Members of the Borden Formation (Mississippian) In North-Central Kentucky

By ROY C. KEPFERLE

CONTRIBUTIONS TO STRATIGRAPHY

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Work done in cooperation with the Kentucky Geological Survey

A redefinition of the Holtsclaw Siltstone Member and a review of the stratigraphic relations brought out by geologic mapping

UNITED STATES DEPARTMENT OF THE INTERIOR

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CONTRIBUTIONS TO STRATIGRAPHY

MEMBERS OF THE BORDEN FORMATION (MISSISSIPPIAN) IN NORTH-CENTRAL KENTUCKY

By ROY C. KEPFERLE

ABSTRACT

The Borden Formation in north-central Kentucky consists of three widespread mappable units: a basal clay shale, a middle siltstone and silty shale, and an upper siliceous silty carbonate rock, respectively called the New Providence Shale Member, the Nancy Member, and the Muldraugh Member. These three mappable units have been recognized along the Mississippian escarpment west of the Cincinnati arch from Jefferson County, Ky., southward and eastward to Casey County, Ky. Two less widespread but locally mappable units are the Kenwood Siltstone Member and the Holtsclaw Siltstone Member of the Borden Formation. The Kenwood Siltstone lies on the New Providence Shale Member in easternmost outcrops in Jefferson and Bullitt Counties, Ky., and intertongues with the New Providence to the west and south. The Holtsclaw Siltstone Member is redefined from its original description in Jefferson County, Ky., where it lies on the Nancy Member and intertongues with the Nancy to the west and south. A widespread glauconitic zone, included in the base of the Muldraugh Member, is correlated with the glauconitic zone in the Floyds Knob Formation as used by Stockdale (1939).

INTRODUCTION

Current mapping in north-central Kentucky in cooperation with the Kentucky Geological Survey shows that previously named units of the Borden Formation are recognizable. In ascending order they are the New Providence Shale, Kenwood Siltstone, Nancy, Holtsclaw Siltstone, and Muldraugh Members. This report describes the use of units in the area from Jefferson County, Ky., southeastward to Casey County, Ky. (fig. 1), presents the historical development of stratigraphic names for the Borden Formation in Jefferson and Bullitt Counties, Ky. (fig. 2), and

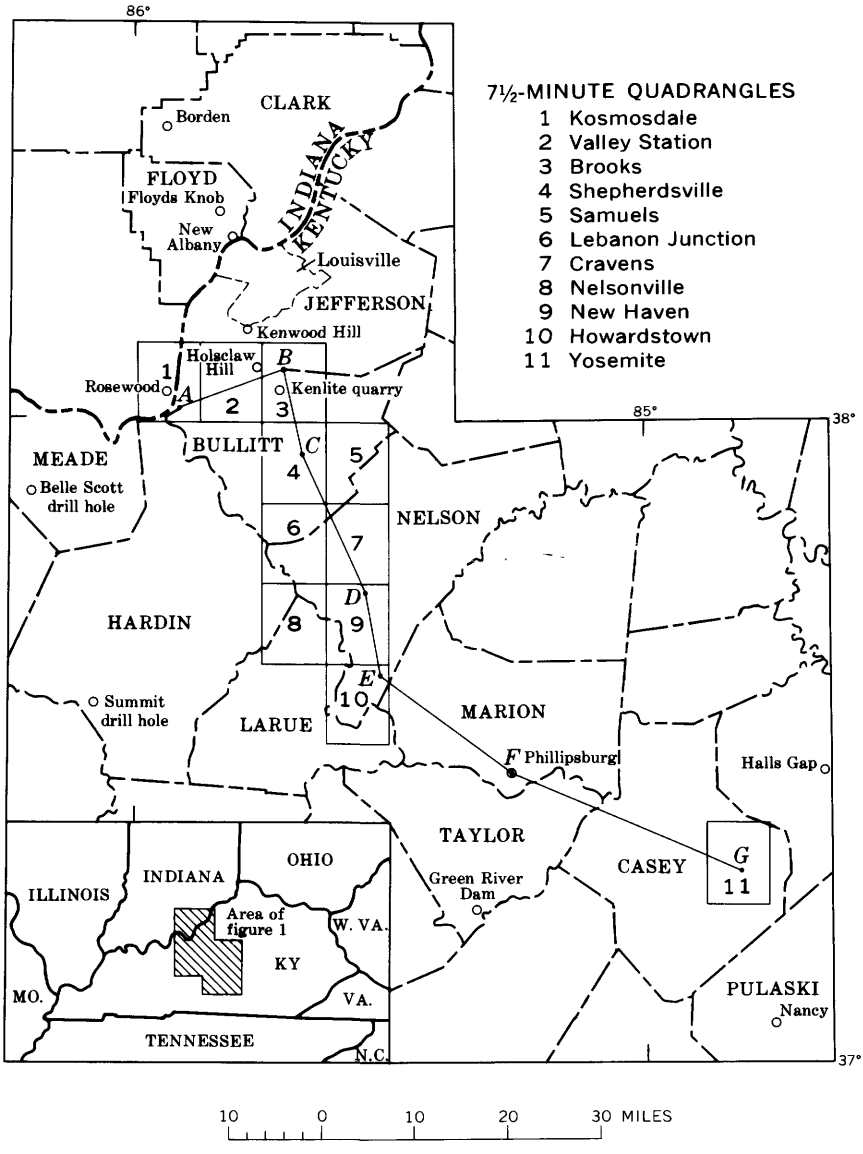
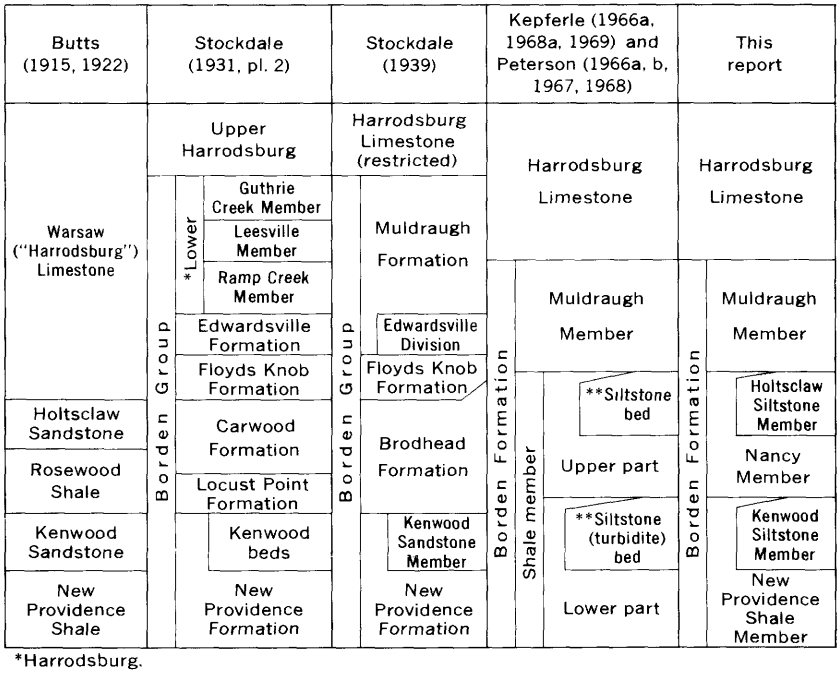


FIGURE 1.—Index map of north-central Kentucky and adjacent areas showing localities and lines of section referred to in text and in figures 3 and 4.



*Harrodsburg.

**Not on all reference maps.

FIGURE 2.—Development of stratigraphic nomenclature of the Borden Formation in north-central Kentucky.

illustrates stratigraphic relations brought out by mapping (figs. 3 and 4).

PREVIOUS NOMENCLATURE

BORDEN GROUP

The Borden Group was named by Cumings (1922) in Indiana, and was first applied by Stockdale (1931, pl. 2) in Kentucky to a sequence of clayey and silty shale and siltstone overlain by silty siliceous and clayey carbonate. The Borden Group was reduced to formational rank during the current mapping program in Kentucky. The following discussion includes only the major stratigraphic names used in north-central Kentucky. Previous nomenclature of Lower Mississippian rocks in north-central Kentucky is shown in figure 2.

New Providence Formation and Kenwood Sandstone

The New Providence Shale was named as a formation by Borden (1874) for exposures near New Providence (now Borden,

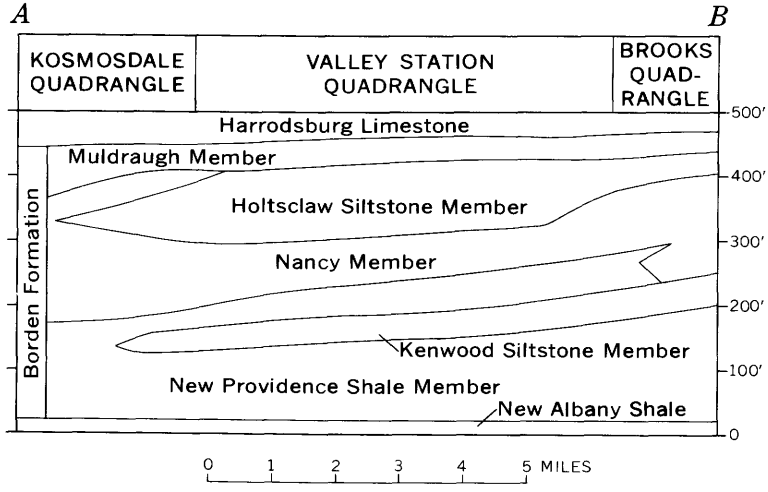


FIGURE 3.—Diagrammatic cross section along Jefferson County line showing units of the Borden Formation mapped in Kosmosdale, Valley Station, and Brooks quadrangles. Line of section shown in figure 1.

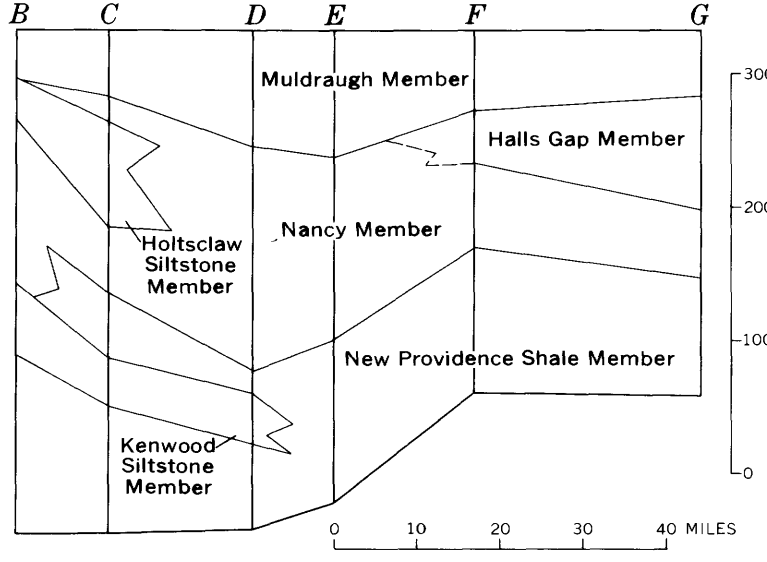


FIGURE 4.—Diagram showing relation of members of the Borden Formation from southernmost Jefferson County to Casey County. Line of section shown in figure 1.

fig. 1), Clark County, Ind. He described the formation as 80-120 feet of greenish shale that immediately overlies the Rockford Limestone (Lower Mississippian) which, in turn, overlies the New Albany Shale. Butts (1915, p. 135-147) used the name New Providence Shale for the green shale in Jefferson County that lies above the New Albany Shale and below a sequence of alternating siltstone and shale that he called the Kenwood Sandstone. The boundaries of the New Providence Shale as used by Butts (1915) differed from the boundaries at the type area in Indiana because the Kenwood is not present in the Indiana type area, and the Rockford Limestone is not present in Jefferson County. Not recognizing that the Kenwood drops stratigraphically relative to the base of the Borden together with the appearance and gradual increase in thickness of an overlying tongue of New Providence, Stockdale modified Butts' definition of the New Providence to include the Kenwood as the upper member of the New Providence Formation. Stockdale (1939, p. 108) believed the Kenwood cropped out only in Floyd County, Ind., and in Jefferson and Bullitt Counties, Ky. The Kenwood is now known to extend southward into the Nelsonville and New Haven quadrangles in Nelson County, Ky. (Peterson, 1966a, b). In these areas Stockdale included the Kenwood equivalents in the New Providence.

Rosewood, Holtsclaw, Locust Point, Carwood, and Brodhead Formations

The interval between the top of the Kenwood and the base of the carbonate sequence in north-central Kentucky was divided locally into two units: a basal silty shale and an overlying sandy siltstone called, respectively, the Rosewood Shale and Holtsclaw Sandstone by Butts (1915) and the Locust Point and Carwood Formations by Stockdale (1931).

Butts (1915, p. 150) assigned a total thickness of 190 feet to the bluish-gray unevenly fissile Rosewood Shale, named for exposures in Indiana, opposite Kosmosdale, Ky. The base was placed at the top of the Kenwood. The top of the shale was defined as the base of the Holtsclaw. Butts (1915, p. 152) assigned a thickness of 15-25 feet to the Holtsclaw Sandstone which, lying immediately below the base of his Warsaw ("Harrodsburg") Limestone, consisted of a "bluish-gray or buffish, rather loosely cemented, soft and easily disintegrated, very fine-grained, thick to massive bedded stratum * * *." He described the basal part as being commonly gradational with the underlying Rosewood.

In a section measured at Holsclaw Hill in Jefferson County,

Stockdale (1931, p. 113) assigned the upper 68 feet of the interval between the top of the Kenwood and the base of the overlying carbonate sequence to the Carwood Formation and the lower 163 feet of the interval to the Carwood(?) and Locust Point Formations, the upper 28 feet of which graded into the overlying massive rock. Stockdale later (1939, p. 140) assigned the entire 231-foot interval to the Brodhead Formation. Weir, Gualtieri, and Schlanger (1966, p. F6) recently abandoned the name Brodhead because the unit was not defined in terms of its lithology and was therefore not mappable as originally defined.

Floyds Knob Formation

Stockdale (1931, p. 193-196) named a thin unit of glauconitic silt and limestone the Floyds Knob Formation, designating the type locality near Floyds Knob, Ind., and later traced this marker bed around the exposures of Lower Mississippian rocks from Indiana through Kentucky, nearly to Ohio (1939, p. 84). He stated (1939, p. 84) "It is an all-important 'key' horizon in the tracing of the lithologic facies of strata both above and below and in establishing correlations across the region." In north-central Kentucky the unit is commonly represented by a single layer of glauconitic silt. Locally, however, it is composed of two thin layers separated by as much as 15 feet of silty dolomite, greenish siltstone, or brownish-gray oolitic limestone. Stockdale misidentified the unit in southeastern Hardin and eastern Larue Counties, Ky., because he did not recognize the abrupt drop of the glauconitic bed(s) relative to the base of the Borden. The recent mapping of this drop (Peterson, 1966a, b; Kepferle, 1966a) emphasizes the pertinence of the Floyds Knob as a key horizon. However, because the Floyds Knob is generally too thin to be considered a mappable unit, it has been included on some recent maps with the overlying Muldraugh Member (Peterson, 1967, 1968; Kepferle, 1968a) and on others with the underlying shale member (Kepferle, 1966a, b, 1967; Peterson, 1966a, b; Weir, 1970, p. 33), according to the affinities of the lithologies represented.

Muldraugh Formation

The Muldraugh Formation was named by Stockdale (1939, p. 200) for exposures of "calcareous, cherty rock" south of Phillipsburg, Marion County, Ky. He equated the unit with the combined Edwardsville and Lower Harrodsburg division in Indiana. The lower contact was the top of the glauconitic Floyds Knob Formation; the upper contact in the area from Jefferson to

Marion Counties was defined as the base of crinoidal limestone of the Harrodsburg Limestone (restricted). Weir, Gualtieri, and Schlanger (1966, p. F22) redefined the base to include cherty and dolomitic limestone and siltstone "a few feet to several tens of feet below the glauconitic siltstone that Stockdale (1939) assigned to the Floyds Knob Formation." More recently Weir (1970, p. 33) conformed to Stockdale by placing the base of the Muldraugh at the top of the uppermost glauconite seam.

Sable, Kepferle, and Peterson (1966) revised the upper contact to exclude all the typical Harrodsburg Limestone as manifested in the equivalents of the Guthrie Creek Member and Leesville Limestone Member of Stockdale (1929, p. 239-240). In part of south-central Kentucky, rocks correlative with the Harrodsburg Limestone are included in the Salem and Warsaw Limestones (Weir and others, 1966, p. F8). To the east, as lithology recognizable as typical Harrodsburg becomes more obscure, the top of the Muldraugh is placed at the base of a persistent sand bed forming the base of the Salem Formation (Weir, 1970, p. 34).

PRESENT NOMENCLATURE

BORDEN FORMATION

The Borden Formation in north-central Kentucky consists of three widespread mappable units: a basal clay shale, a middle siltstone and silty shale, and an upper siliceous silty carbonate rock called, respectively, the New Providence Shale Member, the Nancy Member, and the Muldraugh Member. Two less widespread but locally mappable units are the Kenwood Siltstone and the Holtsclaw Siltstone Members of the Borden Formation. The thickness of the formation here ranges from about 220 feet in the south to 425 feet in the northern part of the study area. Phosphate nodules in a greenish-gray clay shale matrix mark the basal foot of the Borden, which lies conformably on the black fissile-weathering New Albany Shale. The Borden is overlain with apparent conformity by the pelmatozoan-bryozoan limestone of the Harrodsburg Limestone.

New Providence Shale Member

The unit here designated as the New Providence Shale Member of the Borden Formation is generally the same as the unit termed the lower part of the shale member of the Borden Formation (fig. 2) on geologic quadrangle maps of areas in Bullitt, Hardin, Nelson, Larue, and Marion Counties (Kepferle, 1966a, 1967, 1968a, 1969; Peterson, 1966a, b, 1967, 1968). In detail, an

exception is the inclusion of beds that now would be assigned to the Kenwood Siltstone Member. The unit has been mapped as the New Providence Shale Member in the Yosemite quadrangle in Casey County (Taylor and Lewis, 1971) and in Brooks, Valley Station, and Kosmosdale quadrangles, Jefferson and Bullitt Counties (Kepferle, 1971a, b).

As its name implies, the New Providence Shale Member is chiefly shale. It is dark greenish gray, medium gray, or less commonly reddish gray and weathers light greenish gray to yellowish gray. Size analyses indicate that it is composed of nearly equal amounts of clay and silt-sized particles and has a trace of very fine sand (Peterson, 1966b). The silt is quartzose, and the silt content increases upward in the member. Siderite concretions as much as 2 feet in diameter occur sparsely to abundantly along the bedding planes. Flattish phosphate nodules as much as a foot long are very abundant in the basal 12 inches, and scattered smaller nodules occur higher in the unit. The basal nodule-bearing zone, included in the New Albany Shale by Lineback (1968, p. 1300-1301), is correlated with the nodule-bearing zone that underlies the Rockford Limestone in Indiana. The shale is noncalcareous except for local small limestone concretions, scattered crinoidal debris, and rare thin lenses of crinoidal limestone. Dolomite, pyrite, and cone-in-cone concretionary carbonate layers are rare.

The thickness of the New Providence Shale Member is commonly less than 120 feet, although in outcrop its range is from about 250 feet in the Brooks and Valley Station quadrangles (fig. 1) to 55 feet in the Howardstown and Nelsonville quadrangles. The unit thins irregularly to the south and west. It is 50 feet thick in the core of a hole drilled at the Belle Scott quarry in Meade County, Ky. (Kepferle and Peterson, 1964), less than 5 feet thick in the core at Summit, Ky. (Moore, 1964), and 15 feet thick in the core at Green River Dam, Taylor County, Ky. (See fig. 1.) Most of this thinning occurs west of a line extending roughly through the southeast corner of the Howardstown quadrangle and the southwest corner of the Kosmosdale quadrangle and is ascribed to nondeposition rather than to erosion (Peterson and Kepferle, 1970).

West of this line the New Providence is overlain mainly by the Muldraugh Member and is separated from the Muldraugh by a disconformable contact commonly marked by a glauconite-rich zone. Eastward the New Providence Member is overlain mainly by the silty shale of the Nancy Member, except for an area in central Jefferson and northern Bullitt Counties, where it is over-

lain by the Kenwood Siltstone Member. (See fig. 3.) The upper part grades into the Nancy Member, the contact marked only by a subtle upward increase in silt content in the section. The higher silt content imparts greater resistance to the shale and produces steeper and more stable slopes in the Nancy Member, in contrast to gentler slopes that result from slump, sliding, and creep in the less resistant clay shale of the New Providence Shale Member.

The New Providence is readily distinguished from the dark brittle New Albany Shale on which it lies with an abrupt conformable contact.

Kenwood Siltstone Member

The Kenwood Sandstone, named by Butts in 1915 (p. 148-150), is here redesignated the Kenwood Siltstone Member of the Borden Formation. The type exposure is on Kenwood Hill in the southeast part of the Louisville West 7½-minute quadrangle, Jefferson County, Ky. The Kenwood Siltstone Member has been mapped or recognized from the New Haven quadrangle in Kentucky northward into Floyd County, Ind. Its stratigraphic relations are diagrammed in figures 3 and 4. A reference section at Kenlite quarry in Bullitt County, Ky., is described on page B14. The Kenwood Siltstone Member is a sequence of alternating siltstone and shale. The siltstone is light gray to medium gray, weathers yellowish gray, and is generally limonite stained on bedding surfaces and joints. The staining is from oxidation of pyrite which is locally common. Graded, laminated, and ripple bedding and sole marks indicate that the silt was deposited from turbidity currents (Kepferle, 1968b). Individual beds are from less than 0.1 foot to more than 20 feet thick, but commonly are less than 1 foot thick. They occur singly or in a sequence of as many as 30 tabular beds, reaching a maximum aggregate thickness of 100 feet in the Samuels quadrangle (Kepferle, 1969). The shale at places makes up more than 60 percent of the unit.

On Kenwood Hill, in South Park Hills in the Brooks quadrangle, and in the Samuels and New Haven quadrangles, the Kenwood lies above the New Providence Shale Member and below the Nancy Member. South and west it drops stratigraphically from 5 to 20 feet per mile relative to the base of the Borden Formation by intertonguing with the New Providence Shale Member. The Kenwood pinches out within a few feet of the base of the New Providence in the Lebanon Junction quadrangle (Peterson, 1967).

Nancy Member

The Nancy Member was named for exposures of the basal Borden Formation in Pulaski County, Ky., by Weir, Gualtieri, and Schlanger (1966, p. F11-F13). A basal light-greenish-gray clay shale described by Weir (1970, p. 44) in the lower part of the Nancy at Halls Gap is probably equivalent to the New Providence Shale Member of this report. The usage of the name Nancy Member is herein extended northwestward and is applied to the unit mapped by Peterson (1966a, b, 1967, 1968) and Kepferle (1966a, b, 1967, 1968a, 1969) as the upper part of the shale member of the Borden Formation in north-central Kentucky west of the Cincinnati arch. The Nancy Member in this area, chiefly greenish gray to olive gray and comprising clayey to argillaceous silty shale and shaly siltstone, minor resistant siltstone, and thin discontinuous lenses of crinoidal limestone and clayey shale, lies below the Muldraugh or Holtsclaw Siltstone Members and above the New Providence Shale or the Kenwood Siltstone Members (figs. 2, 4). A description of the Nancy Member is included as part of the reference section of the Holtsclaw Siltstone Member (p. B12).

The abrupt disconformable contact between the Nancy Member and the overlying Muldraugh Member is commonly marked by a thin glauconitic siltstone locally associated with an oolitic limestone as much as 12 feet thick in the Muldraugh. Locally in Jefferson and Bullitt Counties, the Nancy Member intergrades with the overlying Holtsclaw Siltstone Member, and the contact between the two is placed at the lowest continuous ledge-forming siltstone bed within the zone of gradation.

Holtsclaw Siltstone Member

The Holtsclaw Sandstone of Butts (1915, p. 148-150) is herein redefined as the Holtsclaw Siltstone Member of the Borden Formation. Detailed mapping indicates that this unit thickens to as much as 130 feet to the south and west before grading into the Nancy Member.

The Holtsclaw Siltstone Member is equivalent to the unnamed siltstone in the upper part of the shale member of the Borden Formation in the Shepherdsville quadrangle (Kepferle, 1968a) and to Stockdale's (1939, p. 147) Lebanon Junction Siltstone Member of the Brodhead Formation. It is similar to the Halls Gap Member of the Borden Formation in south-central Kentucky (Weir and others, 1966). The Holtsclaw pinches out within a few miles south and west of the type section.

No type section was designated by Butts (1915, p. 151-152),

who named the unit for exposures on Holtsclaw Hill, now called Holsclaw Hill on the recommendation of the U.S. Board on Geographic Names. However, because of long established usage, the original spelling of the geologic unit is retained. A type section is here designated along Holsclaw Hill Road on the west side of the ravine west of Holsclaw Hill, Valley Station quadrangle, Jefferson County, and is presented on pages B12 B13. The top of the section is 2.3 miles south of Fairdale, one-fifth of a mile west of the Holsclaw Lookout tower in Jefferson County Memorial Forest; the base of the section is in the creek bed west of the road, about 1.8 miles south of Fairdale. The unit is chiefly medium-gray to olive-gray siltstone that weathers yellowish gray or light olive gray. The silt, somewhat calcareous and clayey, is medium to fine according to size analyses and locally is interbedded with thin shale and crinoidal limestone. The Holtsclaw Siltstone is distinguishable from the Nancy Member on the basis of topographic expression. The Holtsclaw tends to weather to massive cliffs or steep smooth surfaces on southwest-facing slopes in contrast to the shaly slopes characteristic of the Nancy. The Holtsclaw is less clayey than the Nancy.

The siltstone of the Holtsclaw intergrades and intertongues with the shale of the Nancy. Where the Holtsclaw is overlain by the Muldraugh Member, the upper boundary is abrupt and is marked by the distinct basal glauconitic marker bed of the Floyds Knob Formation as used by Stockdale (1939). (See figs. 2-4.)

Muldraugh Member

The Muldraugh Member as here used is the same as that modified from Stockdale (1939) by Weir, Gualtieri, and Schlanger (1966, p. F36-F37) from the type section south of Phillipsburg, Marion County. Throughout, the member consists of a complexly interstratified sequence of yellowish-gray- to light-olive-gray-weathering dolomitic siltstone, silty dolomite, and coarse crinoidal limestone with common to abundant geodes and chert. Nearly everywhere, the base of this unit is marked by glauconite, commonly in a single layer, but locally in two thin layers separated by a sequence which includes as much as 15 feet of silty dolomite, greenish siltstone, or brownish-gray oolitic limestone somewhat dissimilar from the units above and below. This glauconite and associated sequence includes beds that Stockdale (1931, p. 193-217) named the Floyds Knob Formation. Although this unit is persistent throughout most of the area of outcrop of Lower Mississippian rocks in north-central Kentucky, it nowhere attains a mappable thickness. Nevertheless, it is valuable as a marker

bed at the base of the Muldraugh Member. In and southeast of southern Nelson County, the glauconitic bed(s) have been included with equivalents of the Nancy Member as defined by Weir (1970, p. 33).

The upper contact of the Muldraugh Member in north-central Kentucky is placed at the base of the Harrodsburg Limestone as modified from Stockdale (1939) by Sable, Kepferle, and Peterson (1966). The lower contact of the Muldraugh Member is described in the discussion of the underlying units.

MEASURED SECTIONS

Holsclaw Hill section

[Type section of the Holtsclaw Siltstone Member of the Borden Formation. Measured with barometer, hand level, and tape by E. G. Sable and R. C. Kepferle, October 1962; revised by Kepferle, August 1970; along Holsclaw Hill Road on west side of ravine west of Holsclaw Hill, Jefferson County. The top of the section is the top of the hill 2.3 miles south of Fairdale, Ky. (Valley Station quadrangle)]

	Thickness (feet)
Mississippian:	
Harrodsburg Limestone (incomplete):	
24. Limestone, cherty, deeply weathered	23
Borden Formation (incomplete):	
Muldraugh Member:	
23. Limestone, dolomitic, cherty; weathers pale yellowish orange (10*YR* 8/6);[1] poorly exposed	17
22. Limestone, crinoidal; partly silicified to chert in beds 0.3 ft thick; interbedded with limestone as below	5
21. Limestone, dolomitic, very fine grained, medium-light-gray (*N*6) to light-gray (*N*7); weathers pale yellowish orange (10*YR* 8/6) to dark yellowish orange (10*YR* 6/6); obscurely laminated and has "knotty" appearance around small quartz geodes 1-2 cm (centimeters) in diameter; poorly exposed; some beds as much as 1 ft thick; splits with irregular parting to beds commonly 0.1-0.3 ft thick	30
20. Siltstone, dolomitic; weathers dark yellowish orange (10*YR* 6/6); small quartz geodes 1-2 cm in diameter	.9
19. Mudstone, clayey, glauconitic; weathers pale brown (5*YR* 5/2); dusky-green (5*G* 3/2) to greenish-black (5*GY* 2/1) glauconitic pellets concentrated along bedding planes	.7
18. Limestone, light-brownish-gray (5*YR* 6/1); fine to medium fossil fragments with scattered coarse fossil debris including crinoids; oolitic; very finely cross laminated; in a single bed having basal relief of as much as 0.4 ft in sharp contact with underlying unit. This	

[1] Color names with numbers based on "Rock-Color Chart," by Goddard and others (1948).

Holsclaw Hill section—Continued

	Thickness (feet)
Mississippian—Continued	
Borden Formation—Continued	
Muldraugh Member—Continued	
and unit 19 are equivalent to the Floyds Knob Formation as defined by Stockdale (1931)	1.8
Total Muldraugh Member	55.4
Holtsclaw Siltstone Member:	
17. Siltstone, yellowish-gray (5*Y* 7/2); in thin planar beds 0.1 ft thick; contains brachiopods and bryozoan fragments; upper part contains thin silty clay shale interbeds	1.5
16. Siltstone, greenish-gray (5*GY* 6/1); weathers yellowish gray (5*Y* 7/2); slightly sandy, massive, with incipient partings 1-3 ft apart; scattered orthotetid brachiopods	5.9
15. Siltstone, light-greenish-gray (5*G* 8/1); calcareous; partings irregular, average 0.1 ft; grades laterally to more massive limy siltstone; bryozoan bearing	.7
14. Siltstone, greenish-gray (5*GY* 6/1) to dark-greenish-gray (5*GY* 4/1); weathers dark yellowish orange (10*YR* 6/6) to moderate yellowish brown (10 *YR* 5/4); slightly sandy, dominantly massive; discontinuous laminations transected by darker clay lenses 1 mm (millimeter) thick and 1 cm across that may represent burrow cross sections	24.7
13. Limestone, medium-gray (*N*5) to brownish-gray (5*Y* 4/1); crinoidal fossil fragments; silty admixture; matrix microgranular; clay partings 0.1-0.3 ft apart	1.3
12. Siltstone, light-olive-gray (5*Y* 5/2); weathers yellowish gray (5*Y* 7/2) to pale olive (10*Y* 6/2) or pale yellowish brown (10*YR* 6/2); shaly in part; poorly to moderately resistant to weathering; partings as much as 0.5 ft thick average 0.1 ft thick; very porous; contains more clay in lower 16 feet than in upper 10 feet	26.5
11. Siltstone, olive-gray (5*Y* 4/1); having commonly limonite-stained calcareous scattered crinoid columnals	.5
10. Covered	5.3
9. Siltstone, moderate-yellowish-brown (10*YR* 5/4) to dark-yellowish-orange (10*YR* 6/6), sandy, weathered; juts out above unit below; small pits on surface due to differential weathering of borings	1.0
8. Siltstone, yellowish-gray (5*Y* 7/2) to medium-light-gray (*N*6), slightly iron stained; irregularly shaly bedded; grades laterally to massive weathering face; indistinct irregular laminae; scattered medium-dark-gray (*N*4) ellipsoidal to spherical 0.1-0.5-ft-thick limestone concretions that weather with dark iron stain; vertical *Zoophycos* markings as much as 0.2 ft long	32.8
Total Holtsclaw Siltstone Member	100.2

Holsclaw Hill section—Continued

	Thickness (feet)
Mississippian—Continued	
Borden Formation—Continued	
Nancy Member:	
7. Shale, light-olive-gray (5*Y* 5/2); weathers same; silty, clayey; clay-filled borings; hackly parting; sideritic concretions as much as 0.2 ft thick; poorly exposed	14.0
6. Covered	23.9
5. Shale, light-olive-gray (5*Y* 5/2); weathers same; silty, clayey; grades laterally into clayey shale	15.9
Total Nancy Member	53.8
Upper tongue of New Providence Shale Member:	
4. Covered, probably like unit 3 below	70
3. Clay shale, light-olive-gray (5*Y* 5/2) to greenish-gray (5*Y* 6/1); weathers greenish gray	5.0
Total upper tongue of New Providence Shale Member	75
Kenwood Siltstone Member (elev 585 ft by altimeter):	
2. Siltstone, yellowish-gray (5*Y* 7/2), resistant; in single bed; limonite stained at base	.5
1. Shale, olive-gray (5*Y* 6/2) to greenish-gray (5*GY* 6/1); clayey; base not observed	5+
Total Kenwood Siltstone Member	5.5+
Total Borden Formation	290+

Kenlite quarry section

[Reference section of the Kenwood Siltstone and the lower tongue of the New Providence Shale Members of the Borden Formation. Measured with altimeter, hand level, and tape by E. G. Sable and R. C. Kepferle, October 1962; up west face of Kenlite quarry, half a mile west of State Highway 1020 and 1.6 miles south of Brooks, Bullitt County (Brooks quadrangle)]

	Thickness (feet)
Mississippian:	
Borden Formation (incomplete):	
Upper tongue of New Providence Shale Member(?):	
37. Covered to top of ridge, probably clay shale	2.5
Kenwood Siltstone Member:	
36. Siltstone, well-jointed bed	.4
35. Clay shale, medium-gray (*N*5); weathers light olive gray (5*Y* 5/2); interbedded with clayey silt shale	6.0
34. Siltstone, sandy; thin lens	.1
33. Clay shale, poorly exposed	1.4
32. Siderite concretions, iron-oxide-coated	.2
31. Clay shale, very silty, poorly exposed	3.0
30. Siltstone; limonite cemented in part	.5

Mississippian—Continued
Borden Formation—Continued

	Thickness (feet)
Kenwood Siltstone Member—Continued	
29. Clay shale, silty, weathered	1.1
28. Siltstone	.8
27. Clay shale, silty; contains nodular siderite concretions	4.9
26. Siltstone and clay shale, interbedded; thins along line of section from a maximum of 5.0 ft to 0.9 ft siltstone, 0.4 ft shale, 0.6 ft siltstone, 0.7 ft shale, and 0.3 ft siltstone; sole marks on siltstone beds	2.9
25. Clay shale, similar to unit 23; iron stained in part	1.7
24. Siltstone, similar to unit 22; sandy; single massive bed with local limonite concentrations	1.8
23. Clay shale, medium-gray (*N*5), silty; weathers light olive gray (5*Y* 5/2)	2.0
22. Siltstone, yellowish-gray (5*Y* 7/2), sandy; limonite along partings in lower 0.5 ft; upper part massive	1.9
21. Clay shale, dark-gray (*N*3); weathers medium light gray (*N*6) with blue tint	.8
20. Siltstone, yellowish-gray (5*Y* 7/2), sandy, micaceous	.5
19. Clay shale, grayish-olive (10*Y* 4/2), silty; in slightly weathered lower half, fresh surface is dark gray (*N*3)	2.3
18. Siltstone, moderate-yellowish-brown (10*YR* 5/4); weathers dark yellowish orange (10*YR* 6/6) to dark reddish brown (10*R* 3/4); sandy	3.6
17. Clay shale, dark-gray (*N*3) to medium-dark-gray (*N*4); weathers with a blue tint or to yellowish gray (5*Y* 7/2); silty, micaceous; weathers shaly to nodular; reddish-brown 2-mm-wide markings resembling reed impressions or straight borings on bedding surface; medium-light-gray (*N*6) siderite concretions which weather yellowish brown and are 0.4 ft thick and 0.8 ft in diameter	4.2
16. Siltstone, similar to unit 18; sandy	2.0
Total Kenwood Siltstone Member	42.1
Lower tongue of New Providence Shale Member:	
15. Clay shale, medium-gray to medium-dark-gray (*N*3-4); weathers medium light gray (*N*5); slightly micaceous; siltier than underlying unit; shaly parting enhanced by weathering; gypsum in veinlets along partings. Contains layers of brownish-gray (5*YR* 4/1) to light-brown (5*YR* 5/6) spheroidal siderite concretions that weather moderate red (5*R* 4/6) to dark yellowish orange (10*YR* 6/6); septarian; fractures filled with calcite and celestite; contain crinoid plates	13.3
14. Clay shale, similar to unit 15 but somewhat less silty; ellipsoidal siderite concretions fairly abundant, as much as 0.5 by 1.5 ft	15.9
13. Covered	3.0
12. Clay shale, dark-greenish-gray (5*G* 4/1); weathers	

Kenlite quarry section—Continued

	Thickness (feet)
Mississippian—Continued	
Borden Formation—Continued	
Lower tongue of New Providence Shale Member—Continued	
medium gray (*N*4) to medium light gray (*N*5); uppermost 0.2 ft fossiliferous with crinoid columnals and well-preserved brachiopods; scattered ellipsoidal to rounded siderite concretions 0.3 by 0.5 ft	28.8
11. Siderite concretions, discontinuous lenses	.2
10. Clay shale, greenish-black (5*G* 2/1); parting irregular, blocky; scattered concretionary lenses in lower 5 ft	14.6
9. Clay shale, greenish-gray (5*G* 6/1) to dark-greenish-gray (5*G* 4/1); in cross section grayish-red (10*R* 4/2) lenticular borings 1 mm wide on bedding planes; small phosphatic nodules as much as 0.1 ft in diameter	13.5
8. Clay shale, olive-gray (5*Y* 4/1); weathers greenish gray (5*G* 6/1); unctuous; markings on bedding plane like those in unit 17	12.0
7. Clay shale, dark-greenish-gray (5*GY* 4/1); similar to unit 5 below	5.5
6. Siderite concretions, lenses as much as 0.3 ft thick; interbedded with shale; 1-2.5 ft lateral extent	1.0
5. Clay shale, weathers medium light gray (5*GY* 4/1); poorly exposed	7.5
4. Clay shale, olive-gray (10*Y* 4/2) to dark-greenish-gray (5*G* 6/1); slightly silty; blocky with irregular smooth horizontal parting 0.02 ft apart; large sideritic concretions in float	3.0
3. Clay shale, greenish-gray (5*GY* 6/1) to dark-greenish-gray (5*G* 4/1); lower 0.1 ft contains dark-yellowish-orange (10*YR* 6/6) and dark-yellowish-brown (10*YR* 4/2) silty concretionary phosphate nodules; upper 0.1 ft contains medium-gray (*N*5) to medium-dark-gray (*N*4) phosphatic(?) concretions with granular centers	.8
2. Clay and clay shale; dark-yellowish-orange (10*YR* 6/6) clay; greenish-gray (5*GY* 6/1) clay shale	.2
Total lower tongue of New Providence Shale Member	119.3
Total Borden Formation	163.9
Devonian:	
New Albany Shale (elev 551 ft by altimeter):	
1. Shale, grayish-black (*N*2) to brownish-black (5*YR* 6/1); phosphate and pyrite nodules commonly 0.1 ft in diameter. U.S. Geol. Survey fossil locality 7656-SD at base of exposure in which are conodonts of Late Devonian age	3.5+

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