THE UPPER CHESTER OF INDIANA.

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Little attention has been given to the detailed stratigraphy of the Chester series of the Mississippian system of Indiana, especially to the upper part. No description of the upper Chester of Indiana has ever been attempted, so far as the writer is aware. It is the purpose of this paper to present in some detail the physical characteristics of the upper Chester strata as they occur in southern Indiana and to call attention to such principal strata in the upper Chester which may be recognized from place to place and which may receive a name.

The Chester series form the uppermost unit of the Mississippian system of the Mississippi valley. The Chester series are represented in Indiana by a number of formations which outcrop in the southwestern part of the state in a general north and south direction, extending from near Greencastle, Putnam County, to the Ohio River at the southern boundaries of Harrison, Crawford and Perry counties. In the vicinity of Greencastle only a few feet of strata are present beneath the Mansfield sandstone, the basal member of the Pennsylvanian system. Southward the thickness increases. Near French Lick in western Orange County the thickness has increased to a total of about 250 feet. In Perry County at the southern boundary of the state the total thickness has increased to approximately 600 feet. Only the lowest members of the series are present in Putnam County at the northernmost outcrops. Southward younger members appear beneath the overlapping Mansfield sandstone, and the maximum number of formations is attained in the vicinity of the Ohio River. The areal outcrop width at the north is but a few miles, while in the vicinity of the Ohio River it is 25 to 30 miles in width.

The Chester series of Indiana may readily be divided into three divisions, lower, middle and upper. Each division consists of a number of formations or lithologic units. The lower and middle Chester consist of a regular succession of alternating limestones and clastics. The limestones hold their characteristics over wide areas, persisting from their northernmost outcrops to and beyond the Ohio River with little change. With respect to these diagnostic limestones the clastics between them may be considered unit intervals, taking their names from the dominance of the sandstones which chiefly characterize them in their outcrops. The upper Chester, however, does not conform to the stratigraphic simplicity exhibited in the lower and middle divisions.

The lower Chester consists of seven units totaling an average thickness of about 150 feet. These units have been studied in considerable

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detail by the writer, and have been traced throughout their areal outcrop in the State. Their names and thicknesses are as follows:[1]

7. Beech Creek limestone, 10-30 feet
6. Elwren sandstone interval, 10-40 feet.
5. Reelsville limestone, 1-10 feet
4. Sample sandstone interval, 20-30 feet
3. Beaver Bend limestone, 5-20 feet
2. Mooretown sandstone interval, 10-30 feet
1. Paoli limestone, 20-50 feet

Fredonia oölite, St. Genevieve.

The middle Chester consists of two limestone units and two clastic intervals chiefly characterized by sandstone. The total averaged thickness is about 150 feet. The lowermost clastic interval may be divided into a sandstone and a shale unit throughout practically all of the area of its outcrop, making in all five recognized units. They are as follows:

5. Glen Dean limestone, 15-40 feet
4. Hardinsburg sandstone interval, 25-45 feet
3. Golconda limestone, 10-40 feet
2. Indian Springs shale, 15-25 feet
1. Cypress sandstone, 30-45 feet } interval, 50-65 feet

Beech Creek limestone

General Character of the Upper Chester

The upper Chester of Indiana is represented fullest in Perry County, where a maximum of upwards of 290 feet of strata of this division occur. The strata in bulk consists chiefly of shales, though locally massive sandstones stand out in impressive thicknesses. Thin impure limestones are frequently present intercalated between the bluish and olive green shales.

In contrast to the lower and middle divisions of the Chester, no simple alternating succession of limestones and clastics occur. Simplicity in character, in dimensions and in succession of strata end with the Glen Dean limestone. The upper Chester is a unit which does not well lend itself to subdivision. It consists characteristically of a large number of lens-like individual beds in one section, which may fail to be repeated in another section in a nearby locality. Even groups of strata fail to show commonness throughout any considerable area. An outstanding sandstone tens of feet thick, giving rise to great overhanging cliffs on a hillside, may in a short distance dwindle to insignificant thinness. Single units are not easily recognizable either in their limits or characteristics. A few horizons, however, may be traced with the exercise of proper care over considerable distances. But even the most outstanding units are erratic in occurrence, in thickness and in lithic characteristics.

[1] Each of the units of the lower and middle Chester of Indiana has been defined and briefly described by Cumings with the aid of the writer in the "Handbook of Indiana Geology," pp. 514-517, 1922.

Because of the inconstancy of the beds and the consequent lack of ready reference horizons in the upper Chester, the Glen Dean limestone, the uppermost member of the middle Chester has served as an admirable reference plane or base for exploration and study of the stratigraphy of the upper Chester.[2] As the number of sections up from the Glen Dean limestone accumulated in the detailed study of the Perry County locality, a few horizons within the upper Chester began to stand out. Finally the study revealed that two limestone horizons and four sandstone units or horizons, either alone or in groups of two or more, could be used as reference planes. After the characteristics and the stratigraphical relationships of these horizons or units became established through a careful study of numerous well chosen sections, the work passed from that of mere exploration to the details of descriptive stratigraphy and structure, the study having been undertaken for these purposes. One could then advance into the maze-like variety of the upper Chester with some certainty of finding horizons which would indicate the stratigraphic position within the unit without recourse to the Glen Dean limestone which is within reach of only a limited portion of the area covered by upper Chester strata. The variety of the stratigraphic succession, the change in the individual formations from one locality to another and the relationships of the overlapping Mansfield sandstone laid down upon a much eroded surface, made the study always fascinating, and gave to the work that pleasure which only the explorer experiences when advancing into unknown and uncharted areas.

The two limestone and the four sandstone units or horizons, which may serve as reference planes in structural work undertaken in the area covered by the upper Chester, do not all occur in every locality where sections may be obtained. Rarely may all of them be identified in any single section or locality. These recognizable and frequently outstanding units are separated chiefly by shales which may not be identified by their own characteristics. The shales are variable in color, but light blue and olive green colors are the common ones. Occasional shows of accompanying maroon or purplish colorations are erratically present. Thin, impure limestone lenses or limey horizons are commonly intercalated with the shales, but none are recognizable or persistent over any considerable area with two exceptions. The shales are largely hidden by a cover of weathered material on the slopes. They serve as foils to the indurated sandstones which frequently protrude out on

[2] The Glen Dean limestone ranges in thickness from 10 to 45 feet, and has a usual thickness of 20 to 25 feet. This thickness makes it likely to be exposed in the rough country in which it outcrops below the upper Chester. It may be readily identified both by its physical characteristics and by its fossils. It is usually bedded, though frequently it is quite massive. Characteristically it is a creamy-white in color and dominantly oölitic. Its thinner beds are frequently gray or blue in color and are not oölitic usually. The fossils as a rule are large. Masses of bryozoan and crinoid remains make up considerable portions of the limestone in the upper part locally. The wing plates of the crinoid genus *Pterocrinus* are common in these masses. Large angular blastids of the species *Pentremites spicatus*, common on the weathered surfaces, and the triangular, serrated bryozoan fronds of the genus *Prismopora serrulata*, common in the loose weathered fragments, are index fossils for the formation. See Charles Butts, Mississippian Formations of Western Kentucky, Kentucky Geol. Surv., 1917, pp. 97-102.

the steep slopes between the obscured shale zones. Often the competent limestones and sandstones at their outcrops on the steep hillsides have moved down somewhat over their slippery shale bases. Detached blocks of sandstones commonly occur in abundance below the outcropping ledges on the steep slopes, obscuring the incompetent shale horizons below.

On account of the frequent absence of one or more of the expected limestone or sandstone units, or its or their change to shales of varying character, the limits of the shales normally between them are indefinite in many localities. As viewed in a single section or group of sections within a locality the shales then present the aspects of a single unit, where in fact two or more are represented. In some localities this apparent single unit comprehends a goodly portion, if not all, of the upper Chester present. The horizons described and named in this paper are notable expressions of limestone and sandstone within a bulk unit of shale. The shale masses count but little in the stratigraphic expression of the upper Chester, and may not be used in the study of the structural details which the region of their occurrence expresses. They are mere fillers or intervals between the outstanding limestone and sandstone units which alone are given names and definite status. Table 1 is a synopsis of the upper Chester rock succession in southern Indiana, giving the names and showing the stratigraphic positions of the outstanding units.

TABLE 1. UPPER CHESTER STRATIGRAPHY IN PERRY COUNTY, INDIANA

Named Units and Shale Intervals	Representative Thickness Feet	Range in Thickness Feet	Normal Vertical Distance Above Glen Dean Ls.
Negli Creek Limestone	7	0–20	280
Shale Interval	28	15–40	
Mt. Pleasant Sandstone	10	0–35	245
Shale Interval	25	10–35	
Bristow Sandstone	5	0–25	210
Shale Interval	30	15–45	
Siberia Limestone	4	0–20	175
Shale Interval	30	20–45	
Wickcliff Sandstone	20	0–40	140
Shale Interval	60	0–125	
Tar Springs Sandstone	45	0–90	
Shale Interval	15	0–40	
Glen Dean Limestone (Middle Chester)			

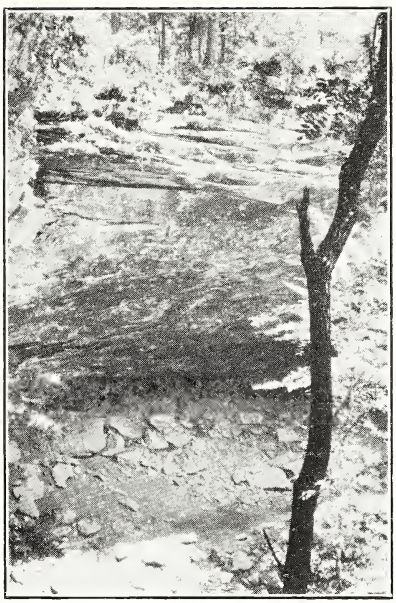
OUTSTANDING UNITS OF THE UPPER CHESTER.

Tar Springs Sandstone.—The Tar Springs sandstone was incidentally named by Owen[3] in 1857, but it was not given definite status as a sandstone unit until 1917 when Butts[4] made a study of the Mississippian of western Kentucky. The name is taken from the Tar Springs three miles south of Cloverport, Breckenridge County, Kentucky. Here petroleum bearing springs issue from near the base of the sandstone which is massively developed in the locality. It is prominent in the

[3] Owen, D. D., Second Rept., Ky. Geol. Surv., 1857, p. 87.

[4] Butts, Chas., Mississippian Series in Western Kentucky, Ky. Geol. Surv., 1917, pp. 103-105.

vicinity of Cloverport, standing out as vertical bluffs along the streams. It is typically a fine-grained, cross-bedded or heavy bedded sandstone about 50 feet thick. (Fig. 1.) Its weathered surfaces are frequently



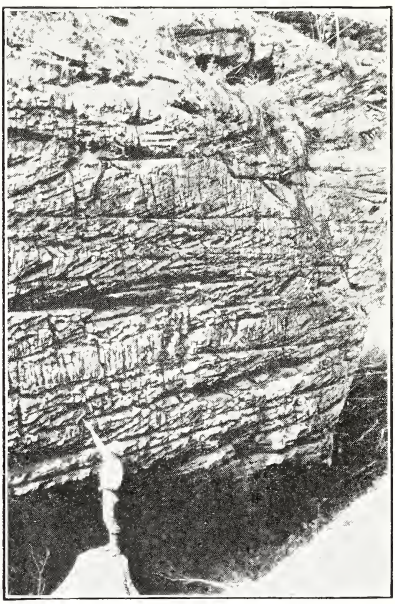


Fig. 1. View of the massive phase of the Tar Springs sandstone, at the head of Abbots Hollow, near Branchville, Perry County. The Tar Springs sandstone is 70 feet thick here and valleys of the box-canyon type are developed in it.

Fig. 2. View of the weathered face of the Tar Springs sandstone showing the fretted and honey-combed surface in conjunction with cross-bedding. One mile northwest of Branchville, Perry County.

much fretted and honey-combed with surface iron concentrations. (Fig. 2.) As a rule it is not a well cemented sandstone, and locally it is quite friable. In Indiana it is typically 45 feet thick where well developed, but its thickness is very irregular, ranging from a few feet to upwards of 80 or 90 feet at its maximum. It is absent entirely from many localities, and in others but poorly developed. It may rest directly on the Glen Dean limestone or on a shale a few feet to 40 feet above the Glen Dean. It is present as far north as the Southern Railway tunnel three miles southwest of French Lick in Orange County, but it may occur in part as far north as Shoals or Dover Hill in Martin County, where the Mansfield sandstone of the Pennsylvanian system comes to rest on or below the Glen Dean limestone.

As a single sandstone unit above the Glen Dean limestone, its upper limits are quite definite when the sandstone is well developed, but its upper surface is very irregular and does not represent a constant structural level. It appears to have a base normally about 15 feet above the Glen Dean limestone, which is fairly uniform, though not without some

exceptions. No place has been observed where its upper surface extends as much as 100 feet above the Glen Dean limestone.

Wickcliff Sandstone.—Northward from the latitude of Bristow and Branchville, Perry County, a sandstone appears in the shales above the Tar Springs sandstone and below the Siberia limestone. Its upper surface occurs at a uniform level about 140 feet above the Glen Dean limestone and about 35 feet below the Siberia limestone where the latter may be found to outcrop. This sandstone ranges from a few feet in thickness to a maximum of 35 or 40 feet. It does not readily weather and is quite resistant to water wear, and therefore, usually stands out on the steep valley sides and gives rise to waterfalls in the beds of small streams. It is usually bedded and very hard or quartzitic where its thickness is but a few feet. Where its thickness exceeds 10 or 15 feet it is usually quite massive and often laminated or cross-bedded. Its hard upper surface, in contrast to the shale overlying it, frequently gives rise to a bench along the main valleys. It is excellently developed along

Fig. 3. View of the joint controlled blocks of the Wickcliff sandstone in a stream bed one-half mile south of Uniontown, northern Perry County. This sandstone is quartzitic in character and gives rise to waterfalls in the small streams. In northern Perry County and adjacent parts of Crawford and Dubois counties, the Wickcliff sandstone is an outstanding unit in the upper Chester, 140 feet above the Glen Dean limestone.

the Middle Fork of Anderson Creek above Bristow to Doolittle in Perry County. It stands out frequently as a sandstone wall 25 or 30 feet high along Anderson Creek northward from the mouth of Sigler Creek east of Siberia. It is well developed north of the Southern Railway and south of the Patoka River. It probably does not extend beyond the Patoka River, as the Mansfield sandstone comes down below its horizon.

This sandstone may be differentiated easily from the Tar Springs sandstone below it in the ravines about Wickcliff in northwestern Craw-

ford County. Here it is separated from the massively developed Tar Springs by some 30 feet of dark, sandy and olive shale. In the small creek leading south from Uniontown to Middle Fork of Anderson Creek, it is well developed. Its upper surface is exposed in the creek bed for 100 yards or more, ending in a waterfall where the great joint-controlled blocks of quartzitic sandstone have tumbled down into the deeply cut valley below. (Fig. 3.) Below it occur some 50 or 60 feet of shales with a few thin bands of yellow limestone. This shale overlies the Tar Springs sandstone which shows up conspicuously along Middle Fork in the locality. Everywhere this sandstone is separated from the Tar Springs sandstone by shale which usually is 50 or 60 feet thick. It varies from 20 to over 100 feet in thickness. In the area of its occurrence north of the latitude of Bristow and Branchville it is a persistent horizon. It was observed in but few places south of Bristow or Branchville. Unlike the Tar Springs sandstone, its upper surface is at a uniform structural level, and it makes a dependable horizon for structure determination.

It is a question which the writer wishes to leave open whether this sandstone should receive a distinct name, say the *Wickliff sandstone*, or whether it should be considered as a member in the *Tar Springs formation*, which may be defined as extending from the Glen Dean limestone up to the Siberia limestone or its horizon. It is not an outstanding and readily recognizable unit or horizon in the southern two-thirds of Perry County. The Tar Springs sandstone also is notably absent in many localities, but where present it is very prominent. It may give its name to the entire unit between the Glen Dean and the Siberia limestones. The procedure adopted in this paper is to refer to the standstone units individually, and the name Wickcliff sandstone is here used.

Siberia Limestone.—The name Siberia was proposed by the writer[5] for a limestone in the upper Chester which appears to represent a rather wide-spread and persistent horizon. It appears beneath the Mansfield sandstone in the latitude of Schnellville and Wickcliff in DuBois and Crawford counties and extends beyond the Ohio River in Breckenridge County, Kentucky. It is well represented in a few exposures in the vicinity of Siberia, Perry County, where it was first observed to occur. It is usually thin, but in some sections attains a thickness of 10 to 20 feet. It is a coarse, crystalline limestone, carrying numerous fossils. It is laminated or cross-bedded on weathered faces. Frequently it is quite silicious. It may be bedded, but usually it occurs as a single ledge in soft shale. It is rarely seen in place. It has the habit of appearing on the shale slopes as slabs or blocks which have slipped out from the buried ledge beneath the mantle rock. Below it occurs a rather persistent yellow limestone ledge which frequently contains fossils. This yellow ledge may be considered a part of it, though it is usually separated from the main ledge by a few feet of shale. The Siberia limestone normally is 175 feet above the Glen Dean limestone.

[5] Science, N. S., Vol. 51, 1920, pp. 521-522.

The Siberia limestone is three feet thick in a ravine one-half mile northeast of Siberia; five feet thick in the J. Schilling quarry two and one-half miles southeast of Siberia (fig. 4); near Doolittle it is three

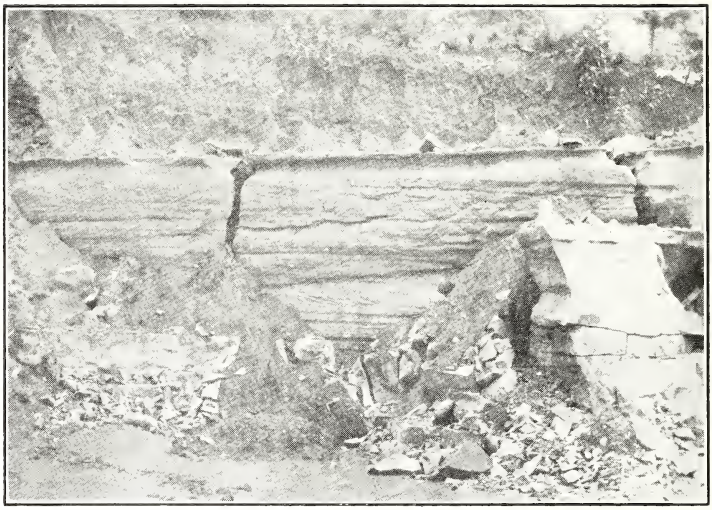


Fig. 4. View of the Siberia limestone in the locality of its type section, J. Schilling quarry, 2½ miles southeast of Siberia, Perry County. This limestone is 175 feet above the Glen Dean limestone. It is quite fossiliferous, and may be identified over wide areas in Perry County, Ind., and Breckinridge County, Ky. Good exposures of it in place are not common.

feet thick; and about Birdseye it is from 3 to 20 feet thick. It is especially well developed along Lick Creek for some three miles north of Birdseye, where the thicker outcrops occur. About one-half mile southeast of Schnellville it is 15 feet thick. It does not occur north of Schnellville, as the Mansfield sandstone occupies its horizon. Near Branchville it is five feet thick. Southward it is thin, ranging from a few inches to two feet. It may be identified in a number of sections in the southern part of Perry County by virtue of being fossil bearing, whereas other thin limestones in the upper Chester are barren of fossils. Exceptions occur, however.

Bristow Sandstone. The Bristow sandstone is a thin to massive sandstone which occurs in the upper Chester shales about 210 feet above the Glen Dean limestone. The name Bristow is proposed for it from the village of Bristow in the valley of Middle Fork of Anderson Creek, Perry County. The sandstone here is massive, somewhat softer than usual, fine-grained, and about 15 feet thick. It outcrops on the valley sides a short distance above the valley floor and is excellently exposed within the limits of the village. (Fig. 5.) The Bristow sandstone is usually three to seven feet thick, consisting of one or more layers which well resist weathering and water wear. The sandstone is fine-grained and hard, often being quartzitic in character. It is well jointed and

blocks of it slump down the hillsides. It frequently gives rise to benches on the hillsides and to waterfalls in the beds of small streams. Figure 6 shows a typical waterfall cliff in a stream-bed, which the hard Bristow sandstone is responsible for.

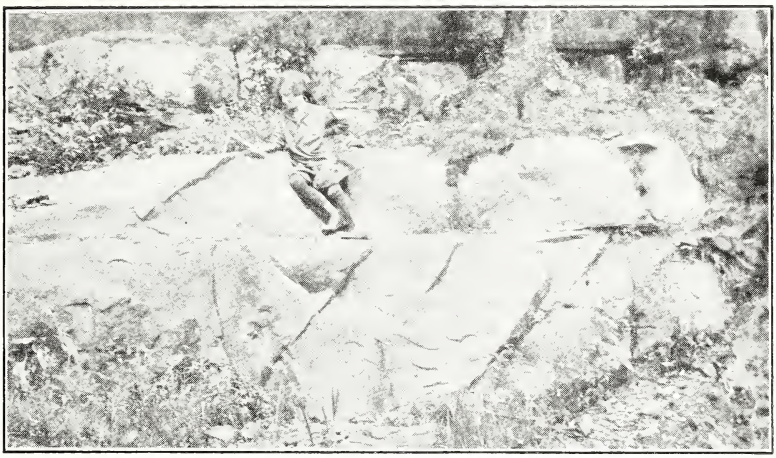


Fig. 5. View of the Bristow sandstone at its type locality in the valley side of Anderson Creek at Bristow, Perry County. The sandstone is 15 feet thick here.

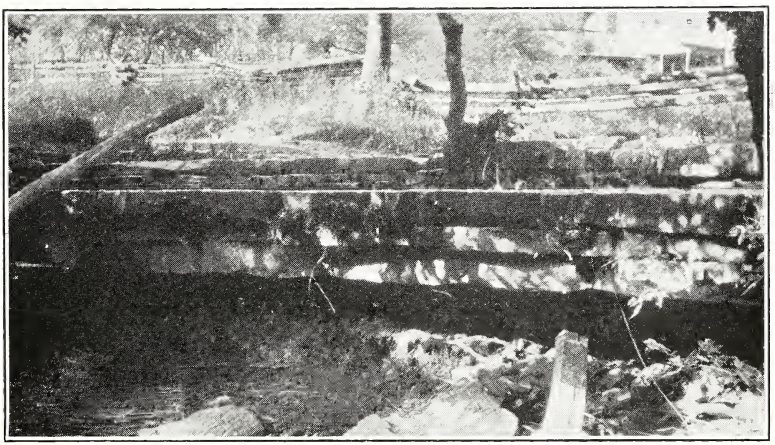


Fig. 6. View of the quartzitic phase of the Bristow sandstone in the bed of a small stream at the roadside one-half mile north of Bandon, Perry County. The Bristow sandstone almost invariably gives rise to small waterfalls in the beds of small streams. This view is typical. The Bristow sandstone makes an excellent structural horizon.

Of all horizons of the upper Chester in Perry County, the Bristow sandstone is most frequently found. It shows in the majority of sections taken which encompass its horizon from the Ohio River northward to the limits of its extension near the northern boundary of Perry

County. In places it thickens into a massive sandstone which stands in wall-like form on the valley sides, but no thickness greater than 25 feet has been observed.

Mt. Pleasant Sandstone. The Mt. Pleasant sandstone is a sandstone very similar to the Bristow sandstone 35 feet below it, but it is usually thicker and is less regular in its characteristics. It is rarely absent in well exposed sections, but in some localities it becomes a sandy limestone breccia. It consists of one or more beds and in places some of the lower beds are separated by the shale. It is quite hard or quartzitic in character, especially its upper ledges where more than one occurs. Its upper surface may serve as an excellent horizon for structural determinations. It is approximately 245 feet above the Glen Dean limestone. It frequently gives rise to local structural flats where it is the uppermost formation between the deeply set valleys of Perry County. Mt. Pleasant, in the middle northeastern part of Perry County, is located on a structural plain of considerable area, and it is from the development of the sandstone here that it receives the name Mt. Pleas-

Fig. 7. View of the hard, quartzitic Mt. Pleasant sandstone, Jones Hill, east of the mouth of Deer Creek, four miles east of Cannelton, Perry County. The upper surface of this sandstone is normally 245 feet above the Glen Dean limestone, and makes an excellent structural horizon.

ant. Its thickness varies from 2 to 35 feet. It extends from near the latitude of Branchville and Bristow in Perry County southward beyond the Ohio River into Kentucky. Its northern extension is limited by the unconformity of the Mississippian-Pennsylvanian contact. Figures 7 and 8 show its two most characteristic outcropping phases.

Negli Creek Limestone. The uppermost formation of the upper Chester in Indiana is the Negli Creek limestone, a limestone ranging from 2 to 20 feet in thickness and occurring at or near the base of the

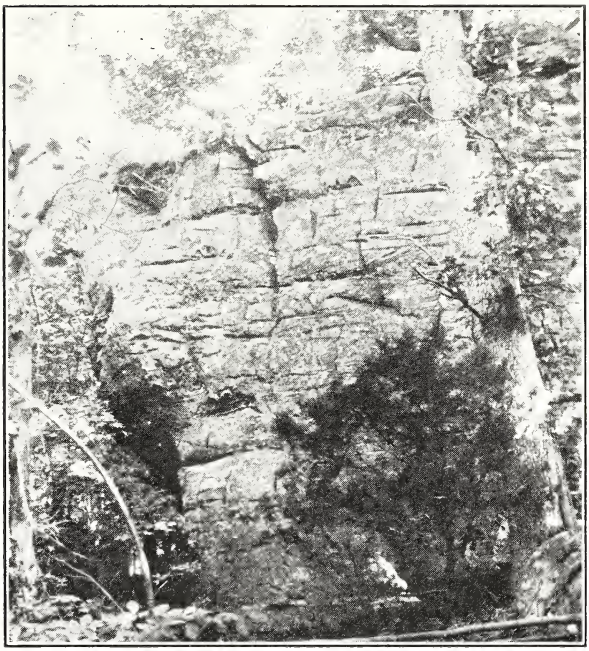


Fig. 8. View of the massively developed Mt. Pleasant sandstone on the Rickert place, near the top of Shank Hill, two and one-half miles northwest of Rome, Perry County. The sandstone here reaches a maximum of 35 feet in thickness. Less than one-fourth mile west it is but five feet thick.

Fig. 9. View of an outcrop of the Negli Creek limestone, Jones Hill, east of the mouth of Deer Creek, four miles east of Cannelton, Perry County. The Negli Creek limestone is the uppermost member of the Chester series in Indiana. It is normally 280 feet above the Glen Dean limestone.

Mansfield sandstone in the southern part of Perry County. This limestone receives its name from its excellent exposures along Negli Creek, a tributary of Little Deer Creek, four or five miles east of Tell City, Perry County. Here it attains a thickness of about 15 feet, thick enough to have small caves in it. It is usually quite massive, but on its weathered faces bedding is well brought out. The beds are from a few inches to a few feet thick. The bedding planes are irregular, giving the surfaces of the bed an uneven appearance. (Figs. 9 and 10.) In color

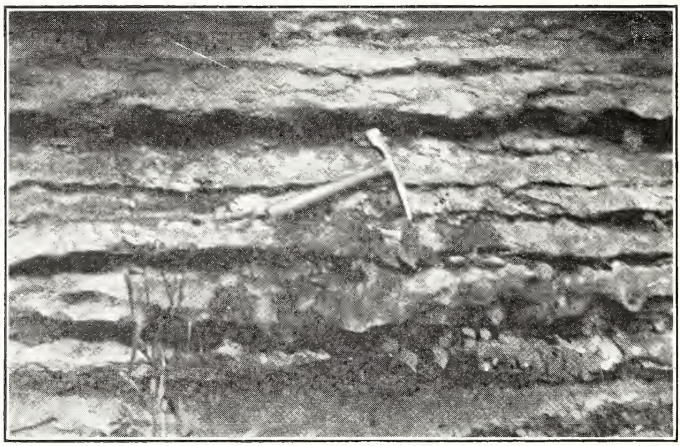


Fig. 10. Near view of the Negli Creek limestone, showing the uneven bedding planes in the weathered face of an exposure at Jones Hill, four miles east of Cannelton.

it ranges from a rusty yellow to white or dove color. It is quite fossiliferous, containing many conspicuous spirifers and many bryozoans. Its weathered surfaces are characterized by a coral colony from an inch to several inches across, and of a hemi-globular shape with concentric structure. It is probably a *Chaetetes*.

In addition to its exposure along Negli Creek, it is well exposed along the south side of Caney Creek to the south, and at various places along the valley sides of the Deer Creeks as far north as the latitude of Gerald. At a number of places along the lower parts of the Deer Creeks it is exposed where it has been taken out for macadam road construction. In other areas its outcrops are rather scarce, as it is at or near the base of the Mansfield sandstone, and is either absent or covered with talus from the massive Mansfield. It was noted to occur in a small locality about one mile northwest of Leopold, not far from the center of Perry County. This isolated occurrence is several miles north of the plentiful exposures in the southern part of the county. Its horizon is approximately 280 feet above the Glen Dean limestone.

SOME DETAILS OF THE UPPER CHESTER.

The character of the upper Chester stratigraphy may best be given by means of a number of detailed sections. Sixteen sections are given below which represent the upper Chester in Indiana. The locations of

the sections are given descriptively, and the sketch map, figure 11, has been prepared to serve as an aid in depicting the locations. Each section is numbered and its location on the sketch map is shown by a dot accompanied by the number of the section. Where possible the sections are given names in terms of the local geography.

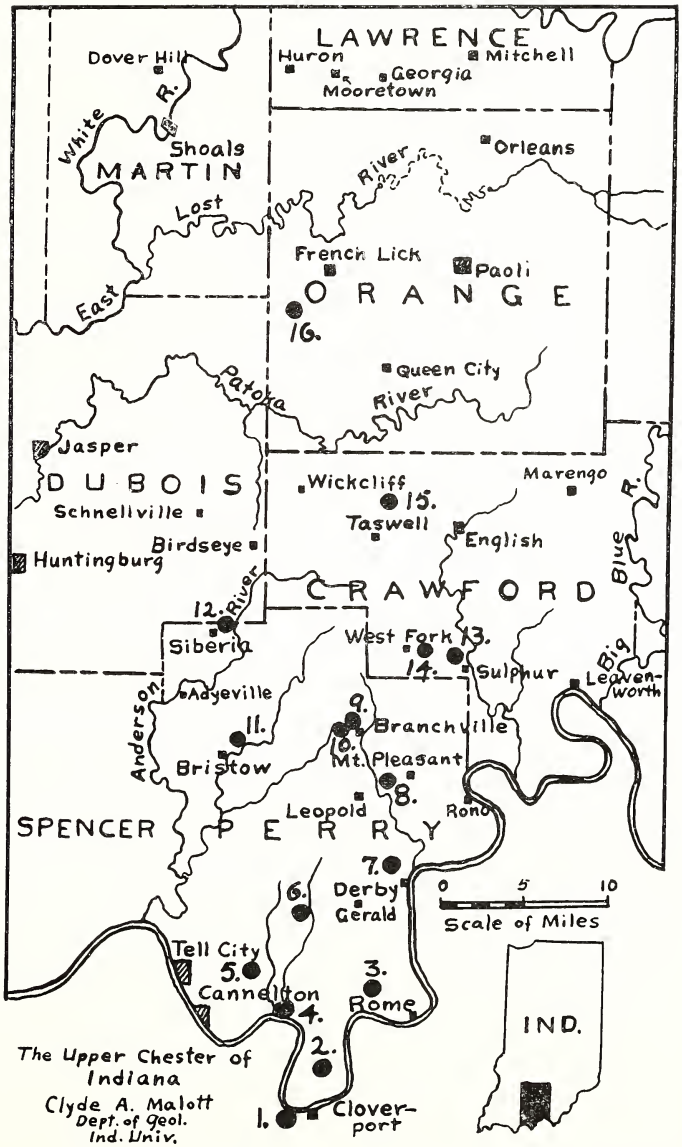


Fig. 11. Sketch map of Perry, Crawford, Orange and parts of adjacent counties, Indiana, showing locations by dot and number of sections obtained from the Upper Chester and given in full in the text.

Perhaps one of the best sections obtained is from the Buffalo Wallow locality, one and one-half miles west of Cloverport, Kentucky. This section is as follows:

Section No. 1. Buffalo Wallow locality, about one and one-half miles west of Cloverport, Ky., adjacent to the Ohio River, Kentucky side.

Mansfield sandstone, 15 feet deep, at top of hill.

		Feet
30.	Shale, blue-gray	5
29.	*Negli Creek limestone*, weathered slabby	2
28.	Covered	10
27.	Shale, light blue	15
26.	Shale, light green	3
25.	Shale, maroon	4
24.	Shale, olive	21
23.	*Mt. Pleasant* (*sandstone*), sandy limestone breccia	5
22.	Shale, shows of	12
21.	Limestone, yellow	1
20.	Shale, light blue	2
19.	*Bristow sandstone*, quartzitic, thins out	0-4
18.	Shale, light blue	8
17.	Limestone, white, weathers into small fragments	2
16.	Shale, calcareous or marl-like	1
15.	Limestone, white and hard	1
14.	Shale, calcareous or marl-like	1
13.	Shale, light	2
12.	Limestone, yellow	2
11.	Shale, light	6
10.	*Siberia limestone*, white and fossiliferous	1½
9.	Shale, shows of	33½
8.	*Wickcliff sandstone*, quartzitic	4
7.	Shale, shows of	21
6.	Sandstone, calcareous, suggestion of chert	1½
5.	Shale, shows of bluish	12
4.	Limestone, coarse, fossiliferous	1½
3.	Shale, sandy	5
2.	*Tar Springs sandstone*, massive, cross-bedded, wall-like along river bluff, waterfalls in ravines	60
1.	Covered	20

Glen Dean limestone, 25 feet, from low water of the Ohio River.

Total thickness of upper Chester ..... 267 feet.

The entire thickness of the upper Chester here is somewhat less than the normal, but every one of the outstanding units described in this paper may be identified, and the shale intervals separating them are nearly normal. The Tar Springs sandstone is excellently developed, standing as a great wall above the Ohio valley floor. Above it occurs the great shale bulk which Butts has selected as the type section for his

"Buffalo Wallow formation."[6] Butts regards the upper Chester above the Tar Springs sandstone as a unit. He recognizes the thin limestone, given as No. 4 in the section, as being rather persistent in occurrence in Breckinridge County, attaining a thickness as great as 15 or 20 feet. He believes it to be representative of the Menard limestone of southern Illinois. This limestone has been observed at a number of places in Perry County, but not with such regularity as to warrant its inclusion as an outstanding unit. Butts calls attention to a very fossiliferous and persistent limestone occurring from 70 to 90 feet above the Tar Springs sandstone. This is probably No. 10 of the section. The writer recognizes it as the Siberia limestone. Here it is 75 feet above the Tar Springs sandstone and 155 feet above the Glen Dean. Butts also calls attention to the limestone conglomerate, No. 23 of the section. This is regarded by the writer as representative of the Mt. Pleasant sandstone. In the Miller Hill section, No. 6 given below, the same horizon is represented by a conglomerate. Also in a few other localities, notably in the vicinity of Terry, Perry County, the Mt. Pleasant sandstone horizon is represented by a limestone conglomerate. Again Butts notes a limestone occurring at or near the top of his "Buffalo Wallow formation," which is probably the Negli Creek limestone. This same limestone is present in the Buffalo Wallow section, given as No. 29. Its presence here was not noted by Butts. It is a white or dove-colored limestone, and has on its weathered surfaces the hemi-globular coral colonies which are so characteristic of the Negli Creek limestone.

The Peach Hill section, No. 2, three miles northwest of the Buffalo Wallow section offers some contrasting features, especially with respect to the Tar Springs sandstone. This section is as follows:

Section No. 2. Peach Hill composite section, up Ohio River valley side from flood-plain to top of Peach Hill, two miles northeast of Tobinsport, Perry County.

Top of hill.
Covered with Tertiary gravels (Lafayette), 40 feet.

		Feet
31.	*Negli Creek limestone*, hard, gray, fossiliferous	7
30.	Shale, green	2
29.	Limestone, yellow	1
28.	Shale, light olive	12
27.	*Mt. Pleasant sandstone*, upper half, cross-bedded, ripple-marked and micaceous; lower half, hard and massive, forming a waterfall ledge	18
26.	Shale, shows of light	19
25.	Limestone, yellow	1
24.	Shale, light	5
23.	*Bristow sandstone*, quartzitic, waterfall ledge, lower part thin bedded	5

[6] Butts, Chas., Mississippian Formations of Western Kentucky, Ky. Geol. Surv., 1917, pp. 112-116.

22.	Shale, bluish	6
21.	Sandstone, impure	1
20.	Shale, bluish	9
19.	Limestone, yellow	2
18.	Shale, shows of light and bluish	37
17.	Limestone, hard gray, with shale parting	5
16.	Shale, green	3
15.	Limestone, yellow	1
14.	Shale, light	7
13.	Limestone, yellow	2
12.	Shale, light	18
11.	Limestone, hard gray	2
10.	Shale, light	3
9.	Limestone, impure	2
8.	Shale, shows of light to bluish	55
7.	Shale, light and maroon	10
6.	Sandstone, quartzitic, fine grained	4
5.	Shale, light to bluish	11
4.	Limestone, fossiliferous	1
3.	Shale, light to bluish	9
2.	Shale with thin bands of yellow limestone	6
1.	Shale, light	10

Glen Dean limestone, 30 feet.
Flood-plain of Ohio River.

Total thickness of upper Chester present .....274 feet.

The Tar Springs fails almost entirely. The four-foot quartzitic ledge 41 feet above the Glen Dean is its sole representative, and in itself would never be recognized as the Tar Springs. Neither the Wickcliff sandstone nor the Siberia limestone show in the section. The Bristow sandstone is typically represented and the Mt. Pleasant sandstone is more than its usual thickness. The Negli Creek limestone is excellently represented. In a section down a ravine southeast from the top of Peach Hill, the Tar Springs sandstone is 35 feet thick, consisting of laminated and shelly sandstone, its base being 35 feet above the Glen Dean limestone. The Siberia may be identified in five feet of hard blue and gray limestone separated from the Bristow sandstone above by 18 feet of bluish shale.

Farther to the northeast the Shank Hill section shows the following strata:

Section No. 3. Shank Hill composite section, along road and nearby, 2½ miles northwest of Rome, Perry County.

		Feet
24.	*Mt. Pleasant sandstone*, very massive, overhanging cliff in places about brow of hill, at Rickert's "dripping spring"..	35
23.	Covered	10
22.	*Bristow sandstone*, quartzitic ledge at top three feet thick, seven feet of shelly and flaggy sandstone at bottom.....	10

21.	Shale, bluish	5
20.	Limestone, yellow	1
19.	Shale, light	9
18.	Limestone, white	2
17.	Shale, bluish	12
16.	Limestone, white	1
15.	Shale, green	2
14.	Limestone, white	1
13.	Shale, light	2
12.	Limestone, yellow	1
11.	Shale, light	3
10.	Limestone, yellow	1
9.	Shale, light and bluish	45
8.	Limestone, yellow	1
7.	Shale, blue and green	34
6.	Limestone, hard gray	5
5.	Shale, blue and green	25
4.	Limestone, shelly, silicious	5
3.	Shale, blue and green	30
2.	Limestone, shelly, silicious	1
1.	Shale, blue	4

Glen Dean limestone, 30 feet.
Foot of hill.

Total thickness of upper Chester represented .....245 feet.

Here only the Bristow and Mt. Pleasant sandstones may be identified. No sandstone at all occurs between the Glen Dean and the Bristow. Some rather heavy limestones in the great bulk of shale are within the horizon normally occupied by the Tar Springs sandstone. The Bristow is but little thicker than usual, and its upper quartzitic ledge shows as a pavement at the top of the hill. The Mt. Pleasant sandstone shows in the road a little west of the top of the hill, but it is best exposed about the hill on either side. Here it attains its maximum known thickness in Indiana, being 35 feet thick and without bedding. (Fig. 8.) In less than one-quarter mile west of this locally developed great thickness it has thinned down to a quartzitic ledge only five feet thick. It appears that its upper surface retains its normal position, and that the increased thickness comes in below at the expense of the shale interval between it and the Bristow sandstone. One-half mile west of the section the Negli Creek limestone is present in the Cannelton-Rome road, where it is two feet thick.

The section at Jones Hill near the mouth of Deer Creek is interesting because of the excellent development of the Mt. Pleasant sandstone and the Negli Creek limestone. The section is as follows:

Section No. 4. Jones Hill, just east of the mouth of Deer Creek, five miles east of Cannelton, Perry County.

Covered slope to top of hill, shows of sandy shale and shelly sandstone, probably Mansfield, 35 feet.

		Feet
14.	*Negli Creek limestone*, nodular and irregular bedding planes on weathered face, massive where fresh	10
13.	Shale, light blue	15
12.	*Mt. Pleasant sandstone*, in part quartzitic	5
11.	Sandstone and shale, bedded and shelly, Mt. Pleasant	8
10.	Covered, great blocks of Mt. Pleasant sandstone and some shows of shale	12
9.	Shale, light blue	10
8.	Covered	25
7.	Shale, light blue	35
6.	Shale and thin beds of limestone	10
5.	Shale, light blue	8
4.	Limestone	1
3.	Shale, light blue	14
2.	Shale and thin limestone layers	5
1.	Shale, light blue	10

Valley floor of Deer Creek and Ohio River.

Total upper Chester exposed .....168 feet.

The Mt. Pleasant sandstone here stands out conspicuously 140 feet or more above the valley floor of the Ohio River. (Fig. 7.) It ranges from 3 to 12 feet in thickness in the 300 yards of its continuous exposure along the brow of the hill. Great joint-controlled blocks of the heavy quartzitic sandstone have tumbled and migrated down the steep slope. Some of them lie flat and others stand spectacularly on end. They are conspicious down the slope to the very floor of the valley. About 300 yards back from the spur-point of the hill may be seen a number of blocks of the Negli Creek limestone which have slid down from their true stratigraphic position. These blocks of limestone show the typical weathered faces of the Negli Creek limestone. The views shown in figures 9 and 10 were obtained here. This section is further interesting because of the contrast with the strata at the same level on the other side of Deer Creek one mile west. The Mansfield sandstone over 150 feet thick comes down to the very floor of the valley or even lower. A fault of 150 to 200 feet occurs between the two sides of the valley, extending in a north-south direction across the Ohio River and parallel with Deer Creek valley. It is only one of the series of faults which occur in the locality.

The uppermost Chester strata along Negli Creek are given in the following section. This is the type section of the Negli Creek limestone.

Section No. 5. Type section of the Negli Creek limestone, on the west side of Negli Creek, NW. quarter of Sec. 36, T. 6 S., R. 3 W., four and one-half miles east of Tell City, Perry County.

Mansfield sandstone, 100 feet or more.

		Feet
5.	Covered, probably shale	10
4.	*Negli Creek limestone*, consists of one ledge with imperfect, nodular or wavy bedding planes on weathered surfaces and on fresh faces appears massive	12
3.	Shale, bluish	23
2.	*Mt. Pleasant sandstone*, hard, weathers out and slides into creek bed in great blocks	7
1.	Shale, bluish, somewhat sandy	8

Bed of Negli Creek.

Total upper Chester exposed .....50 feet.

The Miller Hill section, No. 6, shows the upper part of the upper Chester, beginning at the bottom near the horizon of the Wickcliff sandstone. The Siberia, Bristow, Mt. Pleasant and Negli Creek units are present in the section with the intervals of shale separating them about normal in thickness. The section is as follows:

Section No. 6. Miller Hill, west side of Deer Creek valley, NE. quarter of 16, T. 6 S., R. 2 W., about nine miles northeast of Tell City, Perry County.

Covered slope and Mansfield sandstone.

		Feet
22.	*Negli Creek limestone*, a single ledge with imperfect wavy bedding planes on weathered faces	7
21.	Shale, greenish	14
20.	Shale, maroon	4
19.	Shale, greenish	10
18.	*Mt. Pleasant* (*sandstone*), a calcareous sandy conglomerate, fossiliferous	3
17.	Shale, light	8
16.	Limestone, yellow, weathers shelly or into laminas	2½
15.	Shale, light	1
14.	Limestone, yellow	2
13.	Shale, green and blue	13½
12.	*Bristow sandstone*, shelly	2
11.	Shale, bluish	18
10.	Sandstone, shelly	2
9.	Shale light green and bluish	22
8.	*Siberia limestone*, white, fossiliferous	2
7.	Shale, bluish	3
6.	Limestone, white	1
5.	Shale and yellow limestone layers	13
4.	Sandstone, shelly or laminated	2
3.	Shale	2
2.	Limestone, yellow	1
1.	Shale, light	2

Valley floor of Deer Creek.

Total upper Chester exposed in section.....135 feet.

It is to be noted that the Mt. Pleasant here is a limestone conglomerate similar to that shown in the Buffalo Wallow section. Across the valley the Mt. Pleasant is present in its normal sandstone phase and is about 10 feet thick. The Bristow sandstone is poorly developed in the section.

Excellent sections may be obtained of the middle and upper Chester in the vicinity of Derby. The boat landing at Derby is a broad platform of Beech Creek limestone which extends for about one-half mile along the river. The various members of the middle Chester stand out along the river bluff, the top being capped by 15 or 20 feet of Tar Springs sandstone, the base of which is about 35 feet above the Glen Dean limestone. At Koohns Hill, 1 mile northwest of Derby, is an excellent section of the upper Chester, as follows:

Section No. 7. Koohns Hill, roadway one mile northwest of Derby, Perry County.

Covered slope and Mansfield sandstone to top of hill, 30 feet.

		Feet
28.	*Bristow sandstone*, consisting of an upper ledge of quartzitic sandstone three and one-half feet thick and a lower ledge of similar sandstone five feet thick, separated by six and one-half feet of shale	15
27.	Shale, blue and green	9
26.	Limestone and sandy shale	2
25.	Shale, greenish	9
24.	Limestone, yellow	2
23.	Shale, sandy	15
22.	Limestone, yellow	1
21.	Shale, light	3
20.	Sandstone, shelly	2
19.	Shale	8
18.	Limestone, yellow	2
17.	Shale	22
16.	Limestone, white	1
15.	Shale	5
14.	Limestone, yellow	2
13.	Shale	22
12.	Limestone, white	1
11.	Shale	9
10.	Limestone layers separated by shale	10
9.	Shale	10
8.	Sandstone, green, calcareous	2
7.	Shale	8
6.	Sandstone, shelly or laminated	5
5.	Shale	10
4.	Limestone, white	2½
3.	Shale	2½
2.	Sandstone, impure, friable	1
1.	Shale, green and blue	54

Glen Dean limestone, 25 feet.

Foot of hill.

Total thickness of upper Chester in section.....235 feet

Here, shale prevails above the Glen Dean for 215 feet. It takes considerable imagination to correlate the five feet of shelly sandstone, No. 6 of the section, 70 feet above the Glen Dean, with the Tar Springs sandstone. The Bristow sandstone is divided into two parts, a rare feature. It is possible that the upper ledge is representative of the Mt. Pleasant instead. Heavy, coarse-grained Mansfield sandstone caps the top of the hill.

Excellent sections with continuous exposures of 250 feet or more may be obtained along Oil Creek northward from Derby. Courcier Hill, on the road between Rono and Mt. Pleasant, exhibits a practically continuous exposure of strata with a total thickness of over 400 feet. It begins at the top of the Beech Creek and ends with the top of the Mt. Pleasant. Elder Hill, near Union Township High School, two and one-half miles southwest of Rono, exhibits but little less. On either side of Oil Creek valley along the Mt. Pleasant-Leopold road excellent sections occur. The one given below is representative of the upper Chester in the Mt. Pleasant locality.

Section No. 8. Mt. Pleasant-Oil Creek section, along the Leopold-Mt. Pleasant road, on the eastern valley-side of Oil Creek, Perry County.

Top of hill or edge of the structural plain one mile west of Mt. Pleasant village.

		Feet
40.	*Mt. Pleasant sandstone*, consisting from bottom up of three feet of shelly sandstone, two feet of shale, four feet of hard sandstone, five feet of sandy shale, and nine feet of hard yellow sandstone, giving rise to a structural plain	23
39.	Shale	2
38.	Limestone, yellow	1
37.	Shale, blue and green	9
36.	*Bristow sandstone*, three feet of quartzitic sandstone overlying seven feet of shelly sandstone	10
35.	Shale, green and blue	8
34.	Limestone, yellow	½
33.	Shale, greenish	6
32.	Shale, bluish	20
31.	Limestone, yellow	2
30.	Shale, green	8
29.	Limestone, yellow	3
28.	Shale, green	5
27.	Limestone, yellow	2
26.	Shale, green	10
25.	Limestone, yellow	1
24.	Shale, green and blue	3

23.	Limestone, yellow	1
22.	Shale, green	3
21.	Limestone, yellow	1
20.	Shale, green	6
19.	Limestone, yellow	2
18.	Shale, green and blue	4
17.	Limestone, yellow	2
16.	Shale, green	3
15.	Limestone, yellow	1
14.	Shale, green	2
13.	Limestone, yellow	½
12.	Shale, blue and green	38
11.	Limestone, hard blue	2
10.	Shale, green	5
9.	Limestone, with much shale	5
8.	Shale, maroon and green	15
7.	Limestone, impure, hard	1
6.	Shale, greenish	8
5.	Shale, sandy	9½
4.	Limestone, impure	1½
3.	Shale, bluish	5
2.	Sandstone, very calcareous (Tar Springs?)	6
1.	Shale, bluish	9

20 feet of Glen Dean limestone.

30 feet of Hardinsburg sandstone.

Valley floor of Oil Creek.

Total thickness of upper Chester present.....244 feet

In the above section 294 feet of Chester strata are exposed, 244 feet of which is upper Chester. Between the Glen Dean limestone and the Bristow sandstone occurs a monotonous succession of greenish shales and thin bands of yellow limestone. The Tar Springs is represented by a very calcareous sandstone six feet thick a few feet above the Glen Dean limestone. Such a sandstone is common in the locality, but in some of the sections obtained it is somewhat thicker and less calcareous. The Mt. Pleasant sandstone contains some shale between the well cemented beds. The total thickness of the formation is not great, but it gives rise to plateau-like upland expanse preserved on its upper surface. The village of Mt. Pleasant is located on this structural flat. Small streams flow over it in shallow valleys and leave it by plunging over waterfall cliffs into deeply cut valleys below.

In the vicinity of Branchville the Tar Springs sandstone is unusually thick and massive. The Abbott Hollow section is typical of the locality. It is as follows:

Section No. 9. Abbott Hollow section one-half mile northwest of Branchville, Perry County.

Covered slope.

		Feet
9.	Shale, light	7
8.	Limestone, hard, fossiliferous	2
7.	Shale and covered	6
6.	*Tar Springs sandstone*, one great single ledge, cross-bedded, honey-combed and fretted surfaces, gives rise to box-canyon of Abbott's Hollow headed by a 60-foot waterfall.	70
5.	Shale, blue, clay-like	5
4.	Limestone, impure	1
3.	Shale, blue	2
2.	Limestone, impure	1
1.	Shale, blue	3

Glen Dean limestone 20 feet.

Here the Tar Springs sandstone is 70 feet thick, and it gives rise to a box-canyon typical of a number of others in the vicinity. The sandstone is very massive, fine-grained, rather friable and in places its surface exhibits beautifully developed honey-comb weathering in association with elaborate cross-bedding. (Fig. 2.)

In the section up the road west of Branchville, about one-fourth mile southwest of Abbot Hollow the Tar Springs sandstone is but 40 feet thick. This section is as follows:

Section No. 10. Branchville section, in road up hill from one-half to three-quarters mile west of Branchville, Perry County.

Top of hill.

		Feet
28.	Shows of shale	15
27.	Shale, light	10
26.	Shale, maroon and reddish	4
25.	Shale, light	6
24.	Sandstone, shelly with thin bands of shale	5
23.	Shale, shows of light	10
22.	*Siberia limestone*, gray, coarse, semi-crystalline, bedded	5
21.	Shale	3
20.	Limestone, hard	1
19.	Shows of light and olive shale	16
18.	Limestone, yellow	2
17.	Shale	3
16.	Limestone, yellow	1
15.	Shale, light, olive and bluish	10
14.	Limestone, yellow	2
13.	Shale, light and olive	10
12.	Limestone, yellow	1
11.	Shale, light and olive	10
10.	Limestone, yellow	½
9.	Shale, light	10
8.	Sandstone, very fine and dense, novaculite	½
7.	Shale, blue, olive and light	35
6.	Limestone, hard, blue, fossiliferous	1
5.	Shale, light	5

4.	*Tar Springs sandstone*, massive, cross-bedded, yellowish to white	40
3.	Shale, bluish	15
2.	Limestone, silicious	2
1.	Shale, bluish	3

Glen Dean limestone, 10 feet or more.

In this section the interval between the Tar Springs sandstone and the Siberia limestone is composed of shale with the usual intercalated impure limestone bands. No suggestion of the Wickcliff sandstone unit is present, but over the ridge in Winding Creek valley, two miles west, the Wickcliff sandstone is excellently developed. It does not show in the Aders Hill section, one and one-half miles northeast of Bristow, though it is present in the locality. The Aders Hill section is as follows:

Section No. 11. Section shown on hillside across the road from Aders residence one and one-half miles northeast of Bristow, Perry County.

Mansfield sandstone, 20 feet.
Shale, 5 feet.
Iron ore, 3 feet.

		Feet
13.	Shale, greenish	9
12.	Limestone, yellow	1
11.	Shale, greenish	2
10.	Limestone, yellow	1
9.	Shale, light	10
8.	*Bristow sandstone*, a single massive ledge, quartzitic	8
7.	Shale, light	27
6.	*Siberia limestone*, gray, semi-crystalline, fossils	3
5.	Shale, bluish	12
4.	Limestone, yellow	1
3.	Shale, light	2
2.	Limestone	1
1.	Shale, bluish	11

Valley floor.

In this section the Mt. Pleasant horizon is taken up by the Mansfield sandstone. The Siberia limestone occurs in a number of ravines in the locality and is about three feet thick. The Bristow sandstone is excellently developed, but is much thinner than at the village of Bristow where it is 15 feet thick. This sandstone continues above the valley floor of Middle Fork of Anderson Creek for about three and one-half miles south of Bristow. Only a few feet of shale occur between it and the massive Mansfield sandstone, and on the west side of the valley the Mansfield in places rests directly on the Bristow or occupies its horizon.

A composite section along the small creek northeast of Siberia is as follows:

Section No. 12. Composite section along and near road about one-half mile northeast of Siberia, Perry County.

Covered slope.

		Feet
11.	*Bristow sandstone*, hard, massive	10
10.	Covered	18
9.	Shale	2
8.	*Siberia limestone*, coarse, silicious, fossiliferous	3
7.	Shale, greenish	12
6.	Limestone, yellow	2
5.	Shale	2
4.	Limestone, yellow	1
3.	Shale, sandy, blue	15
2.	*Wickcliff sandstone*, very hard, massive	10
1.	Covered	15

This is about as far north as the Bristow sandstone has been observed. It is present along Anderson Creek as far southwest as Adyeville, where the dip carries it below the valley level. On the west side of Anderson valley about two and one-half miles south of Siberia, it attains its maximum observed thickness. Here it is 25 feet thick and stands as a massive wall above the valley floor.

The Wickcliff sandstone, shown in the above section, is well developed along main Anderson Creek, and in places is approximately 40 feet thick. Two miles southeast of Birdseye it forms the upper part of the steep valley side, its upper surface giving rise to a sharp shoulder and a bench about 100 feet above the valley floor of Anderson Creek. About 30 feet above it may be seen occasional outcrops of the Siberia limestone from 5 to 10 feet thick. Thick blocks of it occur as they have slipped from position in the shale mass of the slopes. In the Birdseye locality the Mansfield sandstone frequently rests on the Siberia limestone, and in places comes down below its horizon.

Just south of Wickcliff, along the Birdseye road and in a small creek or branch, the upper part of the Tar Springs sandstone gives rise to a cliff 35 feet high. The Tar Springs here is a laminated massive sandstone. It is succeeded by 30 feet of dark sandy and olive shales. Above the shales is the Wickcliff sandstone, consisting of massive cross-bedded sandstone chiefly, though the lower part is well bedded. It appears to be about 35 feet thick. It is followed by about 20 feet of light and olive green shales in which is a ledge of yellow limestone a foot or more in thickness. This limestone apparently is the one which usually occurs beneath the Siberia limestone. The Siberia does not appear to be present, as its northern limits are terminated here by the overlapping Pottsville of the Pennsylvania system.

At "Pilot Knob", eastern Crawford County, four miles south of Marengo, some 50 feet of shale occurs above the Glen Dean limestone, and this shale in the spectacular "Knob" is capped by some 35 feet of coarse, massive Mansfield sandstone. "Indian Ridge," one and one-half miles northwest of Leavenworth, is composed of shale and Tar Springs sandstone, with a total thickness of about 75 feet above the Glen Dean limestone.

An excellent section of the Chester may be obtained up the valley-side west from the bridge across Little Blue River just north of Sulphur. The section begins with the Beaver Bend limestone at the bridge level. The upper part of the section encompasses 85 feet of upper Chester strata, as follows:

Section No. 13. Upper part of west side of valley of Little Blue River, in and near road one-half mile north of Sulphur, Crawford County.

Top of hill.

		Feet
14.	Sandstone, bedded, forming hill crest in road	10
13.	Shale, blue	11
12.	Sandstone, shelly or laminated	3
11.	Shale, light	2
10.	Sandstone, shelly	5
9.	Shale, purple	2
8.	Shale, light and olive	20
7.	Sandstone, flaggy	5
6.	Shale, olive	3
5.	Limestone, silicious	2
4.	Shale	4
3.	Limestone, silicious	2
2.	Sandstone, shelly	5
1.	Shale, blue	11

Glen Dean limestone, 20 feet.

This is essentially a shale section, and is in contrast to a section obtained from a ravine by the side of the road about one-half mile to the west, where 40 feet of massive Tar Springs sandstone rests on 15 feet of shale occurring above the Glen Dean limestone. Again, two miles farther west, just east of West Fork, the Tar Springs sandstone appears to be entirely absent. This section is as follows:

Section No. 14. West Fork section, in road leading east from West Fork, Crawford County.

		Feet
8.	Shale, light, sandy near top	25
7.	Shale, olive	10
6.	Limestone, coarse, silicious	1½
5.	Shale, gray, sandy	5
4.	Limestone, coarse, silicious	3
3.	Shale, light, sandy	10
2.	Limestone, coarse, silicious	1
1.	Shale, olive	9

Glen Dean limestone, 15 feet.

The Tar Springs sandstone is remarkably developed in the Taswell locality. One mile southeast of Taswell, at "Spruce Pine Bluffs," the Tar Springs sandstone rests directly on the Glen Dean, and is 90 feet thick. This is the greatest thickness known for this formation in In-

diana. About three miles north of "Spruce Pine Bluffs" the following section was obtained:

Section No. 15. Section in road and ravine about two and one-half miles north of Taswell and about three miles southwest of Brownstown, Crawford County.

Top of high ridge.

Mansfield sandstone and cover, 35 feet.

		Feet
8.	Shale, greenish, mottled with maroon colorations	15
7.	Sandstone, bedded, part of it friable (Wickcliff?)	5
6.	Shale, green and maroon	20
5.	Shale, light, sandy	10
4.	Sandstone, shelly and flaggy	5
3.	Shale, light and olive, somewhat sandy	20
2.	*Tar Springs sandstone*, massive, somewhat friable, honeycombed and fretted weather surfaces, waterfall and box-canyon	85
1.	Covered	10

Spalls of Glen Dean limestone.

The thickness of the Tar Springs sandstone here rivals that at "Spruce Pine Bluffs." The sandstone, No. 7, of the section, 60 feet above the Tar Springs probably represents the Wickcliff. This section is rather exceptional in the locality, nearly reaching the horizon of the Siberia limestone.

At the Southern Railway tunnel three miles west of English, the Pennsylvania strata rest on shale about 30 feet above the Glen Dean limestone.

North of the Patoka River in southwestern Orange County the Tar Springs sandstone occupies the upper parts of the ridges, though towards the southwestern part of the county the Mansfield sandstone becomes prominent. At Queen City the Tar Springs sandstone is about 35 feet thick, and rests on a shale interval about 15 feet thick above the Glen Dean limestone. At the western end of the Southern Railway tunnel, three miles southwest of French Lick the following section was obtained:

Section No. 16. Section at and near the western end of the Southern Railway tunnel, three miles southwest of French Lick, Orange County.

Mansfield sandstone, 80 feet.

		Feet
3.	*Tar Springs sandstone*, massive, fine-grained	35
2.	Shelly sandstone and shale	3
1.	Shale, sandy	3

Glen Dean limestone, two massive ledges, 12 feet.

Hardinsburg sandstone interval, shale and sandstone, 22 feet.

Railway level.

This is as far north as the upper Chester has been traced and differentiated. It is quite likely that isolated parts of the Tar Springs

sandstone or its equivalent shale horizon may occur in the area between French Lick and Shoals or Dover Hill. At these latter places the Mansfield comes to rest on the Glen Dean limestone or on strata below it.

SUMMARY AND CONCLUSION.

It is shown in this paper that order in stratigraphic succession prevails in the upper Chester of Indiana. This order may best be seen when the Glen Dean limestone below is used as a reference plane. It is shown that a number of individual stratigraphic units within the upper Chester may be recognized from place to place and that they have a specified position. Six units, consisting of four sandstones and two limestones, are recognized, described, named and given definite stratigraphic status. Two of these units had previously been recognized as present, but their detailed characteristics, stratigraphic relationships and limits of distribution were largely unknown. Numerous sections are presented which show the details of rock succession in the many localities represented. The common outstanding units of the sections are given their individual names, thus showing the distribution of the units, their marked charactertistics from place to place, their reliability of occurrence, and their relationships to the strata above and below them.

Butts[7] has described the same group of rocks south of the Ohio River. He divides the upper Chester into two divisions, consisting of the individual Tar Springs sandstone and the aggregate Buffalo Wallow formation. The Tar Springs sandstone is described as a sandstone of varying character, but is not recognized as being absent in any section or locality. The shale interval between it and the Glen Dean limestone below is considered as a part of the Glen Dean formation. The Buffalo Wallow formation is defined as a unit of Mississippian rocks above the Tar Springs sandstone, consisting principally of shales with a subordinate aggregate of limestone and sandstone, the whole formation having a thickness of 150 to 200 feet. Little attempt is made to divide the Buffalo Wallow, though certain strata are noted which may be recognized from place to place. Butts uses the name Buffalo Wallow because the natural sub-divisions present in southern Illinois may not be distinguished northward from Warren County, Ky. He presents faunal evidence to show that they are represented in the Buffalo Wallow shales, but are not distinguished by contrasting lithologic units.

In view of the character of the Tar Springs sandstone in Indiana, the question may be asked: What is the upper limit of the Glen Dean formation when the Tar Springs sandstone is absent? What is the lower limit of the Buffalo Wallow formation when the Tar Springs sandstone is absent? Answers to these questions call for an establishment of stratigraphic horizons which may be projected in

[7] Butts, Chas., The Mississippian Formations of Western Kentucky, Ky. Geol. Surv., 1917.

the local absence of the formation unit which has been used to establish the horizon.

A detailed study of the upper Chester strata, such as that undertaken by the writer before preparing this paper, will show that it is expedient to regard *as a unit* all Mississippian strata above the Glen Dean limestone or above the recognized base of the Tar Springs sandstone or the *horizon* of its base. This unit is composed principally of shales, but it has within it certain outstanding limestones and sandstones, which, by virtue of their fairly persistent characteristics and their general reliability of occurrence in definite stratigraphic positions, become fixed *horizons*, though the limestones and sandstones themselves may be locally absent. The Tar Springs sandstone is a stratigraphic unit sufficiently impressive in character and certain enough in occurrence in a particular stratigraphic position to establish a fixed stratigraphic horizon within a group of rocks to which it belongs. It is evident that Butts in his estimation of the limits of the Glen Dean formation did not use this principle, and as a consequence assigns a thickness of 180 feet to the Glen Dean formation[8] along Caney Creek five miles southeast of Cloverport, Breckenridge County, Ky. The normal thickness of the Glen Dean in this locality is 40 to 50 feet. Butts here includes all the strata above the Glen Dean limestone in the Glen Dean formation as far up as the first sandstone, which in the individual section used is probably the Wickcliff sandstone. He thus includes some 130 or 140 feet of the upper Chester strata with a unit which belongs to the middle Chester.

It may be admitted that the Tar Springs sandstone has a well established horizon at or near the base of the upper Chester. Likewise the Wickcliff sandstone, the Siberia limestone, and the other units described and differentiated in this paper have each their own horizon within the upper Chester. This is a feature which this paper attempts to establish. These units, or their horizons in Indiana, occur above the Glen Dean limestone as follows: Wickcliff sandstone, 140 feet; Siberia limestone, 175 feet; Bristow sandstone, 210 feet; Mt. Pleasant sandstone, 245 feet; and Negli Creek limestone, 280 feet.

It does not appear to the writer that any advantage is gained by applying the name Buffalo Wallow to the aggregate of the upper Chester strata exclusive of the Tar Springs sandstone. The name Buffalo Wallow would have been better used had it included the entire upper Chester, thereby including the Tar Springs sandstone. It would, therefore, serve as a name for the aggregate strata of the upper Chester as expressed in the area north of Warren County, Kentucky, where the individual divisions of the unit do not conform to series in southern Illinois.

This paper should not close without a suggested correlation of the units described and established with those which have been fixed by Weller farther south in Kentucky. Without a careful checking of the strata lying between the Ohio River and the Princeton Quadrangle area, Kentucky, it is somewhat hazardous to attempt such a correlation. With-

[8] Mississippian Formations of Western Kentucky, Ky. Geol. Surv., 1917, p. 98.

out presenting the evidence the writer will merely give his opinion with respect to the probable equivalent strata of the two areas. The Siberia limestone appears to have the same stratigraphic position as the Vienna limestone in southern Illinois and as recently extended eastward as far as Caldwell County, Kentucky, by Weller.[9] The Bristow and the Mt. Pleasant sandstones together appear to be the stratigraphic equivalent of Weller's Waltersburg sandstone as described in the Princeton, Kentucky, Quadrangle. The Negli Creek limestone is likely the equivalent of the Menard limestone of the Illinois Chester. The Menard limestone is recognized as being present in the Princeton, Kentucky, Quadrangle area. The Wickcliff sandstone does not appear to have an equivalent in Kentucky which as yet has been differentiated. It may be no more than a localized development of sandstone.

[9] Weller, Stuart, Geology of the Princeton Quadrangle, Kentucky, Ky. Geol. Surv., Series VI, Vol. X, 1923.