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WICKCLIFF SANDSTONE (UPPER CHESTERIAN, MISSISSIPPIAN) OF MALOTT, REVISITED

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ABSTRACT: Midway in the Buffalo Wallow Group (upper Chesterian, Mississippian) of southwestern Indiana is a minor rock unit that C.A. Malott in 1925 named the Wickcliff Sandstone. The precise stratigraphic position of this bed remained a mystery, however, until the fortuitous discovery, just south of Patoka Reservoir in southwestern Orange County, of an occurrence of the Leopold Limestone Member (Branchville Formation), a key limestone bed that closely overlies the sandstone. The Wickcliff Sandstone is not, as Malott came to think, equivalent to, or even part of, the Waltersburg Formation of the standard Chesterian section in southern Illinois. Instead, the Wickcliff is very near the top of the Branchville Formation of Indiana outcrop usage and is equivalent to a part of the Menard Limestone, identifiable tongues of which just barely extend to the Indiana outcrop area. The position of the Wickcliff Sandstone appears to be analogous to that of the "Chapman sand," a bed that is productive of oil in Daviess and McLean Counties in western Kentucky. The stratigraphic relationships outlined and the nomenclatural puzzle that they presented are another indication that the upper Chesterian section of southwestern Indiana should be regarded as a shale-dominated sequence into which tongues of sandstone extend from the eastern (outcrop) edge and into which tongues of limestone extend from the western (basin) portion. The name Wickcliff has been little used and the rock unit is not sufficiently important or extensive to require reincorporation into the Indiana formal stratigraphic nomenclature at this time.

INTRODUCTION AND HISTORICAL REVIEW

In the standard section of Chesterian-age rocks in the Illinois Basin (Figure 1), the Waltersburg Formation directly overlies the Vienna Limestone, but in discussion of a stratigraphic section of Mississippian rocks exposed near Sulphur in southern Indiana, Malott and Esarey (1940, p. 7) made this puzzling statement: "The sandstone above the Vienna . . . is not the Waltersburg (Wickcliffe [sic])." To understand this statement, one must trace Malott's thinking on the classification and nomenclature of the upper part of the Chesterian Series in Indiana.

The Chesterian section, and specifically its upper part, was the last of the surface stratigraphic section in Indiana to be studied and classified. Malott and Thompson (1920) first identified a key limestone, the Siberia Limestone, now classified as a member. Subsequently, Malott traced the extent of this limestone and other key beds throughout Perry County on a blueprint map of limited circulation (Malott, 1923). Only one copy of this map, which represents a working stage in Malott's thinking on the nomenclature of the upper Chesterian, seems to have survived. Many of the names that he would later propose are in the legend (Figure 1; Malott, 1923). Below "a sandstone" of the explanation, the next unit mapped was the Glen Dean Limestone, which marks the top of the middle Chesterian. The trace of each of these named units was signified on this map by a unique patterned line.

Malott (Figure 1; 1925) next classified the entire upper Chesterian, indicating in discussion that within the dominantly shale sequence only the limestone and sandstone members were worthy of being named. This concept, which was in contrast with the

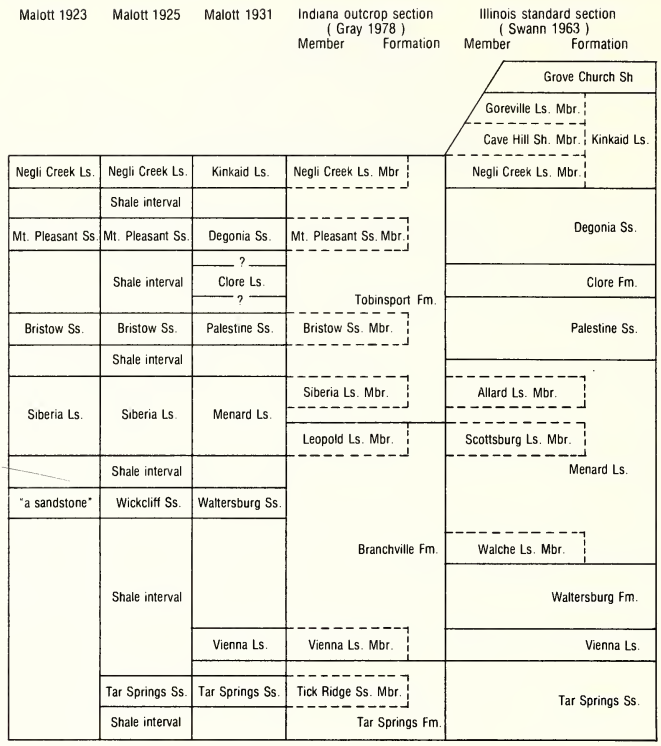

Figure 1. Chart showing evolution of nomenclature for upper Chesterian rocks in the Indiana outcrop area. The name Siberia was applied by Malott (1923, 1925) to two limestone members, the lower of which is now called the Leopold (Gray, 1978).

then-developing practices of stratigraphic nomenclature that were soon to be codified by Ashley, *et al.* (1933), has proved to be the source of many nomenclatural problems. As a final step, Malott (Figure 1; 1931) asserted correlations of the upper Chesterian units with the now standard Chesterian sequence of southern Illinois and recommended abandonment of the Indiana names. Thus, the rock unit signified on the 1923 map as "outcrop of a sandstone" below the Siberia Limestone became in 1925 the Wickcliff Sandstone, which in 1931 was transmuted into the Waltersburg. Note that most of the "shale intervals" are missing from this final list — though they were still conceptually present.

A note in passing on spelling: on modern maps, the crossroads settlement after which the sandstone is named is spelled "Wickliffe," but in Malott's (1925) initial use, and in what little subsequent geologic use there has been, the name was spelled "Wickcliff." It is so spelled in the Wilmarth (1938, pp. 2330-2331) lexicon, and that spelling is adhered to herein where reference is to the stratigraphic unit. The spelling "Wickliffe" is used where reference is to the locality.

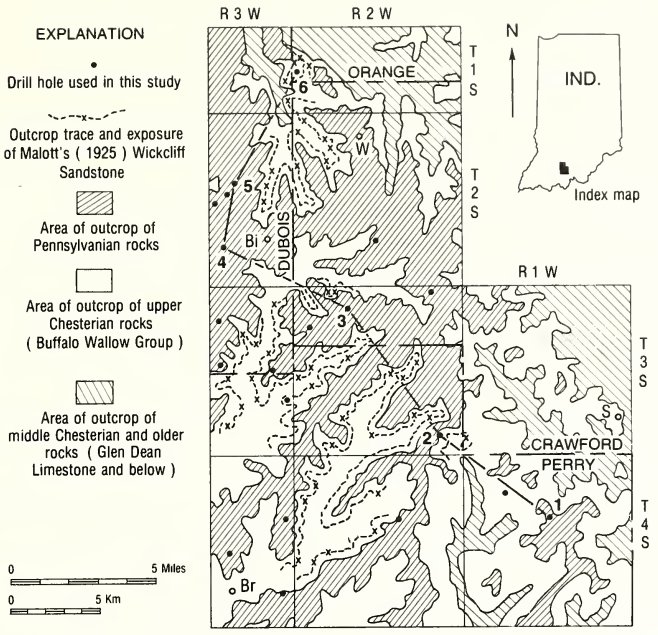

Figure 2. Geologic map showing crop-line of Malott's (1925) Wickcliff Sandstone (dashed line, in part after Malott, 1923) and location of selected datum points. Numbers and line of section refer to Figure 3. Other contacts are based on Gray, Ault, and Keller, 1987. Bi, Birdseye; Br, Bristow; S, Sulphur; W, Wickliffe.

THE STRATIGRAPHIC PROBLEM

But why was "the sandstone above the Vienna" not the Waltersburg? First, because in Malott's concept, only a relatively thin sandstone (Wickcliff of his 1925 paper) could be the Waltersburg; and second, because to be the (Wickcliff) Waltersburg, this sandstone should be "fully 60 feet [18 m] above...the Vienna" (Malott and Esarey, 1940). Malott (1925, p.127) had not specifically designated a type section for the Wickcliff, and he also questioned whether the sandstone should receive a name (Malott, 1925, p. 109). All this contributed to uncertainty that surrounded the stratigraphic identity of this member. As a result, when the upper Chesterian was restudied (Figure 1; Gray, 1978), the (Wickcliff) Waltersburg of Malott again became merely "a sandstone" somewhere in the upper part of the Branchville Formation — until a key to the stratigraphic position of this member was discovered.

South of Patoka Reservoir, in the Newton Stewart Recreation Area, about 3 miles (5 km) north and a little west of the crossroads of Wickliffe (Figure 2), is a prominent and rather extensive rimrock of sandstone that at first glance one is likely to assign to

the Mansfield Formation, which is basal to the Pennsylvanian System in Indiana. The ledge is about 20 feet (6m) thick, is prominently cross-stratified, and makes bold rock cities near hill crests in the recreation area. In recent mapping (Gray, Wayne, and Wier, 1970), this ledge was assigned to the basal Pennsylvanian.

Yet, new facts intrude. While doing unrelated fieldwork in the area in 1980, Carl Rexroad and I came upon a large slab and several smaller pieces of limestone that had been excavated from a utility trench at the top of the hill near the Newton Stewart Visitor Center. The limestone does not crop out, and unfortunately the rock was not observed in place in the trench, but it certainly overlies the rimrock sandstone that had previously been held to be Mansfield. The limestone contains a Chesterian conodont fauna dominated by *Cavusgnathus unicornis* (Carl B. Rexroad, pers. comm., 1991), which, along with other indications, demonstrates that the sandstone of the rimrock ledge is Mississippian in age. Malott's Wickcliff Sandstone had been rediscovered.

THE PRESENT STUDY

Subsurface data. A modest drilling program had been planned by the Indiana Geological Survey to determine the northernmost extent of some of the Chesterian stratigraphic units, and so it was obvious that a core hole in the Newton Stewart Recreation Area was essential. This became Survey Drill Hole 311 (Figure 3 and Appendix, well record A), which established the top of the Wickcliff Sandstone of the nearby outcrop as some 134 feet (40.8 m) above the Glen Dean Limestone, about as Malott (1925) had indicated. The Leopold Limestone Member, which defines the top of the Branchville Formation, is not present in the core hole, but on the adjacent hilltop it is about 160 feet (49 m) above the top of the Glen Dean Limestone, well within normal range (Gray,

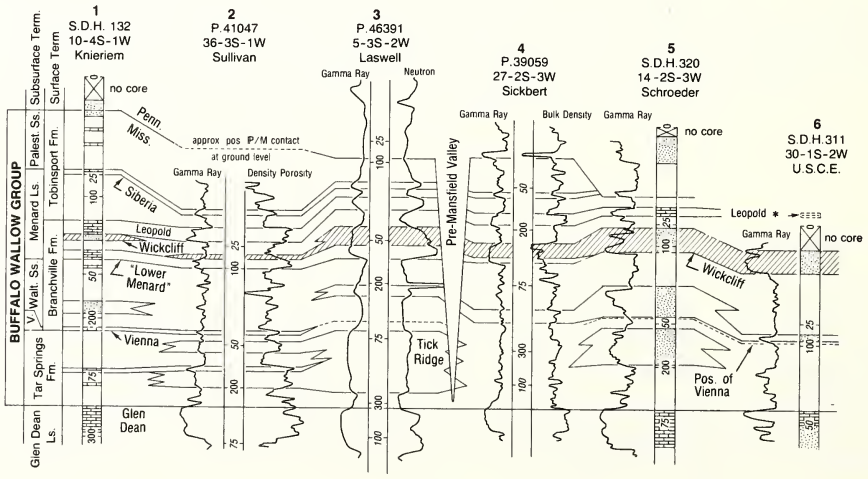

Figure 3. Selected core-hole and wire-line drilling records correlated from northeastern Perry County to southwestern Orange County, showing the stratigraphic placement of Malott's (1925) Wickcliff Sandstone within the Buffalo Wallow Group. The asterisk marks the position of the Leopold Limestone Member projected from hilltop excavation near core hole. No horizontal scale. Metric depths are shown in italics. See Figure 2 for location of wells.

1978). A second core hole, Survey Drill Hole 320 (Figure 3 and Appendix, well record B), verified the placement of the Wickcliff in respect to the Leopold and also confirmed that nearby long- abandoned limestone quarries probably were in the Siberia member of the Tobinsport Formation.

A number of commercial wire-line logs from the area were selected for further study (Table 1). These logs made possible correlation of the Wickcliff Sandstone and associated stratigraphic units to units routinely recognized in the subsurface and to Survey Drill Hole 132 (Figure 3), a key record that displays nearly all the upper Chesterian of the Indiana outcrop area. In these records, the Wickcliff Sandstone is characteristically about 20 feet (6 m) thick and is positioned just below the Leopold Limestone Member of the Branchville Formation and above the "lower Menard" of subsurface usage. Thus, the Wickcliff is stratigraphically equivalent to rocks that in the subsurface are assigned to the Menard Limestone. The Siberia Limestone Member of Indiana outcrop usage appears to correlate with the "upper Menard" of subsurface usage and thus to the Allard Member of the Illinois standard section (Figure 1).

Type locality and type section. Malott did not designate a type section for his Wickcliff Sandstone, but of the sections he described, only one (Malott, 1925, p. 127) suits. Its location is given as "just south of Wickcliff, along the Birdseye road and in a small creek or branch." The exact location of this section is uncertain, but for purpose of discussion, Malott's text description is recast here in the style of his other described sections:

	Ft	(m)
4. Light and olive green shales	20	(6.1)
3. Wickcliff Sandstone, massive, cross-bedded	35	(10.7)
2. Dark sandy and olive shales	30	(9.2)
1. Tar Springs Sandstone, laminated, massive	35	(10.7)

Within unit 4 is "a ledge of yellow limestone a foot or more in thickness" that "apparently is the one which usually occurs beneath the Siberia limestone" (Malott, 1925, p. 127). This is the Leopold of present usage. The sandstone Malott identified as Tar Springs must be within the Waltersburg and probably is the "not the Waltersburg" of Malott and Esarey (1940); at no place within the area of study is the interval between the Tick Ridge Sandstone Member of the Tar Springs Formation and the Wickcliff as short as 30 feet (9 m). Furthermore, Malott and Esarey (1940) expected to find the (Wickcliff) Waltersburg "fully 60 feet [18 m] above...the Vienna." Compare this section with the log of Survey Drill Hole 320 (Figure 3, datum point 5), which is at no great distance southwest.

Character of the sandstone. Following discovery of the Leopold limestone at the Newton Stewart State Recreation Area, the character of the rimrock sandstone just below it came under closer scrutiny. Where most boldly expressed, the sandstone is strongly cross-stratified in large, simple sets of planar strata that incline gently and almost uniformly to the west. The unit also is extensively marked by honeycomb weathering. Neither feature is typical of sandstones in the Mansfield Formation.

Table 1. Well records consulted in this study, showing thickness of Wickcliff Sandstone of Malott (1925) and interval from top of sandstone to top of Glen Dean Limestone. Numbers refer to correlated wire-line logs shown on Figure 3.

County	Location	Permit	Name	Thickness	Interval	Comment	Number
Orange	NE/SW/NW 30-1S-2W	458NP	S.D.H. 311 U.S. Corps of Engineers	19+ ft (5.8 m) of record	134+ ft (40.8 m)	Wickcliff at top	6
Crawford	SW/SW/NE 28-2S-2W	46230	Atkins No. 8 Fields	Absent	————	Base Penn. on Waltersburg	
Dubois	SW/NW/SW 14-2S-3W	572NP	S.D.H. 320 Schroeder	21 ft (6.4 m)	148 ft (45.1 m)	Base Penn. on Menard, just below Siberia	5
do	SE/SE 15-2S-3W	39059	Anschutz No. 21 Hoffman	19 ft (5.8 m)	151 ft (46.1 m)	Base Penn. on Siberia/ upper Menard	
do	NW/NW 22-2S-3W	39059	Anschutz No. 2 Schnell	20 ft (6.1 m)	149 ft (45.5 m)	Leopold at top of record	
do	SE 27-2S-3W	39059	Anschutz No. 6 Sickbert	16 ft (4.9 m)	137 ft (41.8 m)	Base Penn. on Palestine	4
Crawford	NE/SE/NE 2-3S-2W	36127	Reynolds and Vincent No. 1 Newton	6(?) ft (1.8 m)	130 ft (39.7 m)	Base Penn. on Leopold/ middle Menard	
do	SW/NE/SE 5-3S-2W	46391	Atkins No. 1 Laswell	18 ft (5.5 m)	152 ft (46.4 m)	Base Penn. on Palestine	3
do	SE/SE/NW 7-3S-2W	46340	Atkins No. 1 Wright	8(?) ft (2.4 m)	138 ft (42.1 m)	Base Penn. on Palestine	
Perry	NW/SE/NW 17-3S-2W	35679	Reynolds and Vincent No. 1 Zehr	17+ ft (5.2 m)	155 ft (47.3 m)	Wickcliff at top of record	
do	SW/NW/NW 36-3S-2W	41047	Tamrack No. 9 Sullivan	6 ft (1.8 m)	130 ft (39.7 m)	Palestine at top of record	2
Dubois	NW/NW/NE 10-3S-3W	12347	Kingwood No. 1 Peak	Absent	————	Base Penn. on Waltersburg	
do	SE/SW/SW 13-3S-3W	40338	Loper No. 2 Critchfield	6(?) ft (1.8 m)	141 ft (43.0 m)	Base Penn. on Siberia/ upper Menard	
do	NE/NW/SE 15-3S-3W	10811	Kingwood No. 1 Boeckman	May be present	135 ft (41.2 m)	Base Penn. on Menard, just below Siberia	
Perry	SW/SE/SE 24-3S-3W	32588	Par No. 1 Seufert	6 ft (1.8 m)	131 ft (40.0 m)	Menard, just below Siberia, at top	

County	Location	Permit	Name	Thickness	Interval	Comment	Number
do	SW/SE 5-4S-1W	43558	Citizens No. 1 Galey	7 ft (2.1 m)	140 ft (42.7 m)	Menard, just below Siberia, at top	
do	SW/SW/SW 10-4S-1W	——	S.D.H. 132 Knieriem	5 ft (1.5 m)	144 ft (43.9 m)	Base Penn. on Mt.Pleasant/ Degonia	1
do	NE/NE 15-4S-2W	40026	Turner No. 2 Ray and Flamion	6(?) ft (1.8 m)	134 ft (40.9 m)	Base Penn. on Palestine	
do	SW/SE 12-4S-3W	621NP	Vickery No. 1 Beard	8(?) ft (2.4 m)	138 ft (42.1 m)	Base Penn. on Clore	
do	NE/NW/NE 22-4S-3W	621NP	Vickery Nos. 1-3 Gehlhausen	5 ft (1.5 m)	144 ft (43.9 m)	Base Penn. on Clore	
do	NE/NW/SE 2524-3S-3W	39421	Rogers No. 1 Styline	6(?) ft (1.8 m)	120 ft (36.6 m)	Base Penn. on Clore	

Traced northward along the ridge where the capping limestone was discovered, sandstone of this character disappears and is replaced, at the same topographic position, by a less continuous ledge that does not form rock cities, is chaotically cross- stratified on a smaller scale, and includes many ferruginous concretions and a few plant impressions. These features indicate that this sandstone is Pennsylvanian in age and is properly assigned to the Mansfield Formation, although the contact between the two sandstones cannot be seen. Still farther northward, the Mansfield progressively cuts out more and more of the upper Chesterian section, so that in the vicinity of Patoka Dam, about 3 miles (5 km) northwest of the core-hole site, the Mansfield rests on the Glen Dean Limestone. From there northward, rocks of the Buffalo Wallow Group are unknown along the outcrop, although the Glen Dean Limestone is widely present.

Malott (1925, p. 108) described the Wickcliff Sandstone, entirely from outcrop reconnaissance, as having a thickness of as much as "35 or 40 feet [11 or 12 m]," but these figures could not be verified. The maximum thickness observed during this study was 21 ft (6.4 m; Table 1). On outcrop, the sandstone characteristically forms shelving, overhanging, discontinuous ledges that are most prominent in ravines, where waterfalls over the ledges are common.

Within the area of its occurrence, the Wickcliff Sandstone forms, as Malott (1925, p. 109) observed, "a dependable horizon for structure determination." The median interval from the top of the Glen Dean Limestone to the top of the sandstone, as determined from the 19 datum points listed in Table 1, is 138 ft (42.1 m), very close to the figure given by Malott. Determination of sandstone thickness in these wire-line logs is subject to too great a relative error to produce reliable statistics, but it appears that the thicker sections outline a vague northwest-southeast trend, essentially from datum point 6 to datum point 3 (Figure 2). The area of thicker sandstone corresponds to an area where the Glen Dean-Wickcliff interval is thicker than normal.

Areal distribution of the sandstone. Geologic mapping (Figure 2) shows that the Wickcliff Sandstone crops out in two distinct areas — one between Wickliffe and Birdseye, the other south of Birdseye in the various branches of the Anderson River. The two areas are separated by a pre-Mansfield valley, now expressed by the trace of the Mississippian-Pennsylvanian unconformity. This valley trends southwestward across T2S, R2W from the outcrop area southeast of Wickliffe, where basal Mansfield rests on Glen Dean in an exposure along State Route 145 (Gray, *et al.,* 1957, pp. 28- 29), to a cluster of wells at the southeastern corner of Dubois County. In this area, the Wickcliff is missing as a consequence of pre-Mansfield erosion.

Along the Indiana outcrop south of the area mapped on Figure 2, a nearly complete section of upper Chesterian rocks is present (Gray, 1978), but neither drill-hole data nor outcrops outline additional areas of sandstone at the appropriate stratigraphic position. It seems probable that in this area the Wickcliff is missing by nondeposition. Farther south, in a section just across the Ohio River in Kentucky, Malott (1925, p. 116) described a thin sandstone that he identified as Wickcliff. This bed lies, however, too low in the section (Gray, 1978, Figure 3, section 1). Furthermore, detailed surface mapping in this part of Kentucky (Bergendahl, 1965; Crittenden and Hose, 1965) failed to find a sandstone of significant extent at the position of the Wickcliff.

In the subsurface of southern Indiana, a sandstone in the lower part of the Menard Limestone, and therefore possibly equivalent to the Wickcliff Sandstone, is known in parts of Spencer and Warrick Counties (S.J. Keller, pers. comm., 1991). A sandstone in similar position in Daviess and McLean Counties, western Kentucky, is called the "Chapman sand" by drillers (Swann,1963, pp. 38, 63). These areas of sandstone are about 40 miles (60 km) southwest of the outcrop area of the Wickcliff Sandstone and may have had a source and origin different from that of the sandstone in the outcrop area.

CONCLUSIONS

The eastward tonguing-out of the Menard Limestone at the outcrop, along with the limited distribution of the Wickcliff Sandstone, imply a continuation of basin geometry as outlined by Swann (1963, Figure 4 and pp. 11-17). The Wickcliff may be a remnant of a ribbon or pod of Potter's (1963) classification of sandstone bodies; if so, a near approach to the paleoshoreline would not be indicated and, indeed, should not be expected from the close association of the sandstone with tongues of the Menard Limestone. The sandstone does not extend far into the subsurface and most probably represents a distal end of the Michigan River deltaic complex envisioned by Swann (1963).

Although an outline of the basic conclusions presented herein has appeared in the current compendium of Indiana stratigraphic nomenclature (Gray, 1986), it has seemed advisable to present also the analysis that supports those conclusions. The limited distribution of the Wickcliff Sandstone and the former enigma of its stratigraphic position seem sufficient to explain the infrequent past use of the name. Cited herein are almost all of its mentions. The name Wickcliff properly makes an appearance in Wilmarth (1938, pp. 2330-2331), where it is not, however, marked as a term abandoned by its originator, but rather as a name whosestatus had not been officially considered by the U.S. Geological Survey. At this juncture, despite a new and corrected understanding, there seems no point in rejuvenating the name.

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APPENDIX

A. Description of upper part of core from Survey Drill Hole 311, U.S. Corps of Engineers, Newton Stewart State Recreation Area, NE¼, SW¼, NW¼, Sec. 30, T1S, R2W, Orange County, Indiana. Datum point 6 on Figures 2 and 3. Surface altitude 705 ft (215 m). Summarized from description by Henry H. Gray, December 1981-January 1982. Metric conversions in parentheses. Conodont identifications by Carl B. Rexroad.

Description	Thickness	Depth
No record. Core starts at 20 feet (6.1 m)	20.0 (6.1)	20.0 (6.1)

MISSISSIPPIAN SYSTEM

Buffalo Wallow Group - 133.7 ft (40.8 m) cored

Branchville Formation - 78.5 ft (24.0 m) cored

Sandstone, light yellow-brown to light gray; indistinct even thin to medium strata, mostly in small tabular cross-sets; fine to medium sand; scattered light gray clay chips in several zones; friable. *Wickcliff Sandstone* of Malott (1925)	19.0 (5.8)	39.0 (11.9)
Mudstone and shale, mostly medium gray; some interstratified siltstone. Much core loss in this unit	25.5 (7.8)	64.5 (19.7)
Shale, dark gray; distinct even very thin strata; unit is uniform and distinctive on gamma-ray log	26.6 (8.1)	91.1 (27.8)
Rubble zone; contorted shale, ironstone, and sandstone chips	0.3 (0.1)	91.4 (27.9)
Sandstone, light gray; few calcareous zones near top	6.6 (2.0)	98.0 (29.9)
Rubble zone; contorted ankerite nodules in medium gray silt matrix.Probable position of *Vienna Limestone Member*	0.5 (0.2)	98.5 (30.1)

Tar Springs Formation - 55.2 ft (16.8 m)

Mudstone and siltstone, medium green-gray	7.0 (2.1)	105.5 (32.2)
Shale, very thinly interstratified with siltstone and very fine-grained sandstone; medium to dark gray	13.5 (4.1)	119.0 (36.3)
Siltstone and mudstone; calcareous, medium green-gray; bryozoans abundant throughout. *Cavusgnathus* and *Kladognathus* rare in basal 13.1 ft (4.0 m)	19.1 (5.8)	138.1 (42.1)

Mudstone-limestone, medium green-gray; a hash of calcareous fossils in a mud matrix. *Kladognathus* rare	1.6 (0.5)	139.7 (42.6)
Shale, dark gray; distinct even very thin strata	14.0 (4.3)	153.7 (46.9)

Stephensport Group

Glen Dean Limestone

B. Description of upper part of core from Survey Drill Hole 320, property of Walter and Marie Schroeder, SW¼, NW¼, SW¼, Sec. 14, T2S, R3W, Dubois County, Indiana. Datum point 5 on Figures 2 and 3. Surface altitude 677 ft (206 m). Summarized from description by Henry H. Gray, February-April 1983. Metric conversions in parentheses. Conodont identifications by Carl B. Rexroad.

Description	Thickness	Depth
No record. Core begins at 7.0 ft (2.1 m)	7.0 (2.1)	7.0 (2.1)

PENNSYLVANIAN SYSTEM

Raccoon Creek Group

Mansfield Formation - 51.4 ft (15.7 m) cored

Sandstone, light gray; in part thinly interstratified with medium gray shale; scattered carbonaceous material and mica flakes throughout	21.9 (6.7)	28.9 (8.8)
Shale, coaly, medium to dark gray	0.5 (0.2)	29.4 (9.0)
Claystone, medium green-gray	3.6 (1.1)	33.0 (10.1)
Shale, dark gray; even very thin strata and minor interstratified siltstone	20.2 (6.1)	53.2 (16.2)

Sandstone and shale, irregularly interstratified; in part cemented by large luster-mottled crystals of calcite; toward base contains scattered well-rounded pebbles of limestone and chert as large as 2 cm	3.3 (1.0)	56.5 (17.2)
Limestone and shale interstratified; coarse to medium grainstone containing rounded clasts as large as 5 cm, and dark gray shale. Contains *Adetognathus lautus* and *Idioprioniodus conjunctus,* on the basis of which this and the unit above have been assigned to the Pennsylvanian System	1.9 (0.6)	58.4 (17.8)

MISSISSIPPIAN SYSTEM

Buffalo Wallow Group - 174.8 ft (53.3 m)

Tobinsport Formation - 9.7 ft (3.0 m)

Shale and sandstone interstratified, medium gray; even to wavy very thin strata	9.7 (3.0)	68.1 (20.8)

Branchville Formation - 91.2 ft (27.8 m)

Leopold Limestone Member - 6.9 ft (2.1 m)

Dolomite, micritic, light yellow brown; in part a breccia with a matrix of light green-gray mudstone. *Cavusgnathus* and *Kladognathus* rare in basal 2.1 ft (0.6 m)	6.9 (2.1)	75.0 (22.9)

Unassigned as to member - 84.1 ft (25.6 m)

Shale and siltstone interstratified, medium gray; distinct even to contorted thin strata	9.9 (3.0)	84.9 (25.9)
Sandstone, fine- to very fine-grained, in part interstratified with shale; light to medium gray. *Wickcliff Sandstone* of Malott (1925)	21.0 (6.4)	105.9 (32.3)
Shale and mudstone; dark gray to medium green-gray	27.8 (8.5)	133.7 (40.8)

Sandstone, fine- to very fine-grained; light gray, increasingly interstratified downward with dark gray shale	25.4 (7.7)	159.1 (48.5)
Vienna Limestone Member - 0.2 ft (0.1 m)		
Limestone, argillaceous, medium yellow- brown; abundant coarsely crystalline fossil fragments, including bryozoans and brachiopods, in an argillaceous matrix. *Cavusgnathus* and *Kladognathus* rare	0.2 (0.1)	159.3 (48.6)
Tar Springs Formation - 73.9 ft (22.5 m)		
Unassigned as to member - 8.9 ft (2.7 m)		
Sandstone and shale interstratified, medium to light gray	8.9 (2.7)	168.2 (51.3)
Tick Ridge Sandstone Member - 30.7 ft (9.4 m)		
Sandstone, in part interstratified with shale, light gray	30.7 (9.4)	198.9 (60.7)
Unassigned as to member - 34.3 ft (10.5 m)		
Shale and siltstone interstratified, medium gray; two minor beds of sandstone	29.9 (9.1)	228.8 (69.8)
Limestone, intramicrudite(?); abundant irregular clasts as much as 1.5 cm across are light yellow-brown, earthy, dolomitic, in a medium green-gray matrix. *Cavusgnathus altus, Hindeodus cristulus,* and *Lochriea commutatus* present	0.6 (0.2)	229.4 (70.0)
Shale, calcareous, medium gray; abundant fenestrate bryozoans, two *Archimedes* observed. *Cavusgnathus altus, C. unicornis,Kladognathus primus,* and *Hindeodus cristulus* common	3.8 (1.2)	233.2 (71.2)

Stephensport Group

Glen Dean Limestone

C. For a summary description of Survey Drill Hole 132, datum point 1 on Figures 2 and 3, see Gray, 1978, Appendix 2.