The Geology of the Dicksburg Hills, Knox County, Indiana

CLYDE A. MALOTT, Indiana University.

In the counties bordering the Wabash River in southwestern Indiana very few studies have been made which clearly depict the character and succession of the formations of the upper Pennsylvanian series forming the areal geology inward from the eastern margin of the Illinoian basin. Several factors have combined to make studies of the surface bedrock formations rather difficult in much of Posey, Gibson, Knox, and parts of Sullivan and Vanderburgh Counties. No coals of commercial thickness occur above the Millersburg coal (Coal VII), and the economic incentive has been small. The deep alluvial materials of the broad floor of the Wabash River and the adjacent mantle of dune sands and loess flanking the upland on the east form such an effective cover that rock exposures are few. Thick silts of lacustrine deposits extend up many valleys and often expand in extensive flats leaving no rock formations uncovered over wide areas. Also glacial drift is an effective cover over much of the area of the Wabash River counties. Most of the prominent exposures, such as those at Merom Bluff in Sullivan County, at old Fort Knox, Chimney Hills, and the Dicksburg Hills in Knox County, at Bald Hill and Skelton Cliff in Gibson County, at the New Harmony Cut-off, Brewer Hill, and Bufkin in Posey County, are mere key-hole glimpses of various sandstones, which, in their isolated exposures, exhibit very similar characteristics and in themselves are only doubtfully distinguishable. The intervening shale formations, containing the stratigraphic markers of the thin coals, black sheety shales, and thin limestones, are usually only about one-half the thickness of the massive sandstones and are much less ostentatiously exposed. They are so susceptible to weathering and erosion that they rarely exhibit vertical faces and are usually covered. The best exposures of these more diagnostic beds are found usually in the bottoms of creek beds in steep ravines, and only rarely do they occur at the foot of the bluff-like sandstone exposures. Still another difficulty in the study of the surface formations is the tendency of many of the sandstones to become shaly and lose their characteristics as massive sandstones. Also some of the more diagnostic beds, such as the marine limestones, thin out or disappear in one direction or another. For instance, the well known West Franklin limestone, 200 feet or more above the Millersburg coal (Coal VII), is not known to outcrop in Knox County. The Maria Creek limestone, extending along the outcrop through eastern Sullivan County about 75 feet above the Millersburg coal (Coal VII), disappears southward near Bicknell and the beds above it and below it merge without a stratigraphic marker.

The region of the Dicksburg Hills in southern Knox County exhibits some of the difficulties of a study of the surface formations in the upper Pennsylvanian of southwestern Indiana, but, because of certain circumstances in its geomorphic development, some rather excellent rock exposures occur which permit a study of several formations in that locality. It is the purpose of this paper to present the details of some of these exposures and to establish the stratigraphy and nomenclature, not only for the rocks of the locality, but for all the area of southwestern Indiana which comes within the same stratigraphic range.

Location and Physiography

The Dicksburg Hills are two prominent hilly masses which rise abruptly above the broad alluvial plains of the Wabash and White Rivers in the extreme southern part of Knox County, about 12 miles south of Vincennes, Indiana. The village of Hazelton is just across White River in Gibson County one or more miles to the southeast, and Decker is a similar distance to the northeast. U. S. Highway 41, between Vincennes and Princeton, passes along the east side of the eastern isolated hill, where a roadside park is maintained by the Indiana Highway Division. White River comes out of the upland from the east in a valley a mile wide and makes a northward loop which cuts directly into the broad Wabash alluvial plain. It turns back into its own valley, skirting closely the eastern hill as it does so. Thence, it turns westward, passing south of the two Dicksburg Hills, and enters the broad alluvial plain of the Wabash Valley which here is 7 or 8 miles in width. See figure 1.

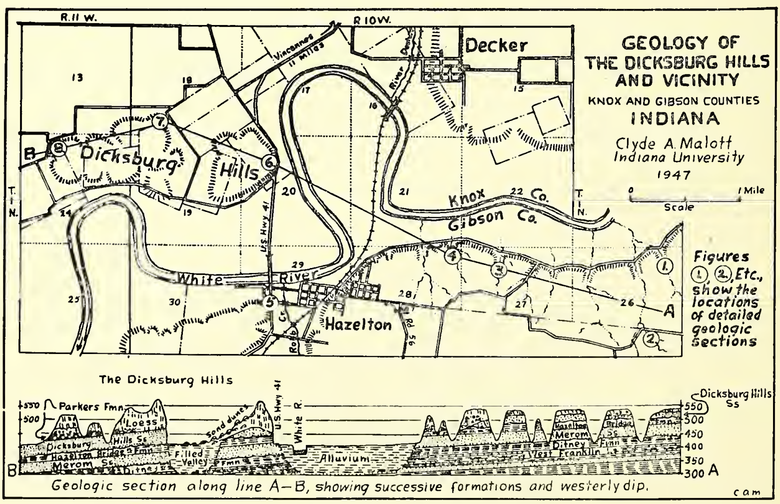

Fig. 1. Map of the Dicksburg Hills locality with cross-section depicting the upper Pennsylvanian formations present in the region.

The Dicksburg Hills are specially severed and isolated sections of the nearby upland. They have a bedrock foundation which has been covered with Illinoian drift, encroached upon by dune sands and heavily mantled by loess. The eastern hill occupies an area of about 200 acres and has a variable topography of mantling sand and loess. It culminates in a hill crest near its eastern edge which rises 150 feet above the alluvial plains of the Wabash and White Rivers. The western hill, with a similar mantle of loess and encroaching dunes, is a rugged tract of about 325 acres. It is separated from the eastern hill by a strip of lake silts about half a mile in width which is partly covered with wind-blown sands and dune hillocks. The upland surface of the western hill, composed of loess, has been deeply eroded, and its highest hill crests also rise 150 feet or slightly more above the surrounding floodplain area which has an altitude of 405 to 410 feet above sea level. The bedrock aspects of the hills are clearly discernible only on the northern and eastern sides. The geographic and topographic aspects of the region are depicted on the Vincennes, Princeton, and Petersburg quadrangles of the U. S. Geological Survey, which served as the basis of the sketch map shown in figure 1.

The Dicksburg Hills, with their mantles of glacial drift, dune sand, and loess, are good examples of many such isolated hills in the broad alluviated valley of the lower Wabash River. They have been described by Fidlar (1933, 135; 1936, 178) as whittled-down remnants of land masses severed from the upland along and adjacent to the Wabash where the great volumes of melt-waters of the Wisconsin glacial epoch encroached upon the uplands and cut out great valley fluves or valley braids, which upon being widened left the bedrock hills with their topping of Illinoian drift, sand dunes, and loess within the expansive valley plain. Fidlar (1935, 60-62) expressed the belief that White River formerly entered the Wabash Valley in the wide opening just west of Decker, and was later diverted to the route south of the Dicksburg Hills. He suggests that the strip of lacustrine floor at an altitude of about 435 feet between the two Dicksburg Hills was once connected with the lake plain of Robb Creek which now enters White River just west of Hazelton. A study of the topography revealed by the Vincennes and Iona quadrangles leads to the conclusion that the course of White River was formerly north of Decker. A dune-clogged valley 2 miles or more in width joins the Wabash Valley north of Decker. This vacated valley extends eastward and connects directly with the wide valley of White River. Some 2 miles northeast of Decker, the present river turns southward from its wide valley and enters one only half as wide, which it follows for about 5 miles before entering the Wabash Valley west of Hazelton. The bluffs along this stretch of White River Valley are rather abrupt, and the ravines coming in from the upland on the south are narrow and have bedrock floors to their debouchures into the river valley, a condition expressive of rejuvenation. Also bedrock is present in the bed of White River itself both at Hazelton and a half mile west of the bridge at Hazelton. Why White River should have been diverted southward into a new course is not clearly evident. The union of the alluvial plains of the Wabash and White Rivers between Decker and the Dicksburg Hills was a matter of lateral planation and was incidental in severing the Dicksburg Hills from another sand- and loess-covered bedrock mass east of Decker and south of the earlier broad course of White River.

Stratigraphy

The upper Pennsylvanian series in Indiana begins with the persistent Anvil Rock sandstone a short interval above the Millersburg coal (Coal VII), the highest of the more widely mined coals in the middle series. The upper series aggregates a thickness of about 500 feet and is composed of 12 or more stratigraphic units south of White River in southwestern Indiana.

The geologic formations exposed locally in the Dicksburg Hills and in the bluffs at Hazelton and eastward for 3 miles consist of several formational units within the upper Pennsylvanian series. Two of them receive their names from the region, while four others have been named from other localities and extend through the region. The formations will be described in this paper in their natural stratigraphical order. Since the formations dip gently westward, the lower formations are exposed on the east and the higher on the west. See geologic section, A-B, figure 1.

West Franklin Limestone. The West Franklin limestone is exposed at two or three places in the bed of a small creek in the NE¼ sec. 26, T. 1 N., R. 10 W., 3 miles east of Hazelton. The best exposure extends across the bed of the creek and is much dissolved along the rather close-spaced joints. It is a hard, fossiliferous bed about 2 feet thick. Only the upper member is exposed. It is uncertain that the lower member extends this far north. Only the upper member has been observed in the Mt. Olympus locality, some 3 or 4 miles southward. South of the Patoka River, the West Franklin limestone is a well known double bed of limestone about 200 feet above the Millersburg coal (Coal VII). Its outcrop is shown across parts of the Ditney and Patoka quadrangles of the U. S. Geological Survey, where it is described under the name "Somerville formation" by Fuller (1902, 2 and 1904, 2). Normally it consists of a lower bed of brecciated limestone 5 to 10 feet in thickness and an upper bed 2 to 5 feet in thickness. The two beds are usually separated by shale ranging from 2 to 15 feet in thickness. It is not definitely known to outcrop north of White River throughout Knox County. The name of West Franklin limestone was first applied to this formation by Lesquereux (1862, 294, 297) from the excellent exposures in the bluff of the Ohio River at West Franklin in the southeast corner of Posey County, Indiana, and later it was used by Collett (1884, 61-62). This name was restored to it by Shrock and Malott (1929, 1301-1302) and the name "Somerville" was dropped.

Ditney Formation. While it is believed that the best procedure for the division of the upper Pennsylvanian series into its natural stratigraphic units should be based upon the recognition that the massive sandstones constitute individual units of one type and the shales, thin coals, black sheety shales, limestones, etc., constitute a second type of formation, certain exceptions should be made. The West Franklin limestone would normally become a member of the second type of formation lying between a sandstone occurring about 10 feet below it and the massive Merom sandstone from 0-35 feet above it. Because of the importance of the West Franklin limestone as a stratigraphic marker at the outcrop and in the subsurface to the west, it is believed best to consider it as a stratigraphic unit in itself rather than as a member of a formation. Hence, the strata above it and below the Merom sandstone must be recognized as a formation. To this formation Fuller (1902, 2) applied the name Ditney, from the locality of the Ditney Hills, about 25 miles south of the Hazelton locality. This name is retained for these beds. They are well exposed along the bluff and in the ravines in sec. 26, especially in the NE¼, 3 miles east of Hazelton. There the Ditney formation measures 33 feet in thickness and is composed mainly of shales containing ferrous carbonate concretions and bands, near the bottom of which is a coal bed 14 inches thick topped by a black sheety shale and an impure limestone clod. A detailed section is given below. (See section 1.) Farther south the formation consists of a shale 12 to 20 feet in thickness with ferrous carbonate concretions and locally beds of firm sandstone, followed by the underclay, thin coal and the black sheety shale, and locally a still higher shale a few feet in thickness. In many places, however, the upper part of the Ditney formation has been eroded and the Merom sandstone rests upon the lower part of the formation with a marked disconformity. In some places the Ditney formation is entirely gone and a part of the West Franklin is also missing along this marked unconformity.

Merom Sandstone. The Merom sandstone is well exposed in the White River bluffs and in the ravines in sections 26 and 27 east of Hazelton, and shows of its upper massive portion occur in White River and in Robb Creek just east of White River bridge of Hazelton, and the top of it shows near road level at the Dicksburg Hills roadside park. It is also exposed in the artificial channel of diverted River Deshee for 1,000 feet on either side of the bridge just west of Decker. It is well exposed to the southeast of Hazelton in sec. 36, T. 1 N., R. 10 W., and southward to the Mt. Olympus locality. It is about 40 feet thick in the Hazelton locality. Its base does not exhibit its usual unconformable relationship on the beds below, such as is the case farther south and in the exposures north of Vincennes, and there is not the usual few inches of iron ore concentration containing sand and shale pebbles. In fact, in the Hazelton locality its basal portion appears quite conformable on the Ditney shales below, and its basal portion, while soft and micaceous, is locally shaly. Its shaly aspects, however, exhibit the usual marked cross-bedding so characteristic of the massive sandstones of the Pennsylvanian system. The Merom sandstone is everywhere a soft, massive, cross-bedded sandstone rarely exhibiting normal bedding. It is composed of coarse, angular, vitreous quartz grains, mica flakes, and considerable intergranular kaolin. The occurrence of the latter is probably responsible for its soft friable condition.

The Merom sandstone was named from the exposures of massive sandstone in the Wabash River bluff at Merom in western Sullivan County, Indiana, by Collett (1871, 199-200, 208), and, next to the West Franklin limestone was the first individual stratigraphic unit to receive a name in Indiana. Later Collet (1872, 243, 250; 1874, 320-324, 332, 334, 355, 286-389; 1876, 251-258, 272-281) traced the Merom sandstone southward through Knox, Gibson, and Vanderburgh Counties to the Ohio River. It is 35 to 40 feet thick in its type locality at Merom and maintains a similar thickness throughout its outcrop area. Locally it may reach a thickness of 50 feet or slightly more. While the Merom and Graysville exposures in the type region of the sandstone are separated from the extensions of the formation, the continuity of the sandstone may be traced southward from near Hutsonville and Palestine through Crawford County, Illinois, and thence across the Wabash River to the old Fort Knox locality, near where it passes below the Wabash River just north of Vincennes.

Fuller (1902, 2), because of some expressed doubts concerning its correlation in the Ditney Quadrangle area south of White River, included the Merom sandstone in his "Inglefield" sandstone, and this name was continued by Fuller and Clapp (1904, 2) in the area of the Patoka Quadrangle on the west. Since the sandstone at Inglefield in Vanderburgh County, 10 miles north of Evansville, is the same as the Merom sandstone, Cumings (1922, 525) dropped the name Inglefield. Fuller's "Inglefield formation", however, included the shales, thin coal, etc., and another higher massive sandstone which were given separate names by the present writer some years ago (Malott, 1939, 114).

Hazelton Bridge formation. The name Hazelton Bridge formation (Malott, 1939, 114) has been applied to a shaly formation some 20 to 25 feet in thickness, consisting of shales with ferrous carbonate concretions, a hard calcareous sandstone or a thin fossiliferous limestone, and one or two thin coals with or without black sheety shales above them, which lies between the Merom sandstone below and a similar massive sandstone above. The type locality of this formation is from an exposure at road level in White River bluff just south of the White River bridge west of Hazelton on U. S. Highway 41 in northern Gibson County, Indiana. The formation here was well exposed a few years ago, but at present it is partly covered and rather obscure. The exposure of the formation on the east bluff of the Dicksburg Hills is likewise partly covered. Good exposures, however, are still preserved in some of the river bluff ravines in sections 26 and 27 east of Hazelton. The characteristics of the formation are given in several detailed sections presented in the latter part of this paper.

The Hazelton Bridge formation shows above the Merom sandstone as a poorly exposed shale at old Fort Knox, 2 miles north of Vincennes, and its shales, thin fossiliferous limestone, thin coal, and black sheety shale show above road level along the eastern side of the Robeson Hills, eastern Lawrence County, Illinois, just across the Wabash River from Vincennes. Southward from its type locality it is seldom exposed. It has been observed, however, in a ravine east of Bald Hill, 2 miles north of Princeton, and numerous exposures of its shale and its thin coal have been noted in Vanderburgh County northwest and west of Evansville, where it lies 80 to 90 feet above the West Franklin limestone.

Dicksburg Hills sandstone. In the east bluff of the Dicksburg Hills some 25 feet or more above the U. S. Highway 41, a massive, coarse-grained, micaceous, friable, cross-bedded sandstone rests on the Hazelton Bridge formation. Only a few feet of the sandstone are exposed there. In the western hill, especially in the southwest part of sec. 18, this massive sandstone is well exposed, and at "The Rock Bluffs" fully 50 feet of it is exposed. Its top, capped by a shale, shows some 15 feet above road level in the NENW¼ sec. 24. As much as 35 feet of it is exposed in a ravine in the NW part of sec. 27, about 2 miles east of Hazelton. Farther south this sandstone was mapped as a part of Fuller's "Inglefield formation" in the Ditney and Patoka folios of the U. S. Geological Survey. It was named the Dicksburg Hills sandstone by the writer (Malott, 1939, 114) from the exposures in the Dicksburg Hills of southern Knox County. It composes the soft, micaceous, cross-bedded sandstone exposed locally near the base of the Chimney Hills to the north of the Dicksburg Hills, the small sandstone remnant known as "La Mamelle" in the NW part sec. 14, T. 2 N., R. 11 W., and the abrupt western bluff of the Wabash River at St. Francisville, Illinois, where it was formerly thought to have been the Merom sandstone (Collett, 1874, 324, 338; Fidlar, 1933, 137-139). Southward, many exposures are known where it appears above the Hazelton Bridge formation. It is well exhibited in the railway cut under the overhead bridge in the northern part of sec. 22, T. 5 N., R. 11 W., about 8 miles northwest of Evansville and a mile or so northeast of St. Joseph, and occupies the ridges about Kasson just northwest of Evansville.

The Dicksburg Hills sandstone in the area near its type locality is a very coarse sandstone, especially in its lower part. Its base is unconformable on the Hazelton Bridge formation and is composed of very coarse vitreous quartz sand much of which is quite angular, showing little evidence of wear. Some of the angular quartz grains exceed $\frac{1}{16}$ of an inch across, and, along with soft clay pebbles, the basal part of the formation contains much white kaolin in grain-like form or as fillings between the quartz grains. The kaolin in the sandstone is probably an alteration product from grains of feldspar deposited as a part of the formation. If such an interpretation is correct, the sandstone originally was an arkose. It is the writer's belief that the soft or friable condition is caused and maintained by the intergranular kaolin constituent in this and similar sandstones. It is not an uncommon thing to find intergranular white kaolin distributed through the coarse, soft, micaceous sandstones of the Pennsylvanian system, including portions of the Mansfield sandstone and several of the sandstones in the middle series. It is especially conspicuous in the Merom and Dicksburg Hills sandstones. These sandstones in places are merely altered arkoses, and the materials composing them must have come more or less directly from granitic rocks, though such sources are not immediately apparent.

Parkers formation. The Parkers formation has a thickness of 25 to 30 feet or more. It consists mainly of shales, but also of some thin sandy beds near the base, two thin coals with the one near the top capped by a black sheety shale, and usually a fossiliferous limestone. This upper coal is the Parkers coal of the formation. The Parkers formation rests on the Dicksburg Hills sandstone and is succeeded by the St. Wendells sandstone, a name long used in the field by the writer and used in the columnar section of the Geologic Map of Indiana (Logan, 1932), the name coming from the village of St. Wendells on line between Vanderburgh and Posey Counties about 10 miles northwest of Evansville. The name Parkers formation is derived from Parkers Settlement in eastern Posey County, Indiana, about 8 miles northwest of Evansville on State Road 66. The name is a variation of the name Parker, used for the coal, black sheety shale and limestone of the upper part of the formation by Fuller and Clapp (1904, 2-3) in the Patoka Folio of the U. S. Geological Survey. The outcrops used by these authors occur in the hills east of Parkers Settlement, mainly in the western edge of Vanderburgh County. The Parkers formation fills a space between the Dicksburg Hills and the St. Wendells sandstones, very similar to that of the Hazelton Bridge formation between the Merom and Dicksburg Hills sandstones. The very thin coal near the base of the Parkers formation is a very distinct stratigraphic marker a few feet above the Dicksburg Hills sandstone. This coal is very frequently only a smut streak and usually not more than one inch thick. It has a very persistent underclay 2 or 3 inches thick and is overlaid with a clay band or a ferrous carbonate band about one inch thick. This band contains numerous shells and shiny imprints of *Estheria* which help make this horizon a very distinct and elegant stratigraphic marker. This marker I have called the Rabens Branch bed, named from an excellent exposure in Rabens Branch, a small stream crossing the north-south road about a quarter of a mile south of the center of sec. 11, T. 5 S., R. 12 W., 1½ miles southwest of St. Wendells, Posey County, Indiana. The outcrop extends along the bed of this small stream with all members well displayed. The Rabens Branch horizon is about 20 feet below the Parkers coal and its black sheety shale, both of which are well exposed farther up the stream. The exposures of this thin marker are relatively numerous in the St. Wendells region. The same thin marker is exposed at several places with similar characteristics south of the road along the north side of the hill in the NENW¼ sec. 24, of the Dicksburg Hills locality, some 28 miles north and 7 miles east of the type locality. Only the lower part of the Parkers formation is exposed here, consisting of a few feet of shale, the Rabens Branch horizon, and a few feet of shale and sandy beds above. Gravelly Illinoian glacial drift rests on the bedrock of this locality. Some loose limestone blocks, resembling the Parkers limestone, were noted on the south side of the western hill less than one-half of a mile to the southeast, indicating the possibility of the presence of the higher part of the Parkers formation under the cover of glacial drift and the thick deposits of loess.

Detailed Geologic Sections

The following detailed rock sections are given to show the character of the geologic formations and to establish their succession in the Dicksburg Hills region. Only rarely are the formations exposed well enough to permit their identification as individual stratigraphic units or to demonstrate their sequential succession in the stratigraphic column. The sections will be presented from east to west in the order of their rise in the stratigraphic column. Some of the sections are from spot exposures, but most of them are built up from exposures along ravines extending as much as a quarter of a mile or more, or are composed of a number of individual exposures. The sections are shown graphically in figure 2.

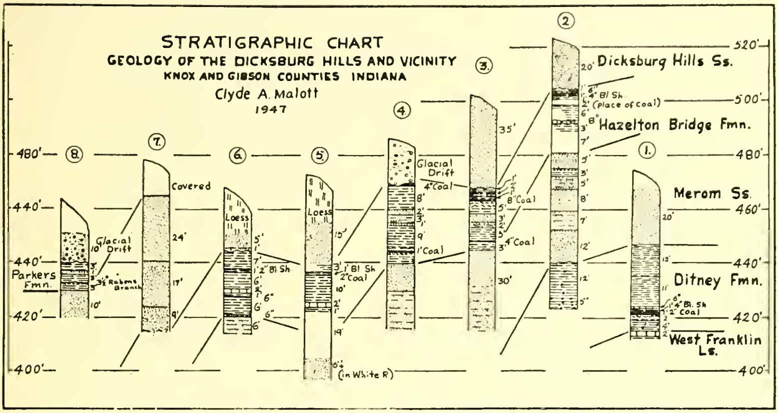

Fig. 2. Upper Pennsylvanian sections in the Dicksburg Hills locality. Section numbers correspond to the locations shown on the map of Figure 1.

Section 1. Exposures in creek bed and western bluff of stream running through the NE¼ sec. 26, T. 1 N., R. 10 W., 3 miles east of Hazelton.

	Ft.	in.
10. Covered slope		
Merom sandstone		
9. Massive, cross-bedded, friable, micaceous sandstone containing intergranular kaolin	20	
Ditney formation		
8. Gray shale with some ferrous carbonate concretions	12	
7. Dark shale with numerous ferrous carbonate concretions and bands	11	
6. Dark, calcareous shale, "calcareous clod," fossils abundant		6
5. Black sheety shale	1	4
4. Coal (Ditney coal)	1	2
3. Light-gray shale, becoming underclay at top	2	
2. Gray shale with ferrous carbonate concretions	4	
West Franklin limestone		
1. Hard, fossiliferous limestone bed	2	

The section given above begins with the top member of the well known West Franklin limestone which is an important stratigraphic marker about 200 feet above the base of the upper Pennsylvanian series in southwestern Indiana. It is exposed in the bed of the creek just south of the road where the creek enters White River Valley, but the best exposure is in the creek bed about 300 yards to the southeast. The remaining part of the section was taken from a ravine entering from the west, and in the creek bed and the western bluff farther southeast. The Ditney coal here is closer to the West Franklin limestone than in the exposures of the Ditney formation farther south in Warrick and Vanderburgh counties. The Ditney formation here is 33 feet in thickness. This is somewhat greater than observed farther south. The massive Merom sandstone rests abruptly on the Ditney formation but does not exhibit its usual disconformable relationship. It is highly cross-bedded and contains considerable intergranular kaolin throughout.

Section 2. From exposures in the road and in the ravine, SE¼ sec. 26, T. 1 N., R. 10 W., 3 miles east of Hazelton.

	Ft.	in.
Dicksburg Hills sandstone		
18. Coarse, gritty, friable, cross-bedded, micaceous, gray sandstone, composed mainly of angular vitreous quartz grains with incorporated clay pellets in the base, some pyrite and carbonized plant fragments, and well impregnated with kaolin throughout	20	
Hazelton Bridge formation		
17. Dark clay shale	1	
16. Dark, calcareous "clod" or limestone, fossils		6
15. Black sheety shale	1	4
14. Dark clay shale	1	
13. Covered (place of coal)	2	
12. Shows of gray shale	6	
11. Hard, impure, bouldery limestone		8
10. Shows of gray shale	3	
9. Covered	7	
Merom sandstone		
8. Coarse, soft, cross-bedded, micaceous sandstone	5	
7. Gray shale with smut streak and thin underclay near top	3	
6. Soft, shaly, micaceous, cross-bedded sandstone	5	
5. Soft, cross-bedded, micaceous sandstone	8	
4. Soft, shaly, cross-bedded, micaceous sandstone	7	
3. Soft, cross-bedded, micaceous sandstone, with streaks of coal at various angles and fossil plant impressions near base	12	
Ditney formation		
2. Gray shale, slightly sandy, ferrous carbonate concretions	12	
1. Dark shale with abundant ferrous carbonate concretions and bands	5	

The Merom sandstone in the above section was measured from the outcrop up the hill in the road from the ravine where the road turns eastward. The Merom sandstone is fully 40 feet thick. The smut streak and thin underclay near the top has not been observed elsewhere. The Hazelton Bridge formation appears to be about 22 feet in thickness, and most of it is well exposed in the ravines to the southeast of the road turn where the Merom is well exposed. The coal near the top was not seen, though at several places excavations had been made in attempts to mine it. As much as 20 feet of the Dicksburg Hills sandstone is exposed in the very head of the sharp ravines entering from the east. Water continually seeps from the base of this sandstone, and the rock is still its original gray color. It is soft, friable, very coarse, micaceous, cross-bedded, and well impregnated with white kaolin. The kaolin particles are very soft when wet, but in the dry specimens of the sandstone the kaolin gives a mealy feel and appearance to the sandstone. The elevation of the base of the Dicksburg Hills sandstone in the section is approximately 505 feet above sea level.

Section 3. Compiled from exposures in and along the ravine, NW¼ sec. 27, T. 1 N., R. 10 W., 1¾ miles east of Hazelton.

	Ft.	in.
Dicksburg Hills sandstone		
12. Coarse, soft, micaceous, cross-bedded, yellow sandstone	35	
Hazelton Bridge formation		
11. Soft, dark clay shale	1	
10. Black sheety shale	2	
9. Dark clay shale	1	
8. Coal		8
7. Light gray clay shale becoming underclay at top	5	
6. Hard, micaceous, lime-bound sandstone	3	
5. Soft, thin-bedded sandstone, shaly	2	
4. Gray shale	5	
3. Coal		4
2. Sandy shale	3	
Merom sandstone		
1. Soft, cross-bedded, micaceous sandstone, shaly in lower part	30	

The Merom sandstone is well displayed along the valley bluff and in the lower part of the ravines in the northern part of sec. 27. Some parts of it are shaly, though remaining cross-bedded. The Hazelton Bridge formation in the section is completely exposed with all of its members and totals 23 feet in thickness.

Section 4. Compiled from exposures in ravine in the NENE¼ sec. 28, T. 1 N., R. 10 W., 1¼ miles east-northeast of Hazelton.

	Ft.	in.
12. Illinoian glacial drift		

	Ft.	in.
Hazelton Bridge formation		
11. Shows of black sheety shale		
10. Coal		4
9. Gray shale	8	
8. Hard, micaceous, calcareous sandstone	2	
7. Shaly sandstone	3	
6. Hard, micaceous, calcareous sandstone	1	
5. Gray shale with ferrous carbonate concretions	9	
4. Shaly or "bony" coal	1	
3. Soft gray shale, becoming underclay at top	4	
Merom sandstone		
2. Soft, cross-bedded, micaceous sandstone	10	
1. Shaly, micaceous, cross-bedded sandstone	15	

In section 4, glacial drift rests on the Hazelton Bridge formation very near the top. The formation appears to be slightly in excess of 28 feet. Large blocks of fossiliferous limestone rest close on the top of the Merom sandstone on the point of the spur east of the ravine a short distance south of the road at the mouth of the ravine. They are likely erratics in the glacial drift which has been nearly washed away at this place.

Section 5. Composite section in bluff and bed of Robb Creek at or near the intersection of U. S. Highway 41 and State Road 56, south of the Hazelton Bridge across White River just west of Hazelton. Middle western ½ of sec. 29, T. 1 N., R. 10 W.

Dicksburg Hills sandstone	Ft.	in.
9. Massive, coarse, cross-bedded sandstone, base not observed	15	
Hazelton Bridge formation		
8. Shows of gray shale	3	
7. Black sheety shale containing *Estheria*	1	
6. Smutty shale with coal streaks		2
5. Gray shale	10	
4. Yellow, impure, fossiliferous limestone	2	
3. Shows of gray shale	1	
2. Covered	19	
Merom sandstone		
1. Coarse, cross-bedded, friable sandstone	5	

This section is now rather poorly exposed. It is the type section for the Hazelton Bridge formation. The yellow, fossiliferous limestone is apparently in the place of the hard calcareous sandstone in the sections east of Hazelton. Much of the limestone at road-level, formerly well exposed on the east side of U. S. Highway 41 a short distance south of the intersection with State Road 56, has been excavated and removed.

The Merom sandstone in the bed of Robb Creek and in White River above the bridge is probably as much as 10 feet below the top of that formation. The Hazelton Bridge formation is probably about 25 feet in thickness. The Dicksburg Hills sandstone is only partially exposed along the bluff west of the highway, and neither the top or the bottom is shown.

Section 6. Along the east bluff of Dicksburg Hills, west side of U. S. Highway 41, NW¼ sec. 20, T. 1 N., R. 10 W., 1 mile north of the White River bridge at Hazelton.

	Ft.	in.
Dicksburg Hills sandstone		
11. Soft, mealy, micaceous, cross-bedded, coarse sandstone	5	
10. Coarse, ferruginous sandstone, incorporating clay pellets, kaolin lumps and kaolin particles, all rather porous with some rather large holes and cavities	1	
Hazelton Bridge formation		
9. Gray shale	7	
8. Black sheety shale with scattered *Estheria*	1	2
7. Gray shale	6	
6. Impure, fossiliferous limestone, cloddy to hard with small brachiopods gastropods and crinoid stems, 6 inches to	2	
5. Gray shale	1	
4. Smutty shale with coal streaks		6
3. Gray shale	6	
2. Hard bed of ferrous carbonate concretions and bands		6
Merom sandstone		
1. Hard shaly sandstone at or near road level	6	

In this section only the base of the Dicksburg Hills sandstone is exposed. It is at an elevation of about 445 feet above sea level. The Hazelton Bridge formation is 25 feet in thickness. Here again the impure limestone replaces the hard calcareous sandstone found east of Hazelton. While this section was well exposed some years ago, it is now partially grown over and covered with its own weathered debris. The upper coal does not show. It was reported present along the highway near the north end of the Dicksburg Hills roadside park when excavations were made there some years ago.

Section 7. Exposures in "The Rock Bluffs," SW¼ sec. 18, T. 1 N., R. 10 W., in the northeastern part of the western hill of the Dicksburg Hills, Knox County, Indiana.

	Ft.	in.
Dicksburg Hills Sandstone		
4. Covered		
3. Massive, cross-bedded sandstone, rather soft beneath a case-hardened surface, weathered yellow and has some surface iron concentration on overhang beneath lip of intermittent waterfalls	24	

2.	Massive, cross-bedded, micaceous, coarse-grained sandstone, somewhat case-hardened and has large niche-like cavities weathered out in the overhang of the intermittent waterfalls and considerably undercut at the base. Contains much intergranular kaolin particles	17
1.	Very coarse, gray sandstone, containing much white kaolin and near the base many included shale and clay pellets, all only partially exposed and in the zone of water seepage at base of intermittent waterfalls	9

Here the Dicksburg Hills sandstone is the only formation exposed, and it is fully 50 feet in thickness. This may be regarded as the type section of the Dicksburg Hills sandstone. More than 30 feet is exposed in the overhang of the intermittent waterfalls. The base was not actually observed, but the rock with the clay and shale pellets in the very coarse, kaolin-impregnated sandstone below the waterfall pit is believed to be near the base of the formation. The altitude here is about 415 feet above sea level.

Section 8. Exposures south of the road and in a small ravine leading west at the northwest edge of the western Dicksburg hill, NENW¼ sec. 24, T. 1 N., R. 11 W.

		Ft.	in.
11.	Steep faces of calcareous Wisconsin loess with bands of gastropods in wash, about	15	
10.	Covered, about	15	
9.	Yellow, gravelly, Illinoian glacial drift, about	10	
Parkers formation			
8.	Gray shale with local patches of disordered and broken fossil plants	3	
7.	Hard, laminated, fine-grained, micaceous, rusty sandstone	1	
6.	Gray shale, slightly sandy	3	
5.	Clay band, rusty, containing *Estheria*..................		1
4.	Smut streak with local shows of coal		½
3.	Underclay		2
2.	Gray shale	3	
Dicksburg Hills sandstone			
1.	Soft, micaceous sandstone with shows of bedding near top	10	

Section 8 shows the top of the Dicksburg Hills sandstone which here is about 430 feet above sea level, or about 15 feet lower than the base of the formation at the eastern side of the hills 2 miles to the east. Assuming that the Dicksburg Hills sandstone is 50 feet thick, these data indicates a westward dip through the hills of 65 feet, a somewhat greater dip than is indicated in the bluffs east of Hazelton. The thin Rabens Branch stratigraphic marker is well exhibited at several places in the outcrops, and possesses about the same characteristics here as in the type locality some 25 or 30 miles to the south. It is described under 2, 3, and 4 of the above section.

Summary and Conclusion

The Dicksburg Hills region in southern Knox County and the adjacent bluffs and ravines across the White River near Hazelton in northern Gibson County compose an area which, because of its rather unusual geomorphic development, possesses much better rock exposures than is common throughout much of southwestern Indiana where the upper Pennsylvanian beds form the surface rocks. The present course of White River runs somewhat south of an older, clogged course north of Decker, and the sharply-cut southern bluffs of the newer course east of Hazelton and the rejuvenated ravines adjacent show good exposures of the rock formations. The Dicksburg Hills, now north of the newer course of White River, have been laterally planed by the glacial floods of Wisconsin time, and the eastern and northern sides of these isolated and circum-alluviated hills have bold bluffs of exposed rock, though much of their area is covered with Illinoian glacial drift and the dune sands and loess of Wisconsin time.

Parts or all of six stratigraphic units are exposed in an aggregate of about 160 feet of rock strata in the Dicksburg Hills and the bluffs and ravines south of White River east of Hazelton. Two of these formations, the Hazelton Bridge formation and the Dicksburg Hills sandstone, receive their names from the locality. Four other formations extend through the locality, having received their names elsewhere. The rock formations show a westerly dip amounting to 125 feet in a distance of 6 miles, 65 feet of which is through the Dicksburg Hills which extend only 2 miles in an east-west direction.

The top member of the West Franklin limestone, exposed 3 miles east of Hazelton, is the lowest stratigraphic unit exposed in the locality. It is succeeded by the following formations in order of their succession: Ditney formation (33 ft.), Merom sandstone (40 ft.), Hazelton Bridge formation (24 ft.), Dicksburg Hills sandstone (50 ft.), and the Parkers formation (10 ft. exposed). The characteristics and habits of these formations are presented in some detail in this paper, and carefully measured sections showing them in order are given for the Dicksburg Hills and Hazelton localities.

The Merom and the Dicksburg Hills sandstones typically are soft, friable, cross-bedded, micaceous sandstones, the basal parts of which are usually quite coarse and contain incorporated shale pellets and considerable intergranular kaolin. This is more apparent in the Dicksburg Hills sandstone than in the Merom sandstone of the locality. These sandstones are distinctly unconformable on the beds upon which they rest. Locally, considerable iron oxide is incorporated in the basal parts of these sandstones. It is believed that this iron oxide is secondary, having been derived through the alteration of pyrite which is abundant in the basal parts where it has not been altered.

The shales, thin coals, and limestones of the formations between the massive sandstones represent beds which have accumulated rather slowly. They are largely indigenous beds which accumulated in waters that had little movements. The coals, limestones, ferrous carbonate concretions and bands, and, to a certain extent, the black sheety shales and the underclays, are organic and chemical in origin. The shales are composed of muds which did not come from long distances and are largely redepositions. Even the sandstones and sandy beds in these formations accumulated rather slowly and are probably redepositions from local origins. They are usually well bedded, firm or hard, and are frequently laminated rather than massive and cross-bedded.

The massive sandstones, on the other hand, bear evidence of rapid accumulation in strongly moving currents. The coarseness and angularity of the quartz grains, the presence of considerable mica, and the occurrence of the intergranular kaolin, probably derived from feldspar, indicate that the Dicksburg Hills, Merom, and other sandstones of their kind probably came from granitoid rocks and, apparently, were deposited as arkosic sandstones. It is believed that their soft or friable condition is largely caused by the presence of the intergranular kaolin. They are composed of imported materials brought in by a vigorous invading sea which overwhelmed and buried the indigenous beds of shales, thin coals, black sheety shales, and thin limestones occurring between them. Their places of origin as sediments are not known, but it is not improbable that they came from long distances, even from the old land mass of Llanoria, and it is very likely that they represent first-cycle deposits and were not derived from previously deposited beds.

The differences in the character and origin of the two types of sedimentary accumulation, described in the Dicksburg Hills region, form the basis upon which the upper Pennsylvanian beds of southwestern Indiana, and probably elsewhere, may be divided into successive formations, receive names, and be given definite status as stratigraphic units.

References

Collett, John, 1871, Geology of Sullivan County, 2nd Ann. Rept., Geol. Surv. of Ind., 191-240.

————, 1872, Geology of Pike County, 3rd and 4th Ann. Rept., Geol. Surv. of Ind., 239-287.

————, 1874, Geology of Knox County, 5th Ann. Rept., Geol. Surv. of Ind., 315-382. Geology of Gibson County, 5th Ann. Rept., Geol. Surv. of Ind., 383-422.

Collett, John, 1876, Geological Report on Vanderburgh County, 7th Ann. Rept., Geol. Surv. of Ind., 240-300.

————, 1884, Geology of Posey County, 13th Ann. Rept., Dept. Geol. and Nat. Hist., 45-70.

Cumings, E. R., 1922, Nomenclature and Description of the Geological Formations of Indiana, Pt. 4, Handbook of Indiana Geology, Publ. 21, Ind. Dept. Conservation, 403-570.

Fidlar, M. M., 1933, Some Hills of Circumalluviation in the Lower Wabash Valley, Proc. Ind. Acad. Sci., vol. 42, 135-140.

————, 1935, Alluviation in a Portion of the Lower Wabash Valley, Unpublished thesis, Dept. Geol., Ind. Univ., 106 pp.

————, 1936, Features of the Valley Floor of the Wabash River near Vincennes, Indiana, Proc. Ind. Acad. Sci., vol. 45, 175-182.

Fuller, M. L., and Ashley, G. H., 1902, Ditney Folio, no. 84, U. S. Geol. Surv., 8 pp.

Fuller, M. L., and Clapp, F. G., 1904, Patoka Folio, no. 105, U. S. Geol. Surv., 12 pp.

Lesquereux, Leo, 1862, Report on the Distribution of the Strata in the Coal Measures of Indiana, Ind. Geol. Surv., 269-341.

Logan, W. N., 1932, Geological Map of Indiana, Ind. Dept. of Conservation, Publ. 112.

Malott, C. A., 1939, The Hazelton Bridge Formation of the Upper Pennsylvanian of Southwestern Indiana, Proc. Ind. Acad. Sci., vol. 48, 114.

Shrock, R. R., and Malott, C. A., 1929, Structural Features of West Franklin Formation of Southwestern Indiana, Amer. Assoc. Petr. Geol., vol. 13, 1301-1314.