revision of the Caseyville to group status (pl. 1). With the exception of Wanless and Weller's 1944 Pennsylvanian correlations chart, the Caseyville remained a group in Illinois stratigraphic nomenclature (Dunbar and Henbest, 1942; Cooper, 1946; Cady, 1952; Wanless, 1955, 1956). The Caseyville was returned to formational status when Kosanke and others (1960) assigned cyclothems to a classification independent of the lithostratigraphic classification scheme.

Formation Boundaries

The base of the Caseyville Formation is the sub-Pennsylvanian or sub-Absaroka unconformity (fig. 2). This formation is underlain by rocks ranging in age from Ordovician to Mississippian. The basal contact of the Caseyville is easily recognized where conglomeratic sandstones of the Caseyville rest directly on Ordovician to Valmeyeran (Middle Mississippian) strata or on limestones of the Chesterian Series (Upper Mississippian). Placement of the contact is more difficult in areas where rocks of the Caseyville are in direct contact with Mississippian siliciclastics. Criteria that aid in identification of the contact in outcrop and in subsurface have been described by Siever (1951), Atherton and others (1960), Bristol and Howard (1971), Davis and others (1974), and Droste and Keller (1989).

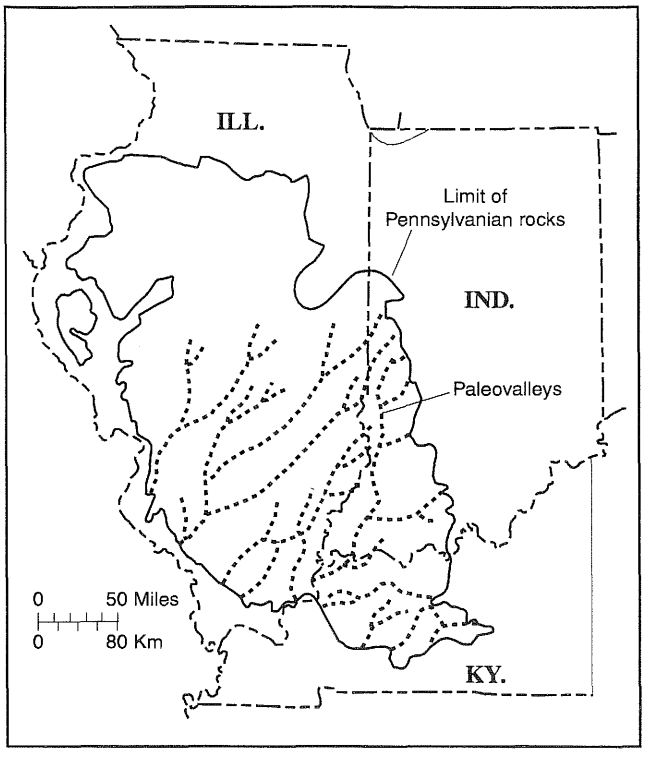

Figure 2. Map of the sub-Pennsylvanian surface showing the locations of paleovalleys.

The top of the Caseyville Formation was originally defined by Lee (1916) as the top of the "pebbly" sandstone exposed at Caseyville, the lateral equivalent of the Pounds Sandstone Member. The Pounds has been mapped in southeastern Illinois along and near the outcrop of the formation. Current mapping in southwestern Illinois and in the subsurface shows the Pounds to be laterally discontinuous (Nelson and others, 1991; Jacobson, unpublished studies).

The Pounds also has not been regionally mapped in Kentucky, and the upper boundary of the Caseyville Formation therefore has been placed at various marker horizons. Along most of the western outcrop margin of the Caseyville Formation in Kentucky, the upper contact of the formation is placed at the top of a cliff-forming, pebbly sandstone lithologically similar to the Pounds. In parts of Union County, Kentucky, however, the top of the formation is placed at the base of the Bell (W. Ky. No. 1b) coal bed that occurs just above the uppermost conglomeratic sandstone in this area and is areally more extensive than the sandstone (Greb and others, 1992).

Establishing the equivalence of Caseyville sandstone bodies is complicated by the confinement of some sandstones to paleovalleys and by the overall lenticular nature of sandstone bodies on the paleo-upland surface (Davis and others, 1974; Greb and others, 1992). In most of western Kentucky (except close to the Illinois border), the Caseyville was not differentiated from the overlying Tradewater Formation in the U.S. Geological Survey/Kentucky Geological Survey Cooperative Geologic Mapping Program. Reasons for the lack of a stratigraphic break include: 1) the possible thinning and lensing of the uppermost conglomeratic quartz arenites in the southeasternmost part of the basin; 2) a lack of exposures in the eastern part of the outcrop belt compared to the western margin of the Western Kentucky Coal Field; 3) the fact that the geologic quadrangles along the eastern part of the outcrop belt were mapped early in the project, are more generalized, and are farther removed from the Caseyville type section than the quadrangles along the western outcrop margin where the top of the Caseyville was mapped; and 4) the possibility that a distinct stratigraphic break is lacking between the Caseyville and Tradewater (Nelson, 1989; Greb and others, 1992).

In the outcrop area of Kentucky and Illinois, distribution of pebble-bearing quartz arenites allows differentiation of the Caseyville lithologies from the Tradewater lithologies of the Raccoon Creek Group, but such differentiation has not been practiced in Indiana or far into the subsurface of the basin. Gray's work (1962, p. 31) suggests that in Indiana it may be difficult to differentiate Caseyville and Tradewater.

Thickness and Extent

The outcrop area of the Caseyville Formation is along the southeastern and southern portions of the Illinois Basin in Illinois and Kentucky (fig. 3). Westward and northward the Caseyville pinches out except for a small outlier in the extreme northwestern part of the Illinois Basin Coal Field (Willman and others, 1975; Wanless, 1975). Younger members of the Caseyville that are recognized in Illinois onlap older members westward as the older members progressively pinch out (Sonnefield, 1981).

Subsurface delineation of the northern extent of the Caseyville Formation in Illinois and of Mansfield rocks exhibiting Caseyville characteristics in Indiana is difficult because these sandstones are indistinguishable from overlying sandstones on geophysical logs. However, cuttings and core descriptions may permit delineating these pebbly sandstones in the subsurface. With the exception of an outlier in the northwestern part of the basin, the Caseyville and Mansfield rocks that have Caseyville characteristics are restricted to an area south of a line drawn from Lafayette, Indiana, to Chester, Illinois (Wanless, 1955, 1975) (fig. 3).

Basal Mansfield strata in parts of Indiana are similar to those of the type Caseyville, consisting mostly of quartz arenite and quartz-pebble conglomerates (Potter and Siever, 1956; Wanless, 1975). The Caseyville lithology in the basal Mansfield thins northward, where the rocks are confined largely to

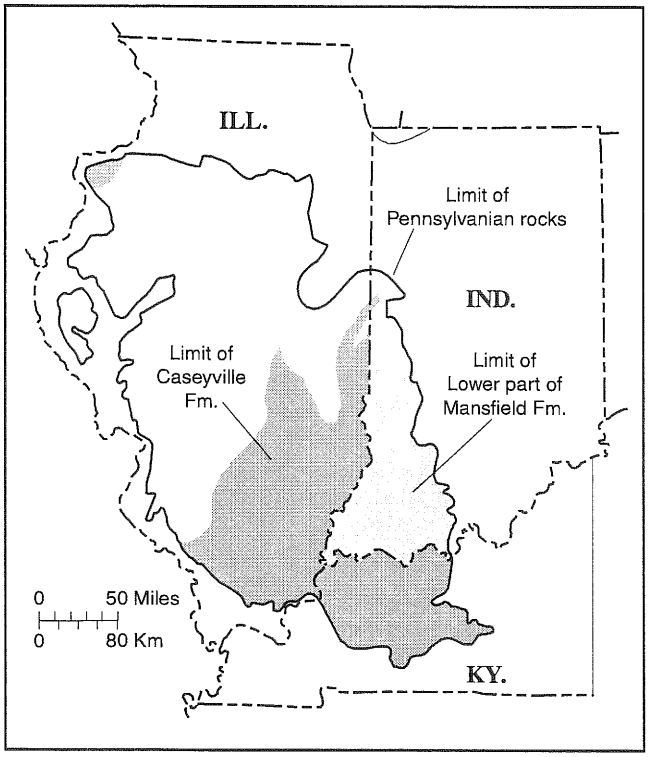

Figure 3. Outcrop limit of the Caseyville Formation in Illinois and Kentucky, and the lower part of the Mansfield Formation in Indiana.

paleovalley fills (Droste and Keller, 1989) (fig. 3). Outliers of Caseyville strata beyond this line may occur in parts of Rock Island County, Illinois, and Scott and Muscatine Counties, Iowa (Ravn and others, 1984; Ludvigson and Swett, 1987). These outliers truncate rocks as old as Devonian and are overlain unconformably by rocks ranging from Atokan to Desmoinesian in age (Potter and Siever, 1956; Kosanke and others, 1960; Ravn and others, 1984; Ravn, 1986; Ludvigson and Swett, 1987). Because of the uneven topography on which the Caseyville was deposited, the Caseyville typically has large local variations in thickness. Between the paleoupland surface and paleovalleys, the Caseyville thickens by as much as 300 feet. Another 300 feet of Caseyville may occur above the paleoupland surface. In the Webster Syncline of western Kentucky, the Caseyville is 600 feet thick (Greb and others, 1992). Regionally the Caseyville thickens southward.

Lithological Characteristics

The Caseyville Formation was originally defined as thick (0 to 160 feet), cliff-forming, quartz-rich, pebble-bearing sandstones near Caseyville (Lee, 1916), but its lithology varies. Paleovalley fill can be entirely composed of quartz pebble-bearing sandstones, mixed sandstones and shales, or thick shaly sequences (Potter and Desborough, 1965; BeMent and others, 1978; Howard and Whitaker, 1988; Greb, 1988, 1989b; Droste and Keller, 1989; Greb and others, 1992). The characteristic Caseyville sandstone is quartz rich (90 to 100 percent), matrix poor, crossbedded, and contains detrital quartz pebbles. In the field, a lack of mica, feldspar, and lithic fragments is used to distinguish Caseyville sandstones from overlying Tradewater sandstones (Potter and Glass, 1958; Nelson, 1989; Nelson and others, 1991).

Caseyville shales are gray to black, and contain fresh-, marine-, and brackish-water fossils (Whaley and others, 1979; Devera and others, 1987; Devera, 1989; Greb, 1989b). In the Caseyville, coals are rarely more than 2 feet thick and generally have a high ash content. Coals have been mapped only in the interval between the uppermost parts of paleovalley fills and the top of the formation (Greb and others, 1992). The few limestones in the Caseyville are argillaceous to arenaceous, often ferruginous, and contain marine- to brackish-water fossils (Wanless, 1939). These limestones occur only in the upper half of the formation.

Future Considerations

Detailed studies of the vertical and lateral extent of sandstones in the Caseyville Formation in Illinois and Kentucky and the basal Mansfield Formation in Indiana are a prerequisite to developing an understanding of the complex stratigraphy of the basal Pennsylvanian strata in the Illinois Basin. The extent of the pebble-bearing quartz arenites that characterize the Caseyville Formation needs to be determined to accurately map the limit of the Caseyville.

TRADEWATER FORMATION

Definition and Justification

The Tradewater Formation modified from Lee (1916) is hereby recognized in Illinois and Kentucky as the interval of strata from the top of the Caseyville to the base of the Seelyville Coal Member or Davis Coal Member/bed (fig. 1, pl. 1).

Recent mapping by the Illinois State Geological Survey in southern Illinois in the type area of the Abbott Formation has documented lateral facies changes which have led to miscorrelations in the past and which have rendered differentiation of the Abbott and Spoon Formations impractical in many areas (Nelson and others, 1991; Jacobson, 1992). Usage of the names "Abbott Formation" and "Spoon Formation" are therefore abandoned and the Tradewater Formation of western Kentucky is reintroduced into Illinois (fig. 1, pl. 1). The Tradewater has precedence as a formation name, having been used previously as both a formation and a group in Illinois (Butts, 1925; Weller, 1940; Wanless, 1938, 1939, 1955, 1956). The Tradewater is not extended into Indiana at this time because the boundary between the Caseyville

and Tradewater Formations has not been identified and mapped in Indiana. The Tradewater is equivalent to the upper part of the Mansfield Formation and the entire Brazil and Staunton Formations in Indiana (fig. 1, pl. 1).

Historical Perspective

Glenn (1912b) first proposed the name "Tradewater Formation" for the interval from the top of the Caseyville conglomerate to the base of the Sebree Sandstone Member. Lee (1916) lowered the upper boundary to the base of the underclay beneath the Davis, and noted that coal number "5" of Glenn was known as the number "6" coal over the rest of the coalfield (pl. 1). He referred to sections by Owen (1857) and Glenn (1912a) as reference sections, although he noted that these sections contained several discrepancies and were not necessarily typical of the strata defined. Lee (1916) also included a composite reference section, but did not designate a type section for the Tradewater.

Because of their composite nature, their lack of accurate locations, and the many gaps between exposures, the sections of Owen (1857), Glenn (1912a, b), and Lee (1916) are unacceptable as type or reference sections according to the guidelines of the North American Stratigraphic Code (North American Commission on Stratigraphic Nomenclature, 1983). However, Glenn (1912b) included a description of a core from Union County, Kentucky, that herein is designated as a reference section. Western Kentucky Stratigraphic Test Hole Gil No. 15 in Union County is also adopted as a reference section because it penetrates the entire Tradewater Formation in the type-locality area.

Glenn (1922) moved the upper boundary of the Tradewater Formation to the base of the Sebree Sandstone Member (pl. 1) reverting to his original proposed boundary (Glenn, 1912a, b). During the U.S. Geological Survey/Kentucky Geological Survey Cooperative Geologic Mapping Program, the Sebree was determined to be difficult to map and the upper boundary of the Tradewater Formation was moved by Calvert (1964) to the base of the Davis coal bed.

Butts (1925) recognized the Tradewater Formation of Glenn (1912a, b) in his mapping of the Shawneetown–Equality area of southeastern Illinois, but miscorrelated the Davis coal bed of Kentucky with the Murphysboro and Colchester Coal Members of Illinois (pl. 1). Other publications in Illinois referred Tradewater-equivalent strata to the Pottsville Formation (Wanless, 1929, 1931).

Wanless (1938, 1939) recognized the Tradewater Formation in southern Illinois, placing the upper boundary at the base of the Murphysboro, and noted the miscorrelations of the Murphysboro, Colchester, and Davis by Butts (1925). In the next ten years there were several changes in the rank of the Tradewater in Illinois. Weller (1940) raised the Tradewater of Glenn (1912a, b) to group status, and divided the group into the Grindstaff, Delwood, Macedonia (Murray Bluff), Stonefort, and Davis Formations (pl. 1). Wanless and Weller (1944) rejected the use of the term "Tradewater" across the Illinois coalfield and preferred to use "Pottsville Formation" for Tradewater-equivalent strata in western Illinois. Other post-1940 studies, such as Wanless (1955, 1956), used the term "Tradewater" and elevated the interval to group status.

In reclassifying the Pennsylvanian strata of Illinois, Kosanke and others (1960) replaced the name "Tradewater Formation" with "Kewanee Group" and introduced two new formations, the Abbott and Spoon Formations (pl. 1). The type locality of the Abbott was designated in southern Illinois, whereas the type locality of the Spoon was established in west-central Illinois, about 200 miles from the Abbott stratotype. The contact between the Abbott and Spoon was placed at the top of the Murray Bluff Sandstone Member in southern Illinois or Bernadotte Sandstone Member in western Illinois.

Formation Boundaries

As discussed previously, the lower boundary of the Tradewater Formation is the top of the Caseyville Formation. Along the northern and western edges of the basin in Illinois, the Tradewater locally rests directly on the sub-Pennsylvanian unconformity and may truncate rocks as old as the St. Peter Sandstone (Middle Ordovician).

The upper boundary of the Tradewater Formation is the base of the Seelyville Coal Member or Davis Coal Member/bed. The Davis is equivalent to the basal part of the Seelyville (Jacobson, 1987). The Seelyville Coal Member (Davis Coal Member/bed) has been mapped in southeastern Illinois (Cady, 1952; Smith, 1957; Jacobson, 1987), southwestern Illinois (Cady, 1952; Jacobson, 1983a), east-central Illinois (Treworgy, 1981), western and southwestern Indiana (Hutchison, 1956, 1958, 1959, 1960, 1964, 1971; Hutchison and Hasenmueller, 1988; Jacobson, 1987; Powell, 1968; Wier, 1952a, 1952b, 1953; Wier and Stanley, 1953; Wier and Powell, 1967), and western Kentucky (Smith and Brant, 1980; Jacobson, 1987). The Seelyville Coal Member or Davis Coal Member/bed has not been extensively mapped in parts of western and northern Illinois. If the Seelyville or Davis is absent, a suitable local marker bed may have to be selected for the upper boundary of the Tradewater in these areas.

Thickness and Extent

Variations in thickness of the Tradewater Formation are more gradual than those of the underlying Caseyville Formation. The maximum thickness of 600 feet occurs near the type area

in Union County, Kentucky, in the Moorman Syncline (Greb and others, 1992). Thicknesses ranging from 100 to 300 feet are common throughout southern Illinois. The Tradewater gradually thins and pinches out to the north and west (fig. 4). Along the northern and western margins of the basin the Tradewater rests on the sub-Pennsylvanian unconformity.

Lithological Characteristics

The Tradewater Formation contains more shale than the underlying Caseyville Formation and has thinner and less extensive coals than the overlying Carbondale Group/Formation. In general, the Tradewater consists of 70 to 80 percent shale and siltstone, 20 to 30 percent sandstone, and generally less than 5 percent coal and limestone. Sandstones are more abundant in the lower part of the Tradewater, where their proportion may increase to 50 percent of the section.

Tradewater sandstones are very fine to coarse grained, quartz rich, and micaceous. Besides containing more mica than Caseyville sandstones, Tradewater sandstones also contain more feldspar, lithic fragments, and interstitial clay. Potter and Glass (1958) petrographically classified the sandstones in the upper half of the Tradewater as lithic arenites, whereas sandstones in the lower half are transitional with the quartz arenites of the Caseyville Formation. Field mappers often use the presence of mica and the "dirty" appearance caused by rock fragments and interstitial clay in these sandstones to differentiate the Tradewater and Caseyville where other key stratigraphic characteristics are lacking.

Siltstones and shales make up as much as 80 percent of the upper part of the Tradewater. Siltstones typically are micaceous and grade laterally into sandstones and shales. Limestones and coals are only minor constituents of the formation but increase in frequency and lateral extent in the upper half of the formation. Many of the limestones and coals in the upper part of the Tradewater are traceable over large areas of the basin (Smith and Brant, 1980; Williams and others, 1982). Unfortunately, the similarity among some limestones used as key beds has led to miscorrelations of coals in the Tradewater Formation (Kehn and others, 1967; Kehn, 1974; Williams and others, 1982; Greb and others, 1992).

Future Considerations

Additional study is needed to determine the regional extent of the Caseyville lithology so the distribution of the overlying Tradewater in the Illinois Basin can be more precisely known. In addition, key beds that are used to mark formation boundaries within the Tradewater interval in Indiana need to be mapped in more detail and traced into adjacent regions. The Seelyville Coal Member or Davis Coal Member/bed, which marks the top of the Raccoon Creek Group, needs to be mapped in those parts of the basin where it has not yet been mapped.

MANSFIELD FORMATION (INDIANA)

T. C. Hopkins (1896, p. 199–200) introduced the term "Mansfield Sandstone" for the rocks exposed at the town of Mansfield in Parke County, Indiana. Hopkins described the Mansfield as the "coarse-grained gray, yellow, red, brown, or variegated massive sandstone . . . at the base of the Coal Measures [which lies] unconformably upon the Lower Carboniferous limestone, or in the absence of the limestone on Lower Carboniferous sandstone or shale . . . [and] is overlain by a series of shales, sandstones, and coal beds. . ." Cumings (1922, p. 527–528) amended the Mansfield to include all of the rocks between the base of the Pennsylvanian System and the base of the Lower Block Coal Member of the overlying Brazil Formation (pl. 1). Kottlowski (1959) recognized that this amended Mansfield included considerable shale as well as thin beds of coal, clay, and limestone and changed the name to "Mansfield Formation," which is the currently accepted usage in Indiana.

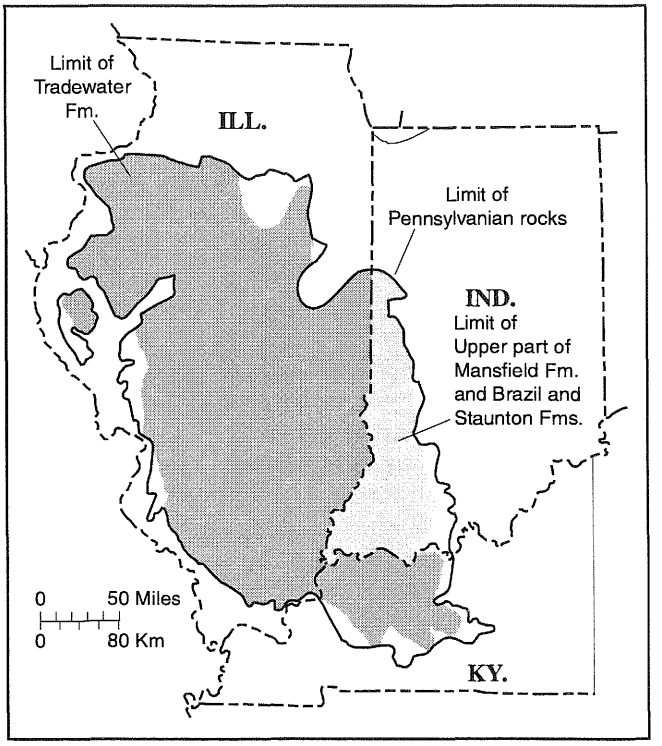

Figure 4. Outcrop limit of the Tradewater Formation in Illinois and Kentucky, and the upper part of the Mansfield Formation and the Brazil and Staunton Formations in Indiana.

The base of the Mansfield Formation (like the Caseyville Formation) coincides with the sub-Pennsylvanian unconformity (pl. 1). The key bed marking the upper boundary of the Mansfield is not well defined and has been mapped at several stratigraphic horizons (Gray and others, 1960; Gray, 1963; Hutchison, 1959, 1961, 1964, 1967, 1971, 1976). More recently Hutchison and Hasenmueller (1988) and Hasenmueller (1993) have also experienced problems with the current definition of the boundary between the Mansfield and Brazil Formations, mostly stemming from difficulty in tracing the Lower Block Coal Member. The Lower Block is a poor boundary marker in parts of the Indiana coalfield because it may be difficult or impossible to identify, its extent is not well known, and it does not always separate rocks with conspicuously different characteristics.

Thicknesses of the Mansfield Formation have been measured mostly from outcrop data (Gray, 1962) and range from 200 to 350 feet in the southern half of the outcrop area, to 50 to 100 feet in the northern half.

BRAZIL FORMATION (INDIANA)

The Brazil Formation, as originally defined by Fuller and Ashley (1902), included the shaly sandstones, shales, and minor beds of coal, limestone, and chert from the top of the Mansfield Sandstone to the base of the "Petersburg Coal" (Springfield Coal Member) (pl. 1). Cumings (1922) amended the Brazil to include the interval from the base of the Lower Block Coal Member to the unconformity above "Coal II" (Minshall [Buffaloville] Coal Member). Hutchison (1976) further restricted the Brazil by placing its top at the top of the more easily mapped Minshall Coal Member (pl. 1).

The base of the Brazil Formation is the base of the Lower Block Coal Member. The top of the formation is at the top of the Minshall (Buffaloville) Coal Member. The Brazil and the overlying Staunton are lithologically transitional, and where the coal is absent the two formations are not differentiated. The thickness of the Brazil in its type area varies from 40 to 90 feet.

STAUNTON FORMATION (INDIANA)

The name "Staunton" was first applied by Cumings (1922, p. 525) (pl. 1) to the rocks from the disconformity above Coal II to the disconformity above Coal IV (the Survant Coal Member). Wier (1950) restricted the Staunton to those rocks in the interval between the disconformity above Coal II (Minshall [Buffaloville] Coal Member) and the disconformity above Coal III (Seelyville Coal Member) (pl. 1). Hutchison (1958, 1960) mapped the Staunton and the bounding key beds in the type area. Later, the upper boundary was moved to the top of the Seelyville by Wier and Gray (1961), and the lower boundary was moved to the top of the Minshall Coal Member by Hutchison (1976) (pl. 1). The Staunton is herein revised to include the rocks from the top of the Minshall (Buffaloville) Coal Member of the underlying Brazil Formation to the base of the Seelyville Coal Member. This upper contact is also the upper boundary of the Raccoon Creek Group.

The Staunton Formation typically contains a greater abundance of limestones, black shales, and fossiliferous shales than do the under- and overlying formations. The transition from Brazil to Staunton lithology is gradational. The Minshall Coal Member and its equivalent, the Buffaloville Coal Member, have been mapped more or less continuously from Warren County at the north end of the Indiana coalfield to Spencer County on the Ohio River (Hutchison and Hasenmueller, 1986a, 1986c). Correlation of the Minshall (Buffaloville) is based in part on identification of the Perth Limestone Member of the Staunton Formation which is slightly higher in the section. Identification of this coal bed is difficult where the Perth is absent or where other similar limestones are present. The Minshall (Buffaloville) has been miscorrelated with various coal beds in the Staunton and with coal beds that underlie the Lead Creek Limestone Member of the Mansfield Formation.

CARBONDALE GROUP/FORMATION

Definition and Justification

The name "Carbondale" is used in all three states but its rank and boundaries vary (fig. 1). The Carbondale is assigned formation rank in Illinois and Kentucky and retains its group rank in Indiana.

The base of the Seelyville Coal Member or Davis Coal Member/bed is herein proposed as the basal boundary of the Carbondale throughout the Illinois Basin. The base of the Colchester Coal Member was also considered, but the base of the Seelyville or Davis was used because: 1) the lithology of the stratigraphic interval from the Davis to the Colchester is more analogous to that of the Carbondale, 2) this datum has widespread usage on the geologic quadrangle maps in Kentucky, and 3) it has potential for being mapped across much of Illinois and Indiana.

The upper boundary of the Carbondale is not the same basinwide (fig. 1). Previously, the top of the Danville Coal Member was the upper boundary in Illinois and Indiana (Kosanke and others, 1960; Burger and Wier, 1986); the top of the Herrin coal bed, which is 32 to 162 feet lower in the section, marked the upper boundary of the Carbondale in Kentucky (Williams and others, 1982).

Selection of a common boundary for the top of the Carbondale is not possible at this time because neither the Herrin Coal Member/bed nor the Danville Coal Member has been recognized throughout the basin. The Herrin Coal Member/bed is widespread in most of Illinois and in western Kentucky, but thins and pinches out in Indiana. The Danville is widespread and prominent in Indiana and parts of Illinois, but the equivalent coal bed is less well known in Kentucky. The Providence (Brereton) Limestone Member, which commonly overlies the Herrin, is recognized in parts of all three states, but the limestone thins northward in Indiana and is absent north of Gibson County.

The base of the Providence (Brereton) Limestone Member herein is proposed as the top of the Carbondale in Illinois and Kentucky (fig. 1, pl. 1). In Illinois this revised boundary is the base of the lowermost limestone of the McLeansboro Group, which is lithologically consistent with the other marker beds used to denote formational boundaries in the group. The selection of the Providence is stratigraphically close to the boundary of the Carbondale as mapped on the geologic quadrangle maps of Kentucky because the Providence overlies the Herrin coal bed by only 0 to 6 feet. The Energy Shale Member directly overlies the Herrin Coal Member in some areas of Illinois and is closely associated with a peat-contemporaneous major river system (Walshville), as well as with the black shale (Anna Shale Member) commonly found below the Brereton Limestone Member. The Energy Shale thus remains in the Carbondale Formation. The upper boundary of the Carbondale in Indiana is not revised and remains at the top of the Danville Coal Member.

Historical Perspective

The strata in the Carbondale interval were originally assigned to the upper part of the Pottsville Formation and to the LaSalle and Petersburg Formations in Illinois by DeWolf (1910) (pl. 1). Lines (1912) was the first to use the term "Carbondale formation" for shale, sandstone, coal, and limestone "extending from the bottom of the Murphysboro Coal (No. 2) to the top of the Herrin Coal (No. 6 or No. 7 locally) . . . " (pl. 1). As previously mentioned, the Murphysboro Coal Member was miscorrelated at that time with the Colchester Coal Member in northern Illinois and the Davis coal bed in western Kentucky.

While Shaw and Savage (1912) have often been credited as the originators of the name "Carbondale formation," Lines (1912) has precedence by several months. Shaw and Savage (1912) described the formation in detail in the vicinity of the town of Carbondale and placed the lower boundary at the base of the underclay beneath the Murphysboro, rather than at the base of the coal as suggested by Lines (pl. 1). The Murphysboro was equated by Shaw and Savage with the Colchester, "Third Vein," and Illinois "No. 2" coal on the basis of paleoflora correlations by White (1907, 1909).

Shaw and Savage (1912) differentiated the Carbondale from the underlying "Pottsville sandstone" with its sandstone dominance, and the overlying "McLeansboro formation," which they considered "barren of workable coal beds. . ." The marker beds of the formation were believed to be "persistent and easily recognized. . ." Their intent was to make the Carbondale equivalent to the Allegheny Formation of the Appalachian Basin on the basis of the correlations of the fossil flora by White (1907, 1909). This original time-rock definition of the Carbondale and the discontinuous nature of some of the marker boundary beds used in each state has prevented a consistent, basinwide recognition of the boundaries of the Carbondale.

Wanless and Weller (1932) recognized that the Colchester (No. 2) was not correlative with the Murphysboro as previously determined by White (1907, 1909) and that the lower boundary of the Carbondale had been incorrectly placed in northern and western Illinois. Wanless and Weller proposed that the lower boundary for the Carbondale be staggered (pl. 1). In northern Illinois the boundary was placed at the base of the Colchester, and in southern Illinois it remained at the base of the Murphysboro (Wanless, 1939; Wanless and Weller, 1932, 1944).

Weller (1940) and Wanless (1939) abandoned the staggered boundary of Wanless and Weller (1932). The lower boundary of the formation was moved to the base of the Palzo Sandstone Member below the Colchester Coal Member, and the upper boundary of the formation was moved from the top of the Herrin Coal Member to the base of the Anvil Rock Sandstone Member. The Palzo is correlative with the Sebree Sandstone Member of Kentucky, thus the boundary was the same as that suggested by Glenn (1922, 1923). The boundaries were moved to conform to the division of cyclothems in Illinois; the then-new base of the Carbondale conformed to the base of the cycle that includes the Colchester. Because cyclothems were ranked as formations, the Carbondale was raised to a group status in Illinois.

The change in the rank of the Carbondale from a formation to a group was first referred to by Weller (1940, p. 36) in a footnote:

> "The principal divisions of the Pennsylvanian system in Illinois (Caseyville, Tradewater, Carbondale, and McLeansboro), considered formations in previous publications, are, according to present usage of the Illinois State Geological Survey, groups."

Cady (1942) also placed the lower boundary at the base of the Palzo (Isabel) Sandstone Member, which was equivalent to the boundary designated by Glenn (1922). Cady (1942) also described the coal beds, but not the formations in the new group.

In the same year, Willman and Payne (1942) used the term "Carbondale Group"; the group was subdivided into cyclothems. Willman and Payne revised the lower boundary of the Carbondale Group, moving it to the base of the underclay of the Colchester, and the upper boundary, raising it from the top of the Herrin up to the base of the Anvil Rock (Copperas Creek) Sandstone Member. Wanless (1956, 1957), following Glenn (1922), placed the lower boundary of the group at the base of the Sebree (Isabel or Palzo). Wanless (1956) also noted that a type section of the Carbondale had not been designated.

Kosanke and others (1960) reduced the rank of the Carbondale to formation and moved the lower boundary to the base of the Colchester and the upper boundary to the top of the Danville (pl. 1). Three separate localities in Fulton County in west-central Illinois were designated as the type section of the Carbondale Formation by Kosanke and others (1960). Because a type locality is the specified geographic locality where the stratotype of a formal unit or unit boundary was originally defined and named, locations designated by Kosanke and others actually constitute reference sections. Geologic section 4 of Kosanke and others (1960, p. 62–63) located in Fulton County, Illinois, is herein designated as a reference section in Illinois for the lower part and the lower boundary of the Carbondale Formation. Peppers (1970) described in detail the flora of the Carbondale and Spoon Formations of the northeastern part of the basin based on spores preserved in the coal seams of the formations.

The name "Carbondale Formation" was introduced in western Kentucky by Lee (1916) to replace the Dekoven and Mulford Formations of Glenn (1912a, b). The base of the formation was placed at the base of the fire-clay underlying the Davis coal bed, which was then considered to be equivalent to the Murphysboro. Lee (1916) combined the two formations into one because "the two formations are both thin and there is no paleontologic nor stratigraphic break at this point, . . ." For the placement of the upper boundary Lee adopted the boundary as defined in Illinois by Shaw and Savage (1912) using the top of the Herrin.

Glenn (1922, 1923) revised both boundaries of the Carbondale in western Kentucky to be more "natural" boundaries, namely, unconformities at the base of sandstones. Lee (1916) had considered the Sebree Sandstone Member as the base of the Carbondale but chose the Davis because the "unconformity" at the base of the sandstone "is rarely so conspicuous as to make it possible to map . . ." In Glenn's (1922, 1923) study area, however, the sandstone was conspicuous. The base of the Carbondale, therefore, was moved to the base of the Sebree, and the upper boundary was moved up to the base of the Anvil Rock Sandstone Member.

Fifty years after Lee had noted the problems associated with using the bases of sandstones as marker horizons, participants in the U.S. Geological Survey/Kentucky Geological Survey Cooperative Geologic Mapping Project recognized that the boundary at the base of the Sebree was not the best choice for regional mapping. Hence, the base of the Carbondale was revised downward to the base of the Davis coal bed (Calvert, 1964; Kehn, 1966; Palmer, 1966) and the top of the formation was lowered to the base of the Providence (Kehn, 1963, 1964a, 1973). The Herrin was considered the uppermost widespread coal in the area by Kehn.

Prior to the use of the term "Carbondale" in Indiana, the strata between the Raccoon Creek Group and McLeansboro Group were assigned to the upper part of the Brazil Formation, the Petersburg Formation, and the lower part of the Millersburg Formation (Fuller and Ashley, 1902) (pl. 1). Cumings (1922, p. 525–529) modified the boundaries of the formations so that Carbondale-equivalent strata were confined to the upper part of the Staunton Formation and the Petersburg Formation (pl. 1).

Wier and Gray (1961) introduced the term "Carbondale" in Indiana as a group name; the group is composed of the Linton, Petersburg, and Dugger Formations. The lower boundary of the Carbondale Group was placed at the top of the Seelyville Coal Member of the Staunton Formation and the upper boundary was placed at the top of the Danville Coal Member of the Dugger Formation. Thus, the Carbondale as introduced by Wier and Gray (1961) in Indiana included strata between the Seelyville Coal Member and Colchester Coal Member, which were not included in the Carbondale in Illinois (pl. 1).

The boundaries of the three formations recognized within the Carbondale Group in Indiana are placed at distinctive key beds, which are generally traceable across much of the southwestern part of the state. In areas where the key beds are absent, it is difficult to differentiate the formations.

Boundaries

The lower boundary of the Carbondale Group/Formation is herein revised to the base of the Seelyville Coal Member or Davis Coal Member/bed or its equivalent. In Indiana and east-central Illinois, the Davis equivalent is the basal bed of the Seelyville (Jacobson, 1987). In western Illinois, the Davis is equivalent to the Wiley Coal Member (Wanless, 1939).

A single, basinwide upper boundary for the Carbondale is not recognized at this time. In Kentucky and Illinois the top of the Carbondale Formation is the base of the Providence (Brereton) Limestone Member. Where the limestone cannot be recognized, the top of the underlying black shale that is common in that area (Anna Shale Member in Illinois) will be used. Locally in Illinois, where the Energy Shale Member is present in thick lenses, both the limestone and the black shale are commonly absent and the boundary will be placed at the top of the Energy. In Indiana the top of the Danville Coal Member will continue to be recognized as the upper boundary of the Carbondale Group. Although the Danville is present in much of Illinois and Indiana, the equivalent coal bed in Kentucky is less well known. The Danville may be equivalent to the Wheatcroft (W. Ky. No. 13a) coal bed (Greb and others, 1992); however, the Wheatcroft is generally thin or absent in western Kentucky.

Thickness and Extent

The Carbondale Group/Formation (fig. 5) ranges from less than 200 feet in the western and northeastern parts of the basin to about 500 feet in southeastern Illinois (Hopkins and Simon, 1975). In Indiana the Carbondale Group ranges from 260 to 470 feet in thickness and averages slightly more than 300 feet (Burger and Wier, 1986). The Carbondale in Indiana reaches a maximum thickness in Posey County and generally thins to the north and east (Burger and Wier, 1986). Across western Kentucky the formation thickness is less variable, generally 375 to 425 feet, but it thins along the eastern margin of the basin (Greb and others, 1992).

Lithological Characteristics

The Carbondale differs from the underlying Raccoon Creek Group and overlying McLeansboro Group in that it contains the majority of the widespread thick coal seams. In addition, the stratigraphic units within the Carbondale are generally more persistent and cyclic in nature than those in the underlying Raccoon Creek Group. Several named coals, limestones, and shales can be traced across the basin (Wanless, 1939; Hopkins and Simon, 1975; Williams and others, 1982; Jacobson and others, 1985; Shaver and others, 1986; Greb and others, 1992). The lithologic cyclicity of the Carbondale continues upward into the overlying McLeansboro Group.

Gray shales commonly occur as parts of the coarsening-upward sequences and may compose as much as 65 percent of the Carbondale Group/Formation (Kosanke and others, 1960). These shales contain marine fossils, plant fossils, thin coals, and siderite nodules, and they locally interfinger with sandstones.

Sandstones make up approximately 25 percent of the formation (Kosanke and others, 1960). They typically are more argillaceous than sandstones in the lower part of the Raccoon Creek and generally are classified as lithic arenites (Potter and Glass, 1958). The sandstones tend to occur as relatively thin (<16 feet) sheet-form deposits at the top of coarsening-upward sequences or as thick (16 to 116 feet) channel sequences, which may truncate underlying strata. Many of the named sandstones in the Carbondale are parts of extensive channel networks (Wanless, 1939, 1955; Harvey, 1956; Rusnak, 1957; Potter, 1962; Beard and Williamson, 1979; Ault and others, 1979; Eggert, 1982, 1987; Eggert and Adams, 1979).

Most coals in the Carbondale and in younger stratigraphic units are overlain by thin (<6 feet) black shales and limestones. These units have distinctive signatures on geophysical logs. The signatures of the dark shales and thin limestones above the Colchester and Springfield have been used to identify these coals across much of the basin (Wanless, 1957; Smith, 1967; Jacobson, 1987; and Greb and others, 1992). The black shales and the limestones are generally overlain by coarsening-upward sequences.

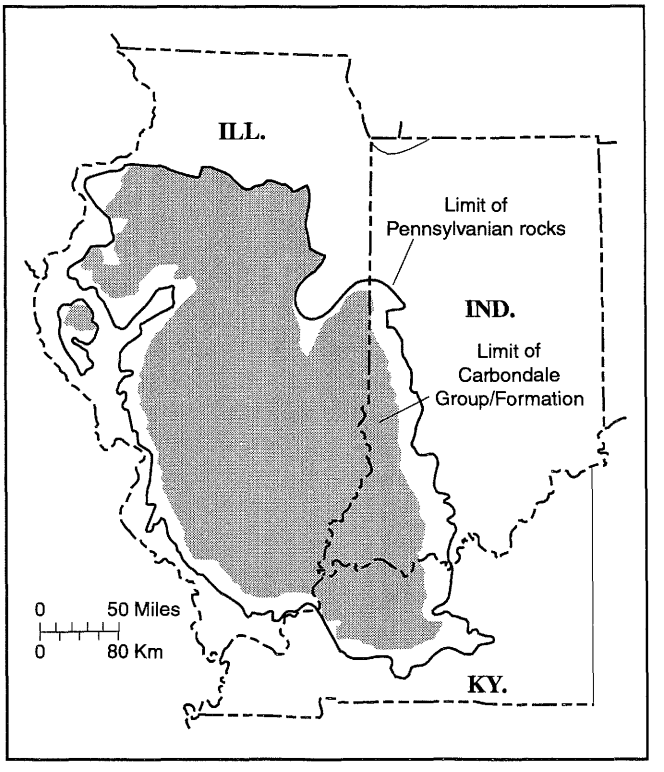

Figure 5. Outcrop limit of the Carbondale Group/Formation.

Future Considerations

Additional work is needed in mapping the Providence (Brereton) Limestone Member to determine its usefulness as a boundary in Indiana. The Danville and equivalent units in west-central and southwestern Indiana and western Kentucky also need to be mapped. Correlations by Wier (1961, 1965) indicate that the coal previously known as the Upper Millersburg Coal in Indiana (Wier and Stanley, 1953; Wier, 1958) is equivalent to the Danville in Indiana. Preliminary work by R. J. Jacobson, D. A. Williams, and R. A. Peppers has determined that the Wheatcroft (W. Ky. No 13a) or Coiltown (W. Ky. No. 14) coal beds in western Kentucky may be equivalent to the Danville. More work is needed to determine which (if any) of these coals is equivalent to the Danville, and what the extent of these coals is in the deeper part of the basin in western Kentucky.

LINTON FORMATION (INDIANA)

The Linton Formation is the lowermost formation in the Carbondale Group in Indiana. The name "Linton Formation" was proposed for exposures of sandstone, shale, limestone, and coal along the tributaries of Lattas Creek in secs. 26 and 27, T. 8 N., R. 7 W., in Greene County, approximately 4 miles north of the town of Linton, by Wier in 1950. Because the lower and upper contacts of the formation were placed at stratigraphic breaks that were discontinuous, Wier (1961, 1965) later designated the top of the Seelyville Coal Member of the Staunton Formation as the base of the Linton and the top of the Survant Coal Member as the upper boundary of the Linton. An abandoned strip mine in the SW ¼ sec. 25, T. 8 N., R. 7 W., in Greene County was designated as a reference section by Wier (1961, 1965). As a result of the current study, the lower contact of the Linton Formation is revised and placed at the base of the Seelyville Coal Member.

Along the outcrop the formation is generally about 80 feet thick; however, it ranges from 43 to 162 feet in thickness (Wier, 1965). Large variations in thickness are common, and locally either the Survant or the Seelyville is absent (Wier, 1961, 1965).

PETERSBURG FORMATION (INDIANA)

The name "Petersburg" was proposed by Fuller and Ashley (1902, p. 2) (pl. 1) for a coal as well as for a formation in the area of the town of Petersburg in Pike County, Indiana. As originally defined, the formation contained the rocks between the base of the Petersburg Coal and the base of the Millersburg Coal. The formation was revised by Cumings in 1922 (p. 529) to include "the interval from the disconformity over Coal IV to the disconformity over Coal VII." (See plate 1.) Wier (1950) restricted the formation to include only the rocks between the unconformity above Coal IV (the Survant Coal Member of the Linton Formation) and the unconformity above the Alum Cave Limestone Member (pl. 1). The formation was further restricted by Wier (1961, 1965) and Wier and Gray (1961) to include only those rocks between the top of the Survant (Coal IV) and the top of the Springfield Coal Member (Coal V) (pl. 1). Wier (1965) stated, "The Springfield coal is a much better marker than the overlying Alum Cave limestone and this revision provides some uniformity by defining each formation in the Carbondale Group so that it is bounded by the top of an extensive well-developed coal." In areas of Warrick County where the Folsomville Member of the Petersburg is present but the upper split of the Springfield is absent, the Folsomville marks the top of the formation (Eggert, 1982).

Indiana Geological Survey SDH-81 core in Pike County, located 4 miles northeast of Petersburg, in the NE NE NE sec. 7, T. 1 N., R. 7 W., was designated as a reference for the Petersburg Formation by Wier (1961, 1965). Thicknesses reported by Wier (1965) range from 70 to 190 feet.

DUGGER FORMATION (INDIANA)

The name "Dugger Formation" was used by Wier (1950, 1952a) for exposures of sandstone, shale, limestone, and coal in secs. 31 and 32, T. 8 N., R. 7 W., and secs. 5 and 6, T. 7 N., R. 7 W., 2 miles northeast of the town of Dugger in Sullivan County, Indiana. Wier (1950, 1952a) placed the lower boundary of the formation at the unconformity above the Alum Cave Limestone Member; later, this boundary was lowered to include both the Alum Cave and the underlying black shale in the Dugger Formation (Wier, 1961, 1965; Wier and Gray, 1961) (pl. 1). As now defined, the Dugger includes the strata from the top of the Springfield Coal Member to the top of the Danville Coal Member.

The formation ranges in thickness from 73 to 185 feet and averages 130 feet (Wier, 1965). The Dugger crops out from Warrick County in southernmost Indiana to Vermillion County in westernmost central Indiana.

MCLEANSBORO GROUP

Definition and Justification

The name "McLeansboro Group" of DeWolf (1910) is herein extended to the entire Illinois Basin for the upper part of the Pennsylvanian. The group consists of the Shelburn, Patoka, Bond, and Mattoon Formations (fig. 1). This subdivision of the McLeansboro is currently used in Indiana. The Shelburn and Patoka Formations are herein proposed for Illinois, and

all four McLeansboro formations are herein proposed for western Kentucky. The adoption of the names "Shelburn" and "Patoka Formations" in place of the term "Modesto Formation" in Illinois unifies basinwide nomenclature for this group.

The extension of the name "McLeansboro Group" in Kentucky facilitates division of the thick sequence of Pennsylvanian rocks, previously assigned to the Sturgis Formation (Kehn, 1973; Kehn and others, 1982), into more practical stratigraphic intervals. The mappability of four of the five marker horizons which delineate the formations of this group has been demonstrated on the geologic quadrangle map series for Kentucky.

The base of the McLeansboro Group is the top of the Carbondale Group/Formation; in most places, the top of the McLeansboro Group is the top of the Pennsylvanian and is also the sub-Cenozoic unconformity. In western Kentucky the top of the group is the Pennsylvanian–Permian boundary (Kehn and others, 1982). Because the top of the Carbondale is not uniform, the base of the McLeansboro similarly is nonuniform. In Kentucky and Illinois the base of the group is the base of the Providence (Brereton) Limestone Member and in Indiana it is the top of the Danville Coal Member (fig. 1).

The type section for the McLeansboro Group is the Delafield core, as designated by Kosanke and others (1960).

Historical Perspective

The name "McLeansboro Formation" was simultaneously introduced in Illinois by DeWolf (1910) and Savage (1910) in the same publication. Because Savage (1910) referred to the formations designated and defined by DeWolf, DeWolf is usually credited with defining the formation (pl. 1). DeWolf proposed that the formation include all Pennsylvanian strata overlying the Herrin Coal Member in Illinois. He did not explicitly state that the unit was named after the town of McLeansboro, but he did refer to the logs of two cores drilled near the town, known as the Delafield core and the Elm Grove core, as "suitable descriptions . . . probably better than can ever be obtained from outcrops." Drillers' logs of both cores were published by Udden (1907) and Blatchley (1910). Kosanke and others (1960) selected the Delafield core as the stratotype, probably because Udden had described portions of the core (only a driller's log exists for the Elm Grove core), and DeWolf had referred to it first. The stratigraphic interval of the Delafield core is from the underclay of the Herrin Coal Member to approximately the lower part of the Mattoon Formation.

Wanless (1939), without explanation, referred to the McLeansboro as both a "Formation" and "Series." The McLeansboro was elevated to a group status in a footnote by Weller (1940). Acceptance of group status for the McLeansboro became widespread with the mapping of cyclothems in the Illinois Basin.

Willman and Payne (1942) subdivided the McLeansboro Group into cyclothems and moved the lower boundary from the top of the Herrin Coal Member up to the base of the Anvil Rock (Copperas Creek) Sandstone Member, to correspond with the base of the Sparland cyclothem. Wanless (1956) and Siever (1956), also divided the McLeansboro Group into cyclothems, but Wanless (1956) did not favor the use of McLeansboro as a group, because it was based on a core description in an area where few outcrops existed.

The subdivision of the McLeansboro Group into three formations by Kosanke and others (1960) was merely the formal recognition of the informal stratigraphic classification of Wanless. On stratigraphic columns constructed for most of the counties in Illinois, Wanless divided the McLeansboro Formation into lower, middle, and upper parts. These divisions are respectively equivalent to the Modesto, Bond, and Mattoon Formations of Kosanke and others (1960) (pl. 1). The contact between the lower and middle part of the McLeansboro on Wanless's stratigraphic columns was the base of either the Shoal Creek Limestone Member or the "Hicks" Limestone (Wanless and Weller, 1944; Cooper, 1946; Jacobson, 1983b); this is the same boundary that differentiates the Modesto from the Bond Formation (pl. 1). The contact between the middle and upper part of the McLeansboro on Wanless's columns was the top of the La Salle Limestone Member. The La Salle is probably equivalent to the Millersville Limestone Member (Jacobson, 1983b), the boundary between the Bond and Mattoon Formations.

Kosanke and others (1960) abandoned Wanless's (1956) use of cyclothems as formations and moved the lower boundary of the McLeansboro from the base of the Anvil Rock (Copperas Creek) up to the top of the Danville Coal Member. The McLeansboro Group was differentiated from the underlying Kewanee Group by Kosanke and others (1960) because the former had more abundant and thicker limestone beds and thinner coals.

Lines (1909) delineated the McLeansboro Group on a state map of Indiana, but he did not name the unit or refer to it in any publications. In mapping the Ditney Quadrangle, which includes nearly all of Pike County in Indiana and parts of Gibson, Vanderburgh, Warrick, Spencer, and Dubois

Counties in Indiana, Fuller and Ashley (1902) recognized the following formations: Millersburg, Somerville (West Franklin Limestone Member), and Ditney Formations, and the Inglefield Sandstone (pl. 1).

Shrock and Malott (1929) also noted the significance of two of these formations, the Somerville and the Inglefield Sandstone. Wier and Gray (1961) extended the usage of the name "McLeansboro Group" from Illinois into Indiana and divided the group into the Shelburn, Patoka, Bond, and Mattoon Formations.

Strata in Kentucky equivalent to the McLeansboro Group were first called the Lisman and Dixon Formations by Glenn (1912a, b). Lee (1916) adopted the term "McLeansboro Formation" for the strata between the top of the Herrin coal bed and the top of the Geiger Lake coal bed (pl. 1). He renamed the Dixon Formation as the Henshaw Formation. Glenn (1922) did not recognize the McLeansboro Formation and continued to use the name "Lisman Formation" for the interval extending from the base of the Anvil Rock to the top of the Geiger Lake (pl. 1).

Early in the U.S. Geological Survey/Kentucky Geological Survey Cooperative Geologic Mapping Program the strata equivalent to the McLeansboro were mapped as the Lisman and Henshaw Formations (Kehn, 1964a). Kehn (1973) later abandoned the usage of these two formations, which were apparently lithologically indistinguishable, and placed all of the strata above the Herrin coal bed in the Sturgis Formation. The Sturgis Formation differed from the McLeansboro Group of Indiana and Illinois in that the lower boundary of the unit was the top of the Herrin, rather than the Danville (pl. 1). Later, Kehn and others (1982) revised the upper boundary as the base of Permian-age rocks of the Mauzy Formation, rather than the subcrop of Pennsylvanian rocks in Illinois and Indiana.

SHELBURN FORMATION

Definition and Justification

The Shelburn Formation is recognized as the lowermost formation of the McLeansboro Group. As previously mentioned, the base of the Shelburn Formation is a staggered boundary. In Indiana the base of the Shelburn is the top of the Danville Coal Member, whereas in Illinois and Kentucky it is the base of the Providence (Brereton) Limestone Member (fig. 1).

The justification for the offset lower boundary of the Shelburn Formation was discussed in the section on the Carbondale Group/Formation. The upper boundary of the Shelburn Formation is the top of the West Franklin Limestone Member. This marker has been mapped throughout much of the basin, although the upper benches of the limestone are locally missing in west-central Illinois (Andresen, 1956, 1961). The West Franklin (previously known as the Madisonville Limestone Member in Kentucky) was mapped on the geological quadrangles compiled during the U.S. Geological Survey/ Kentucky Geological Survey Cooperative Geologic Mapping Program in western Kentucky.

Historical Perspective

Cumings (1922, p. 525, 529) proposed the name "Shelburn Formation" for strata exposed near Shelburn in Sullivan County, Indiana (pl. 1). He defined the Shelburn as the "interval between the disconformity above coal VII (Millersburg coal) and the base of the Merom sandstone." While the name was taken from Shelburn, Sullivan County, Indiana, no type section was designated and it is difficult to recognize the formation from outcrops in the vicinity of Shelburn (Wier, 1961). A core description of a drill hole 3 miles southwest of Shelburn was selected as a reference section by Wier (1961, 1965, appendix 1, loc. 14).

Miscorrelations of the marker beds by various authors (Shrock and Malott, 1929; Logan, 1932; Malott, 1948; Wier and Esarey, 1951) caused a wide range of strata to be mapped as Shelburn Formation. Shrock and Malott (1929) raised the West Franklin to formation status similar to Fuller and Ashley's (1902) designation of the Somerville Formation, now considered to be a synonym of the West Franklin (pl. 1).

Wier and Gray (1961) mapped the Shelburn Formation as the strata from the top of the Danville Coal Member to the top of the West Franklin Limestone Member (pl. 1). According to Burger and others (1986), the revised Shelburn includes only the lower part of the Shelburn of Cumings (1922) in Sullivan County but is equivalent to the Shelburn interval that Cumings recognized in Gibson and Vanderburgh Counties.

Strata equivalent to the Shelburn Formation in Illinois were originally part of the McLeansboro Formation (DeWolf, 1910; Shaw and Savage, 1912; Wanless, 1929, 1931; Wanless and Weller, 1944). The McLeansboro was elevated to group status when cyclothems were mapped in Illinois (Wanless, 1938; Willman and Payne, 1942). Kosanke and others (1960) moved cyclothems to a separate nomenclatural classification and divided the McLeansboro Group into three formations. The lowermost formation was called the "Modesto Formation." Roughly the lower half of the original Modesto Formation is herein assigned to the Shelburn Formation (fig. 1, pl. 1).

Kentucky rocks equivalent to the Shelburn were initially included in the lower part of the Lisman Formation of Glenn (1912a, b, 1923). Strata in this interval were also briefly included in the lower part of the McLeansboro Formation of

Lee (1916). The term "McLeansboro," however, never gained acceptance in Kentucky (pl. 1). During the U.S. Geological Survey/Kentucky Geological Survey Cooperative Geologic Mapping Program, Kehn (1964b) first included all of the Pennsylvanian strata above the Herrin coal bed in two formations: the Lisman and the Henshaw. Later he abandoned these two formations placing the entire interval into the Sturgis Formation (Kehn, 1973). The lower part of the Sturgis Formation is equivalent to the Shelburn.

Formation Boundaries

The lower boundary of the Shelburn Formation is the top of the Carbondale Group/Formation, as previously mentioned. The upper boundary of the Shelburn is the top of the West Franklin Limestone Member. The West Franklin was formerly known as the Madisonville Limestone Member in western Kentucky but the name was abandoned because the term "West Franklin" had precedence (Jacobson and others, 1985). The West Franklin commonly occurs as one to three limestone beds separated by shale. Wier and Gray (1961) and Wier (1961, 1965) defined the upper boundary of the formation as the top of the West Franklin Limestone Member.

In the southwestern, western, and northwestern part of the basin, the West Franklin is equivalent to the interval from the Piasa Limestone Member to the Exline (Scottville) Limestone Member (Andresen, 1956; Manos, 1963; Hopkins and Simon, 1975). The upper boundary of the Shelburn in these areas is the top of the Exline (Scottville). Differentiation of the Shelburn Formation may be difficult in the southwestern portion of the Illinois Basin where the Exline (Scottville) Limestone Member only occurs in scattered patches (Orlopp, 1964). Also, in west-central Illinois the West Franklin, or its correlatives, is locally absent due to erosion and replacement by the overlying Trivoli Sandstone Member (Andresen, 1961; Greb and others, 1992).

Thickness and Extent

The Shelburn Formation is present in the southeastern two-thirds of the Illinois Basin and the north-central part of the basin (fig. 6). Scattered erosional outliers are present in the northwestern part of the basin. The formation ranges from 50 to 250 feet in Indiana (Burger and others, 1986). In Kentucky, the Shelburn crops out across most of Henderson County and through the Webster and Moorman Synclines from Union County to Muhlenberg County. The Shelburn varies in thickness from 155 to 245 feet in western Kentucky and is thickest in the Webster Syncline (Greb and others, 1992). In Illinois the Shelburn Formation thickens from 150 feet in northern and western Illinois to 275 feet in southeastern Illinois. Locally, the formation thins to as little as 100 feet on the Louden Anticline in central Illinois.

Lithological Characteristics

The Shelburn Formation is composed mainly of siliciclastics. More than 75 percent of the formation is sandstone dominated in Illinois and Kentucky where the Anvil Rock Sandstone Member is included in the Shelburn. This sandstone has been mapped throughout much of the southern part of the basin and in places truncates more than 100 feet of underlying Carbondale strata (Hopkins, 1958; Potter and Simon, 1961; Kehn, 1974; Beard and Williamson, 1979; Palmer and others, 1979; Utgaard, 1979). The sandstones are typically fine to medium grained and are lithologically similar to Carbondale sandstones (Hopkins, 1958; Potter and Simon, 1961).

The formation contains widespread beds of limestone, black shale, and coal. In general, the coals are thinner and the limestones thicker than those of the underlying Carbondale Group/Formation. Two of the thicker limestones in the Shelburn are the West Franklin and the Providence (Brereton) Limestone Members. These units commonly consist of several limestone beds separated by gray shale and coal.

Although the coals of the Shelburn Formation are generally thinner than the Carbondale coals, the Shelburn locally contains some of the thickest coals in the basin. The Coiltown (W. Ky. No. 14) coal bed reaches thicknesses of 7 feet in the

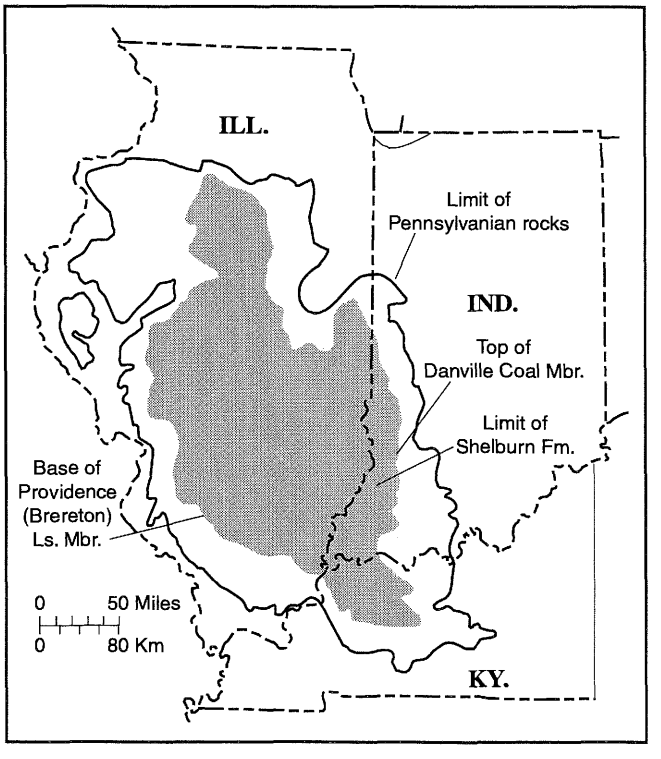

Figure 6. Outcrop limit of the Shelburn Formation (approximated in Illinois and Kentucky).

Moorman Syncline (Palmer, 1969), and the Baker (W. Ky. No. 13) coal bed reaches thicknesses in excess of 6.6 feet in belts adjacent to the Anvil Rock channels (Kehn, 1966; Franklin, 1969; Greb and others, 1992). These coals are not widespread.

Future Considerations

As previously discussed, more work is needed to resolve the boundary at the base of the formation in all three states. The number and thickness of limestone beds within the West Franklin Limestone Member vary in west-central Illinois, and the relationship between the boundary and these local facies changes awaits further study. Once this work is complete, the Shelburn needs to be plotted on new maps in Illinois and Kentucky. The distribution and thickness of the coal beds within the Shelburn Formation and their stratigraphic correlations also need further work.

PATOKA FORMATION

Definition and Justification

The Patoka Formation as defined by Wier and Gray (1961) and Wier (1961, 1965) herein is recognized as the formation overlying the Shelburn Formation and underlying the Bond Formation. The type locality as designated by Wier (1961, 1965) is recognized for the Patoka Formation in the Illinois Basin. The lower boundary of the Patoka is the top of the West Franklin Limestone Member (fig. 1, pl. 1). The upper boundary of the formation is the base of the Carthage (Shoal Creek) Limestone Member of the overlying Bond Formation (fig. 1, pl. 1). In Illinois, the Patoka interval includes the upper part of the former Modesto Formation, and in Kentucky this interval includes part of the former Sturgis Formation (fig. 1, pl. 1).

Historical Perspective

Originally the strata of the Patoka Formation in Indiana were included in part of the Shelburn Formation by Cumings (1922). These rocks were later placed in the Merom Group by Logan (1932). Wier and Gray (1961) following Wier (1961) proposed the term "Patoka Formation" for the strata from the top of the West Franklin Limestone Member to the base of the Shoal Creek (now Carthage) Limestone Member on a stratigraphic column (pl. 1). Wier (1970a) designated the type locality as outcrops of part of the formation along tributaries of the Patoka River near the town of Patoka, Gibson County, Indiana; a continuous type section was not exposed. Many of the discontinuous outcrops of the type locality are now poorly exposed or covered. A continuous core on file at the Indiana Geological Survey from Peabody No. 3 S. A. Butler, sec. 19, T. 6 S., R. 13 W., Posey County, Indiana, is herein designated as a reference section for the Patoka.

In Illinois the rocks of the Patoka Formation were originally part of the McLeansboro Formation of DeWolf (1910). Wanless (1938) raised the McLeansboro to group status when he subdivided the interval into a number of cyclical formations. These cyclical formations were adopted by Weller (1940) and Willman and Payne (1942) and became the accepted stratigraphic nomenclature in Illinois until Kosanke and others (1960) relegated the use of the cyclothems to a separate lithostratigraphic classification and assigned the interval to the upper part of the Modesto Formation (pl. 1).

In Kentucky strata equivalent to the Patoka were first assigned to the Lisman Formation (Glenn, 1912a, b), then to the McLeansboro Formation (Lee, 1916), and again to the Lisman Formation (Glenn, 1922) (pl. 1). Kehn (1973) assigned the strata equivalent to the Patoka to the lower part of the Sturgis Formation.

Formation Boundaries

The lower boundary of the formation, which is the top of the West Franklin Limestone Member, has been discussed earlier. The upper boundary of the Patoka is the base of the Carthage Limestone Member. The Carthage was formerly known as the "Shoal Creek Limestone Member" in Illinois and Indiana, but the latter term was abandoned in favor of the "Carthage" which had priority (Jacobson and others, 1985) (pl. 1). The Carthage is very widespread, produces a very strong response on geophysical logs, and has been recognized throughout most of the Illinois Basin (Wanless, 1939, 1956; Jacobson and others, 1985).

Thickness and Extent

The Patoka Formation occurs in the southeastern two-thirds of the basin and in part of the north-central part of the basin (fig. 7). The formation in Indiana ranges in thickness from 100 feet in northern Sullivan County to 310 feet in southwestern Posey County (Wier and Ault, 1986). Preliminary mapping of the interval in Kentucky indicates that the formation is confined to part of Union County north of the Rough Creek Fault System and a belt between Union and Muhlenberg Counties in the Moorman Syncline (fig. 7). The thickness ranges from 235 to 325 feet (Greb and others, 1992). In Illinois the Patoka reaches thicknesses of 300 feet in the southeast and thins to the northwest. On the extreme northern edge of the outcrop belt the formation thins to as little as 35 feet.

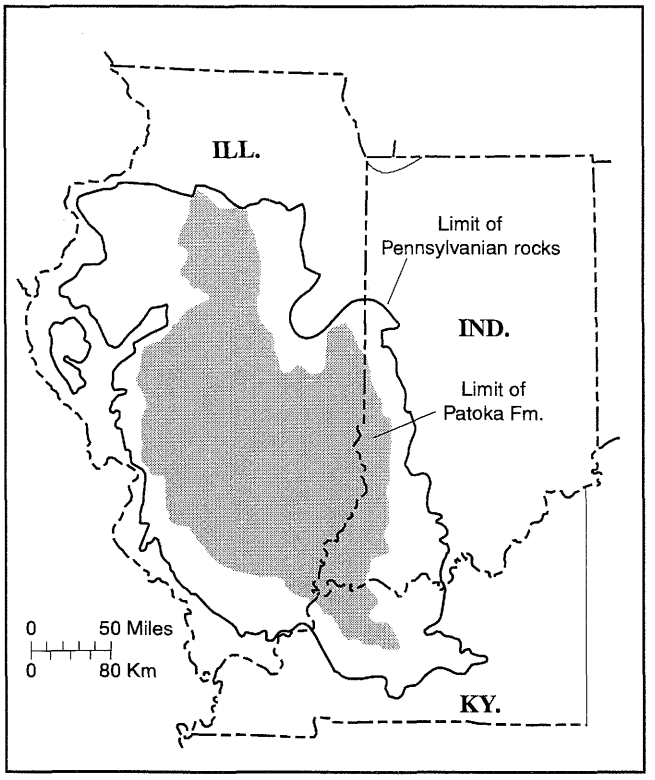

Figure 7. Outcrop limit of the Patoka Formation (approximated in Illinois and Kentucky).

Lithological Characteristics

Shale and sandstone compose more than 85 percent of the Patoka Formation in the type area (Wier and Ault, 1986). Sandstones in the Patoka are similar to those in the Shelburn Formation and Carbondale Group/Formation and typically range from 20 to 81 feet in thickness. Some sandstones contain clay and quartz pebbles (Wier, 1986a). Patoka coals tend to be thin, although several are extensive in the three states. Limestones and black shales in the Patoka also are laterally widespread in Indiana and Illinois, although they are thin (<16 feet) in many places. A number of these thin units are important marker beds and have been named in Illinois and Indiana (Hopkins and Simon, 1975; Wier and Ault, 1986).

Future Considerations

The common boundaries of the Patoka Formation should allow for regional isopach and isolith maps of this stratigraphic interval. Future work should concentrate on the extension of known shale and carbonate marker horizons of Indiana and Illinois into Kentucky.

BOND FORMATION

Definition and Justification

The Bond Formation is recognized as the strata between the base of the Carthage Limestone Member and the top of the Livingston (Millersville) Limestone Member (fig. 1, pl. 1). This name has been used in Indiana and Illinois. In Kentucky the name "Bond" is applied to the middle part of the former Sturgis Formation.

The type section was defined by Kosanke and others (1960) in seven separate outcrops in three counties. These composite sections are inadequate for the Bond Formation because several of the units are repeated in the seven localities, and two large stratigraphic gaps totaling about 100 feet are present. They do not constitute a composite-stratotype, which "consists of several reference sections (which may include a type section) required to demonstrate the range or totality of a stratigraphic unit." (North American Commission on Stratigraphic Nomenclature, 1983, Article 8d). The North American Stratigraphic Code only refers to a single stratotype: "The definition of a lithostratigraphic unit should be based . . . on a strato-type . . . " (Article 22b), and "[t]he definition and name . . . are established at a type section . . ." (Article 22c). The repetition of lithostratigraphic units operates against the fundamental reason for the designation of the stratotype, which is to create a standard reference. The presence of large stratigraphic gaps also makes the "composite" type section inadequate as a principal reference section. Therefore, the composite type section of Kosanke and others (1960) is rejected and the seven sections that made up his composite type section are recognized as reference sections.

Historical Perspective

Kosanke and others (1960) named the Bond Formation in Illinois for prominent exposures in Bond County from the base of the Shoal Creek (Carthage) Limestone Member to the top of Millersville Limestone Member (pl. 1). They designated a composite type section, consisting of seven exposures in three counties in the western portion of the outcrop belt. This description, however, does not meet the specifications outlined in the North American Stratigraphic Code as noted earlier.

Strata from the West Franklin Limestone Member to the Inglefield Sandstone Member in Indiana were originally called the Ditney Formation (Fuller and Ashley, 1902). Cumings (1922) later combined the Ditney and the underlying Somerville and Millersburg Formations into the Shelburn

Formation (pl. 1). The upper boundary of the Shelburn Formation as defined by Cumings (1922) was the base of the Merom Sandstone (pl. 1). Wier and Gray (1961) and Wier (1961, 1965) extended use of the name "Bond Formation" from Illinois into Indiana, and they defined its upper boundary as the top of the Livingston Limestone Member. The lower boundary of the Bond Formation in Indiana was placed at the base of the Shoal Creek (Carthage) Limestone Member (Burger, 1986) (pl. 1).

Strata equivalent to the Bond Formation in western Kentucky were originally part of the Lisman Formation (Glenn, 1912a, b, 1922, 1923). Lee (1916) included this interval in the McLeansboro Formation, but this term did not gain acceptance in Kentucky stratigraphic nomenclature (pl. 1). During the first half of the U.S. Geological Survey/ Kentucky Geological Survey Cooperative Geologic Mapping Program the Bond interval was mapped as part of the Lisman Formation (Kehn, 1964a). During the latter half of the program the interval was included in the Sturgis Formation (Kehn, 1973, 1974) (pl. 1).

Formation Boundaries

The lower boundary of the Bond Formation was discussed in the previous section. The upper boundary is the top of the Livingston Limestone Member. The Livingston is equivalent to the Millersville Limestone Member (Taylor and Cady, 1944; Wanless, 1955; Clegg, 1959). The Livingston is extensive, but it has only been mapped in Illinois and Indiana. In Kentucky the limestone has not been mapped, and the contact is not currently recognized. Smith and Smith (1967) noted limestone in western Kentucky at a position similar to that of the Livingston in southern Illinois. This limestone is located 200 feet below the Geiger Lake coal bed, which is mapped on many geological quadrangles in western Kentucky, but it is not known how extensive this marker may be.

Thickness and Extent

In Indiana the Bond is restricted to western Sullivan County and the area of northwestern Posey County and southwestern Gibson County (Burger, 1986) (fig. 8). The interval is 150 feet in Sullivan County to 250 feet in Gibson and Posey Counties (Wier, 1965). In Illinois the Bond reaches thicknesses of 300 feet in the southeast, but averages between 175 and 275 feet. The Bond thins to less than 150 feet in east-central Illinois and 175 feet in southwestern Illinois. Tentative extrapolation of the Bond into Kentucky indicates that it occurs in parts of Union, Hopkins, Webster, and Henderson Counties (fig. 8). The formation appears to range in thickness from 305 to 360 feet (Greb and others, 1992), however, correlation of the Millersville Limestone Member into Kentucky needs to be established before accurate thicknesses can be ascertained.

Lithological Characteristics

Kosanke and others (1960) described the Bond as being characterized by: 1) thick limestones (Carthage and Livingston [Millersville]) with the intervening strata consisting mainly of shale and containing local prominent sandstones, 2) some coals that are widely traced but are generally less than 1 foot thick, 3) argillaceous limestones except for the boundary beds, and 4) well-developed cyclothems. In Indiana Burger (1986) described the Bond as 95 percent sandstone, shale, and siltstone with minor amounts of limestone, clay, and coal.

Future Considerations

Much work is needed in correlating the Livingston Limestone Member throughout the basin. In Kentucky and southern Illinois where the limestone has not been mapped, detailed cross sections are needed to differentiate the Bond from the overlying Mattoon Formation. If the Livingston

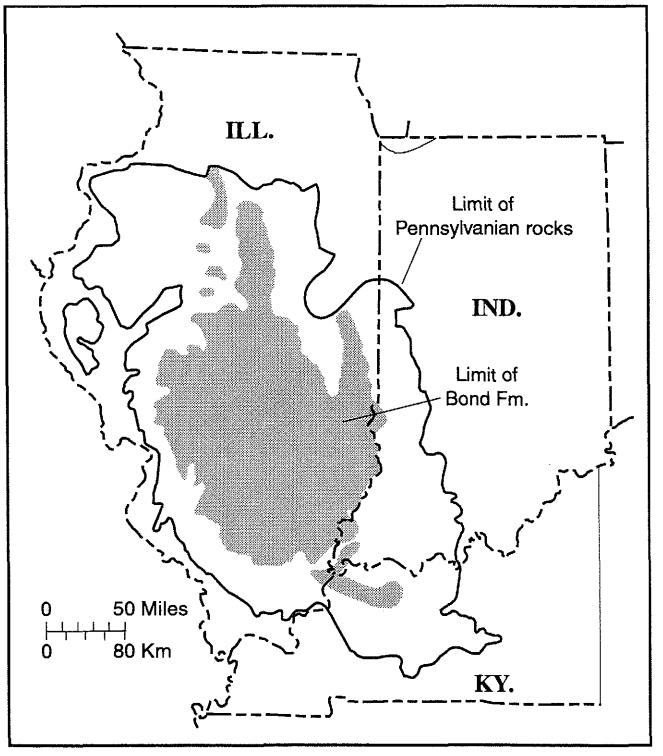

Figure 8. Outcrop limit of the Bond Formation (approximated in Kentucky).

(Millersville), cannot be correlated into western Kentucky, then perhaps a new basinwide boundary will have to be designated.

MATTOON FORMATION

Definition and Justification

The Mattoon Formation, consisting of the strata from the top of the Livingston Limestone Member to the top of the Pennsylvanian is herein recognized throughout the entire Illinois Basin. In Indiana and Illinois the Mattoon is the erosional limit of the Pennsylvanian rocks (fig. 1, pl. 1). In Kentucky, the upper boundary of the formation includes strata up to the base of the Mauzy Formation.

Historical Perspective

Kosanke and others (1960) defined the Mattoon Formation in Illinois as the strata from the top of the Millersville to top of the Pennsylvanian (pl. 1). The formation was named after the town of Mattoon, which "lies in the general outcrop belt of the unit." It is the least exposed of the Pennsylvanian formations in the basin. Kosanke and others (1960) designated the W. H. Krohn-Claud Smith No. 1 petroleum test well as a reference section. The driller's log is based on a drilling time log and cuttings which were sampled at intervals of 5 feet. The stratigraphic interval of the Mattoon Formation included in this well extends from the base of the formation to the top of the Omega Limestone Member, consisting of about half of the formation.

Strata in Indiana equivalent to the Mattoon Formation were originally assigned to the Merom Sandstone (Cumings, 1922; Shrock and Malott, 1929). Because the formation is not well exposed in Indiana, descriptions of the interval are not common in Indiana geologic literature. Use of the name "Mattoon" was extended from Illinois into Indiana by Wier and Gray (1961) and Wier (1961, 1965). The base of the formation in Indiana is the top of the Livingston Limestone Member (pl. 1).

Strata in Kentucky equivalent to the Mattoon Formation were originally included in the upper part of the Lisman Formation and the Dixon Formation (Glenn, 1912a, b). The boundary between the two formations was the base of the Dixon Sandstone (Glenn, 1912a, b) (pl. 1). Lee (1916) noted the problems of using sandstone bases as stratigraphic markers. He abandoned the term "Lisman" and adopted the name "McLeansboro Formation" of Illinois. Lee (1916) introduced the name "Henshaw Formation" for the strata above the McLeansboro Formation. The boundary was the top of the Geiger Lake coal bed, a coal beneath the Dixon Sandstone. During the early part of the U.S. Geological Survey/Kentucky Geological Survey Cooperative Geologic Mapping Program, the Henshaw Formation of Lee (1916) was mapped. However, in the latter part of the mapping the Mattoon-equivalent strata were determined to be lithologically indistinguishable from the underlying strata and were combined with the Sturgis Formation (Kehn, 1973).

Formation Boundaries

The lower boundary of the Mattoon Formation, the top of the Livingston Limestone Member, was discussed in the previous section. The upper boundary of the formation is the top of the youngest Pennsylvanian rocks above the Livingston, usually in unconformable contact with Quaternary or Cretaceous strata. However, in Kentucky Permian rocks are present in a transitional contact in a graben near Camp Mauzy Lake, Union County. The boundary between the Pennsylvanian Mattoon Formation and the Permian Mauzy Formation is arbitrarily placed at the base of a limestone in the uppermost 340 feet of the core (Kehn and others, 1982). This limestone is midway between fossiliferous layers above, which contain Permian fusulinids, and the Sulfur Springs coal bed below, which contains Pennsylvanian (Virgilian) spores (R. A. Peppers, personal commun., 1991).

Thickness and Extent

The main portion of the Mattoon Formation is located in the deeper parts of the basin in east-central Illinois and the Webster Syncline in Kentucky (fig. 9). A large outlier is present on the east side of the La Salle Anticline in east-central Illinois and along the Illinois–Indiana border. The thickest section of the Mattoon Formation in the basin is an outlier found in the graben in Union County underlying the Permian strata. The Mattoon is as much as 600 feet thick in Illinois, and is more than 1000 feet thick in Union County, Kentucky (Kosanke and others, 1960; Wier, 1986b; Greb and others, 1992).

Lithological Characteristics

Kosanke and others (1960) described the Mattoon Formation as: 1) being dominated by shale and sandstone, the sandstone being more characteristic of this formation than any other formation above the McCormick Group, 2) having less uniform, laterally discontinuous, generally thin coal beds, and 3) having fairly widespread, thin limestones that are argillaceous except for the Omega Limestone Member. But recent studies by Weibel (1986, 1987) and Weibel and others (1989) indicated that: 1) the sandstone component is probably similar to that of the other McLeansboro formations, 2) the limestones are only locally traceable, and 3) the most widely traceable strata are black shales.

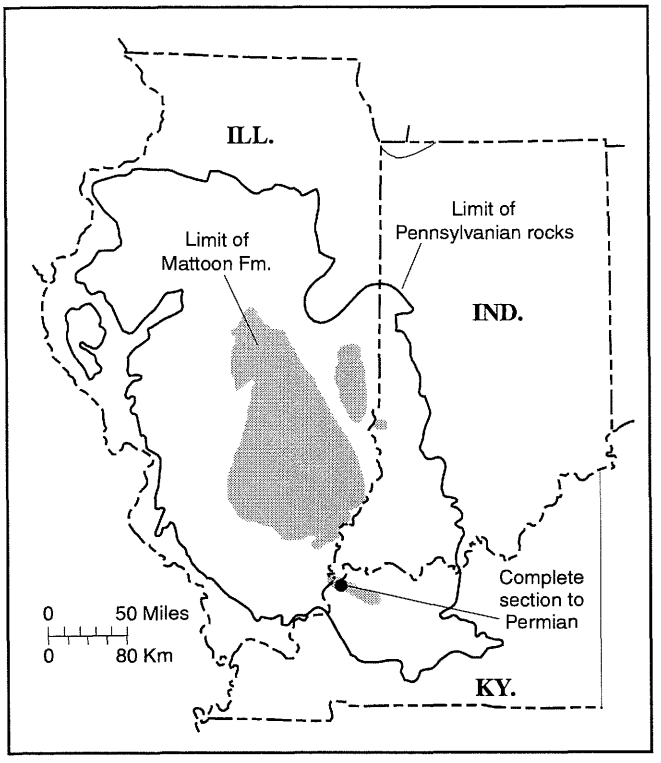

Figure 9. Outcrop limit of the Mattoon Formation. Note the location of the most complete section of Pennsylvanian rocks in Union County, Kentucky.

Future Considerations

As described in the previous section, work is needed to determine the extent of the lower boundary of the formation in the southern half of the basin in southern Illinois and Kentucky. The apparent lack of economic resources in Mattoon strata has limited work on this interval.

SUMMARY

The previous rock-unit nomenclature for the Pennsylvanian System in the Illinois Basin has an unnecessary degree of provincialism. Only one of five group names recognized in Illinois, Indiana, and Kentucky was held in common by any two of these states; only three of seventeen formation names were recognized in any two states, and only one formation name was used in all three states. The Tri-State Committee herein proposes modifications of formation and group names and boundaries that have been accepted by the three state geological surveys. The new terminology eliminates unnecessary names and emphasizes common boundaries for formations and groups. The adopted changes represent a standardization of Pennsylvanian group and formation names in Illinois and Kentucky.

It is not possible to standardize Pennsylvanian group and formation names and boundaries throughout the Illinois Basin on the basis of current knowledge. In Indiana, the Raccoon Creek Group remains divided into the Mansfield, Brazil, and Staunton Formations because the Caseyville lithologies have not been mapped and traced in sufficient detail to justify replacement of existing formations. The upper boundary of the Carbondale Group/Formation is at the top of the Danville Coal Member in Indiana because this bed has been more broadly traced in Indiana. The exceptions to the basin-wide nomenclature reflect either differences in geology or the irregular stratigraphic and areal distribution of geologic data.

The Tri-State Committee has identified areas of future research that are expected to lead toward a more complete unification of Pennsylvanian nomenclature. Implementation of this rock-unit classification will provide a standard nomenclature that conveys the current knowledge of the stratigraphic framework of the rocks which make up the Pennsylvanian System in the Illinois Basin. As such, this classification will facilitate studies of the Pennsylvanian System across the entire Illinois Basin by identifying the extent and limits of current stratigraphic resolution.

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