

# THE LATE NIAGARAN STRATA OF WEST TENNESSEE.

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Probably nowhere in America is a more complete and better exposed section of Niagaran strata than that shown along the Paleozoic geanticline of West Tennessee. This section is well exposed along the Tennessee River and its tributaries, but the many fine fossils that have made this classic ground for the paleontologist have come almost entirely from the conspicuous white-capped, rounded hills or "glades" scattered through portions of Decatur, Perry, Wayne, and Hardin counties. A portion of this Niagaran section contains rather thick beds of white clays and clayey limestones, which weather into soils unfavorable to the growth of much vegetation. Therefore, when these particular strata happen to occupy the top of the hills or are exposed along their slopes, spaces almost entirely barren of vegetation occur in otherwise well-wooded areas, and because of their white clayey soil, such bare spots or glades, as they are locally known, are visible for considerable distances. The strata whose disintegration primarily gave rise to these spots are usually very fossiliferous. In process of erosion the fossils are left behind, so that in the course of time most of the glades become ideal collecting grounds. Indeed, fossils are sometimes so abundant on the glades that specimens can be shoveled up literally by the bushel measure.

Despite the fine fossils and good sections afforded by the area, comparatively little has been done on its paleontology, and but one writer has published on its stratigraphy in any detail. The present contribution is based upon several short seasons of study and collecting by Mr. Pate, and upon a joint study of the rocks by both authors during two weeks of the summer of 1907. Much of the senior

author's time was devoted to collecting the echinoderm fauna of the area for Mr. Frank Springer, but, in tracing the various crinoid horizons, an exceptional opportunity was afforded to study the stratigraphy in detail. This collecting resulted in the addition of many new species to the already considerable crinoid fauna and in the discovery of material affording new data concerning the described forms. These crinoids are at present being studied by Mr. Springer, who expects to publish a special monograph upon them in the near future. Besides the study of the stratigraphy with Mr. Pate, the junior author paid particular attention to the collection of the other classes of fossils, so, by a combination of efforts, it is hoped to add something to the knowledge of the region. Practically all of the echinoderms found on these various trips are a part of the Springer collection, while all of the remaining specimens belong to the U. S. National Museum.

In 1847, Roemer visited this glade region and spent about five weeks collecting the fauna. The country was then very sparsely settled, and his efforts were, of necessity probably, confined to Deatur County, in the vicinity of Dixon Spring and Brownsport Landing, where he could secure living accommodations. Practically all the species which in 1860 were described by him in "Die Silurische Fauna des Westlichen Tennessee" were collected on the glades of the locality mentioned. Since Roemer's species have been procured from the same sections and localities by subsequent collectors, there is now no doubt regarding their geologic position. Troost, Safford, Worthen, Wachsmuth, Rominger, and other paleontologists collected on the glades repeatedly, but, aside from the publication of a new species now and then, nothing further has been done upon the paleontology.

The first account of the stratigraphy of these Silurian rocks was given by Professor Safford in 1861,<sup>a</sup> and later in his *Geology of Tennessee*, in 1869, where the Niagaran rocks are subdivided into two nearly equal portions, each about 100 feet thick, a lower or variegated bed and an upper or sponge-bearing bed. The general section presented by Professor Safford, taken from the type locality at Clifton, is as follows:

(2) Meniscus limestone.

(b) Sponge-bearing bed; gray, crinoidal, and argillaceous limestones, many of them glade-forming, highly fossiliferous, containing sparsely thin layers of chert..... 90 feet.

(a) Variegated bed; gray, red, and mottled limestones, interstratified; many layers argillaceous; *Orthocerata* abundant in its lower part. Clifton is located in part upon it..... 96 feet.

Entire thickness of the formation..... 186 feet.

<sup>a</sup>Amer. Jour. Sci. (2), XXXI, pp. 206, 207.

The name *Meniscus* limestone is misleading, since the characterizing sponge, *Astræospongia meniscus*, is found only in the upper or sponge-bearing bed. In 1876 this name was changed to the Clifton limestone by Safford and Killebrew in their *Elementary Geology of Tennessee*.

In 1903, Dr. A. F. Foerste<sup>a</sup> published his valuable paper "Silurian and Devonian Limestones of Western Tennessee," by far the most important contribution to this subject. Doctor Foerste's studies led him to recognize in Safford's Variegated beds the Clinton, Osgood, Laurel, and Waldron formations of the western flank of the Cincinnati geanticline, and at the top of this division two new formations, the Lego limestones and Dixon beds. To Safford's upper member, or sponge-bearing bed, as exposed at Clifton and Brownsport Furnace, Foerste applied the new name Brownsport. Other new names, the Maddox limestone of early Niagaran age, the Glenkirk limestone for a combination of the Laurel, Waldron, and Lego, when these could not be separated, and the Gant bed for an arenaceous limestone phase of a part of these late Niagaran rocks, were instituted. Doctor Foerste's article contains much valuable information, but his arrangements of facts, particularly in the description of sections, is such that it is difficult to assemble his evidence. We are in accord with most of Foerste's work on the lower portion of the Niagaran, and our efforts in this paper are to present a detailed account of the late Niagaran, with particular reference to the Brownsport division. We have made free use of Doctor Foerste's work and wish to acknowledge our indebtedness to his publication.

A study of the stratigraphy of this general area has shown numerous unconformities in strata which are essentially horizontal. The geologic range is from the lowest Trenton to the Mississippian, but the main geologic divisions are seldom conformable. The lowest Trenton is succeeded by the uppermost Cincinnati strata; the Niagaran rocks are followed by Helderbergian strata of New Scotland age, and even in these larger divisions unconformities are noted between their individual members.

Such minor unconformities are indicated in the table of sections on page 428. It may also be noted that, so far as observed, no single locality affords a complete and continuous section of all the Niagaran strata known to occur in the area. For example, at the type-locality, Clifton, in Wayne County, a considerable portion of the late Niagaran is wanting; even at Decaturville, where probably the most complete section of the entire area may be seen, several members are missing. It is, therefore, only by comparing section after section that the complete succession may be determined. The composite section offered on a subsequent page was thus compiled.

<sup>a</sup> *Journal of Geology*, XI, pp. 554-715.

As noted before, our attention was directed more particularly to the Brownsport bed and succeeding strata, or, in general terms, the late Niagaran rocks. These strata have furnished by far the most of the fossils from the glade region, and reference by most authors to the Niagaran fauna of Western Tennessee is not to the Clifton limestone as a whole, but to this particular division. Careful collecting and detailed stratigraphic work has convinced us that the post-Dixon strata of Niagaran age, instead of being a bed of heterogeneous clayey shale and limestone, referable to only one formation, the Brownsport, contains at least four divisions well marked faunally and lithologically, and interesting furthermore because of their unconformable development. Accepting the term Brownsport and defining it as a group, we would propose in addition the following new formations: Beech River, Bob, Lobelville, and Decatur. The several classifications proposed for these rocks may then be tabulated as follows:

*Niagaran strata of West Tennessee.*

		Safford, 1869.	Foerste, 1903.	Pate and Bassler, 1908.	
Niagaran (Clifton).	Meniscus.	{ Sponge bearing bed.   Variegated bed.	Gant.   Brownsport.	Brownsport.	Decatur.
					{Lobelville. {Coral zone. {Bryozoan zone. {Bob. {Conchidium zone. {Dietyonella zone. {Ucinulus zone. {Beech River. {Eucalyptocrinus zone {Troostocrinus zone. {Coccoocrinus zone.
			Dixon. Lego. Waldron. } Glenkirk. Laurel. } Osgood. } Maddox. Clinton. }		Dixon. Lego. Waldron. Laurel. Osgood. Clinton.

SECTIONS.

In order to show the character and occurrence of these divisions, we have thought it best to first give detailed sections at (1) the type locality of the Clifton limestone, (2) at Brownsport Furnace, whence the Brownsport group derives its name, (3) at Decaturville, and (4) at several other localities where variation from these more complete sections have been noted. The individual formations of the late Niagaran are then discussed, followed by our interpretation of the complete section of the area, constructed from the various localities studied. Finally the occurrence of the same faunas in areas other than West Tennessee, is noted.

## CLIFTON, TENNESSEE.

The section at Clifton is well exposed along the river bank, the lowest beds being shown north and south of the old cement mill, where a fault brings the Middle Ordovician Hermitage limestone in contact with the Dixon. Proceeding southward from this point, the Dixon and overlying formations are well exposed; northward along the river bank and then along the slope of the hill back of Clifton, the entire section can be made out in more or less detail. The Waldron, with its typical fauna, is well shown along the river bank about one-fourth of a mile south of the cement mill and also in the town of Clifton itself. The following section is a combination of these several exposures. In this, as well as in the following sections, the strata are arranged under the formations and subdivisions recognized by us, and described more in detail on succeeding pages.

*Section at Clifton, Wayne County, Tennessee.*

Gravel beds.

Silurian (Niagaran).

## 10. Beech River formation.

Feet.

*c.* Eucalyptocrinus zone. Dark blue shales with many cherty layers. Fossils abundant----- 36½

*b.* Troostocrinus zone. Blue shales and limestones holding *Troostocrinus* and associated fossils and arranged as follows:

5. Limestone layer----- 1

4. Blue shale----- 13

3. Compact limestone----- 2

2. Blue shale----- 18

1. Compact limestone in layers varying from 1 to 6 inches in thickness----- 5

*a.* Coccoerinus zone:

5. Blue shales with thin beds of nodular cherty limestone----- 6½

4. Blue shales with four or more well defined chert bands 1 to 2 inches thick----- 3

3. Blue shales free from chert, irregularly developed. 0-7

2. Grayish white crinoidal limestone with a purplish tinge when freshly broken----- 6½

1. Blue shales weathering white upon exposure----- 2

## 9. Dixon formation.

Red shales and clayey limestones with occasional layers of white argillaceous limestones. *Fistulipora hemispherica* rather abundant----- 44

## 8. Lego limestone.

*b.* Compact gray limestone with layers of reddish, more argillaceous rock----- 14½

*a.* Compact, white, massive limestone----- 31½

## 7. Waldron shale.

White indurated clay and white argillaceous limestones with the typical Waldron fauna, among the species being



	Feet.
<i>Eucalyptocrinus magnus</i> , <i>E. clrodi</i> , <i>Stephanocrinus gemmiformis</i> , <i>Dictyonella reticulata</i> , <i>Meristina maria</i> , <i>Homospira crax</i> , <i>Nucleospira pisiformis</i> , <i>Anastrophia internascens</i> , <i>Leptana rhomboidalis</i> , <i>Rhipidomella hybrida</i> , <i>Callopora elegantula</i> , etc -----	3
6. Laurel limestone. Massive, reddish purple argillaceous and subcrystalline limestone -----	25
5. Osgood limestone. Thin-bedded reddish argillaceous limestone holding <i>Stephanocrinus osgoodensis</i> and typical <i>Caryocrinus ornatus</i> -----	14
4. "Clinton" formation. <sup>a</sup> White to light brown crystalline fossiliferous limestone with greenish brown chert. This layer has yielded the following fossils: <i>Leptana rhomboidalis</i> , <i>Dalmanella elegantula</i> , <i>Platystrophia daytonensis</i> , <i>Orthis flabellites</i> , <i>Cyclonema daytonensis</i> , <i>Illanus daytonensis</i> , <i>Calymene vogdesi</i> , <i>Cyrtoceras subcompressum</i> , <i>Favosites favosus</i> , <i>F. niagarensis</i> , and <i>Halyssites catenulatus</i> -----	1
Ordovician (Cincinnatian).	
3. Fernvale (Richmond) formation. <i>b</i> . Bluish shales with <i>Rhynchotrema capax</i> , <i>Dinorthis subquadrata</i> , <i>D. proarvita</i> , and <i>Rhombotrypa quadrata</i> . Mannie clay of Foerste -----	15½
<i>a</i> . Coarse-grained, cross-bedded, light-colored phosphatic limestone with <i>Rhynchotrema capax</i> and <i>Strophomena planodorsata</i> . Leipers limestone. <sup>b</sup> -----	19
2. Arnheim ("Warren") formation. Coarsely crystalline phosphatic limestone weathering into abundant chert fragments. <i>Dinorthis retrorsa</i> , <i>Leptana rhomboidalis</i> , and <i>Rhynchotrema dentatum</i> var., are the most abundant brachiopods, while several species of bryozoa are sometimes so numerous as to fill the entire layer. The lowest layer of this formation is of dark-colored conglomeratic material made up of the casts of <i>Cycloras</i> , and containing large and small fragments of the underlying Hermitage limestone -----	0-3
Ordovician (Mohawkian).	
1. Hermitage ("Saltillo") formation. Bluish-gray, compact argillaceous limestone layers two to five feet thick, alternating with blue shales of equal thickness -----	70+

## BROWNSPORT FURNACE, TENNESSEE.

In the vicinity of Brownsport Furnace two well-marked glades expose a fine section of the various beds belonging to the Beech River, Bob, and Lobelville formations. The red limestones and shales of the Dixon may be seen at the base of the southern glade, while the youngest Paleozoic rocks of the section—the Devonian black shale—were exposed in the hillside northwest of the furnace.

<sup>a</sup>This name is provisionally employed for the western rocks referred to the Clinton by Foerste and others.

<sup>b</sup>Foerste, not Leipers formation, Hayes and Ulrich.

Section at Brownsport Furnace, Decatur County, Tennessee.

Gravel beds.	
Devonian.	Feet.
Chattanooga shale (exposed along hillside northwest of furnace) --	—
Silurian.	
3. Lobelville formation.	
Coral zone. Yellow clays and argillaceous limestones holding an abundant coral fauna. Contains numerous specimens of several species each of <i>Favosites</i> , <i>Heliolites</i> , <i>Cladopora</i> , <i>Cystiphyllum</i> , <i>Arcolites</i> , and <i>Thecia</i> , and <i>Amplexus shumardi</i> -----	20
2. Bob formation.	
d. Somewhat massive argillaceous limestone with few fossils.	15
c. Blue clay and shales with many brachiopods. <i>Meristina maria-rameri</i> , <i>Dictyonella gibbosa</i> , <i>Gypidula rameri</i> , <i>Merista tennesseensis</i> , <i>Uncinulus tennesseensis</i> , and <i>Wilsonia suffordi</i> , and a small form of <i>Atrypa reticularis niagarensis</i> particularly abundant -----	17
b. Thin yellow argillaceous limestone alternating with shale --	4
a. Gray, rather massive limestone containing large examples of <i>Uncinulus stricklandi</i> -----	4
1. Beech River formation.	
c. Eucalyptocrinus zone -----	10
b. Troostocrinus zone -----	24
a. Coccoocrinus zone -----	15
Dixon formation.	
Red argillaceous limestones and shales, exposed at base of southern glade -----	—

DECATURVILLE, TENNESSEE.

The following section is exposed within a radius of 1 mile of Decaturville, and although exposures are numerous, the section as a whole can be observed at no particular place. The lower part of the section is brought up by an immense uplift just east of Decaturville, while the upper formations may be found on the higher land about the town. At Decaturville itself the Decatur limestone is represented by bowlders only, but at Tuck's Mill, 1 mile north of the town, 70 feet of this limestone is present, and, furthermore, its unconformable position upon the Eucalyptocrinus zone of the Beech River formation is excellently shown. At this point, blasting by Mr. Pate in the upper part of the Eucalyptocrinus zone resulted in a large crinoid fauna.

General section in the vicinity of Decaturville, Decatur County, Tennessee.

Gravel beds.	
Devonian.	Feet.
Chattanooga shale -----	0-10
Hardin sandstone -----	0-4
Camden chert -----	4+

	Feet.
Linden formation.	
Bluish shales with bryozoa.....	3
Residual limestone boulders holding <i>Camarocrinus</i> and Helderbergian brachiopods .....	5
Silurian.	
Decatur limestone. Massive, white crinoidal limestone becoming yellow and shaly at the top.....	70
Beech River formation.	
Eucalyptocrinus zone. Bluish shales becoming yellow toward the top.....	20
Troostocrinus zone. Fossiliferous shales varying from blue through yellow to white in order, with a limestone band in the middle part.....	24
Cococrinus zone. Shaly limestone in the upper part and whitish limestone easily disintegrating into clay in the lower.....	25
Dixon formation. Purplish shales in lower part and red crinoidal limestone in upper.....	35
Lego limestone. Grayish limestone with a few red layers.....	30
Waldron shale. Purplish shales with an intermediate layer of white limestone. <i>Mimulus waldronensis</i> and other Waldron fossils noted.	4
Laurel limestone. Pale purple, massive limestone.....	25
Osgood limestone. Massive white crinoidal limestone with a tendency to form cliffs when favorably exposed.....	10
Ordovician.	
Arlheim ("Warren") formation. Coarsely crystalline phosphatic limestone .....	2
Hermitage ("Saltillo") formation. Argillaceous limestone and shale with usual Lower Trenton fossils. This, the lowest rock of the vicinity, is exposed for a distance of a mile along Rushing Creek east of Decaturville.....	50

## LADY'S BLUFF, PERRY COUNTY, TENNESSEE.

This is one of the highest and most beautiful bluffs along the Tennessee River, and furnishes an excellent section of the Niagaran and Helderbergian rocks. Lady's Bluff is on the east side of the Tennessee River, 1 mile below Mousetail and just below the mouth of Lick Creek, in Perry County. In this section, which follows, the absence of the coral beds normally preceding the Decatur limestone is noteworthy.

*Section at Lady's Bluff, Perry County, Tennessee.*

Gravel beds.	
Devonian.	
Linden (Helderbergian) formation.	Feet.
<i>b.</i> Shales with numerous bryozoa and brachiopods.....	3
<i>a.</i> Massive crinoidal limestone with <i>Camarocrinus</i> .....	4
Silurian.	
Decatur limestone. Massive crinoidal limestone, gray, magnesian in upper part and more yellow in lower portion.....	63
Lobelville formation.	
Coral zone wanting.	
Bryozoan zone.	
Light blue soft shale.....	2
White argillaceous limestone.....	2



	Feet.
Blue shale with bryozoa and a few corals.....	1
Purple shale and argillaceous limestone, containing many bryozoa and a few corals.....	17
Bob formation.	
Conchidium zone. Nodular, cherty, crinoidal blue and gray limestone with <i>Conchidium</i> in upper part especially. Other fossils few.....	15
Dictyonella zone. Blue shales with rather numerous brachiopods.....	5
Uncinulus zone. Grayish, cliff forming limestone breaking into large blocks.....	16
Beech River formation.	
Eucalyptocrinus zone. Blue and yellow shales with <i>Eucalyptocrinus</i> and other characteristic fossils. At one point in the near vicinity this bed has thickened to 40 feet.....	20
Troostocrinus zone. Yellow shales and thin white limestone.....	24
Coccoerinus zone. Only topmost layer exposed.....	—

MOUSETAIL, PERRY COUNTY, TENNESSEE.

The local variability of the beds comprised in the late Niagaran is brought out in a comparison of the Lady's Bluff section and that at Mousetail, 1 mile south. The absence of the Bob formation in the Mousetail section is particularly noteworthy.

*Section at Mousetail, Perry County, Tennessee.*

	Feet.
Decatur limestone.	8
Massive gray and white coarsely crystalline limestone with few fossils.....	8
Lobelville formation.	
b. Coral zone. Yellowish clays and thin limestones with numerous specimens of <i>Favosites</i> , <i>Heliolites</i> , and other corals.....	8
a. Bryozoan zone. Soft shales holding many bryozoa and a few corals of the genera <i>Favosites</i> and <i>Heliolites</i> .	
Bluish white shales.....	2
Purplish shales.....	7
Beech River formation.	
c. Eucalyptocrinus zone. Yellowish shales with crinoids and other fossils characteristic of this horizon.....	27
b. Troostocrinus zone. Thin limestone and shales with <i>T. reinwardti</i> , etc.....	45
a. Coccoerinus zone.....	15
Dixon formation.	
Red shales. Top only exposed.....	—

In the remaining sections studied by us the differences in lithology and in fauna were so slight that it was deemed best to arrange these in tabular form. In this table the bottom and top of each section is indicated by the lowest and uppermost figures, or X, while blank spaces within these limits show the absence of formations. The various thicknesses are given in feet when accurately determined, but by X when only noted.

Table of Sections.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Gravel beds.....																							
Chattanooga shale.....	X	X																					
Camden chert.....				X				X															
Linden.....	4																						
Decatur.....	8																						
	70		X		X			16		63	8	X			42	X	6						
Coral zone.....						20		40		22	8	17		45	X		27						X
Bryozoa zone.....			X					29			9			10			31						X
Conchidium zone.....						15			X	15													X
Dictyonella and Ucnimulus zones.....						25			X	21		23	11										X
Eucalyptocrinus zone.....	20	X	X	20	X	10	36½		X	20	27	32	11										X
Troostocrinus zone.....	24	X	X	24	X	24	30		X	24	45	12											X
Coccolocricinus zone.....	25	X	X	30	X	15	25		X	X	15	16											X
Dixon.....	35			X		X	44				X	18											X
Lego.....	30						46																
Waldron.....	4						3																
Laurel.....	25						25																
Osgood.....	10						14																
Clinton.....							1																
Fernvale.....							34½																
Arheim.....	2						3																
Hermitage (Salttillo).....	50						70																

1. Vicinity of Decaturville, Decatur County.
2. Robard's old mill, 2 miles northwest of Decaturville, Decatur County.
3. One mile south of Dixon Sulphur Spring, Decatur County.
4. Big Glade, 2 miles south of Perryville, Decatur County.
5. One and one-half miles southeast of Jeannette, Decatur County.
6. Brownsport Furnace, Decatur County.
7. Clifton, Wayne County.
8. Webb or Rise Mill, Perry County.
9. One mile east of Webb's Landing, Perry County.
10. Lady's Bluff, Perry County.
11. Mousetail, Perry County.
12. Lick Creek, 4½ miles east of Mousetail, Perry County.
13. Beardstown, Perry County.
14. Bridge over river 1 mile north of Lobelville, Perry County.
15. Spring one-half mile north of Lobelville, Perry County.
16. Wolf Creek, on road from Whitfield to Lobelville, Perry County.
17. Peeler's pond, 1 mile north of Whitfield, Hickman County.
18. One-half mile north of Martin's mill, Wayne County.
19. Schoolhouse at Houston, Hickman County.
20. Montgomerie at Houston, Wayne County.
21. Two miles below Craven's old mill, on Indian Creek, Hardin County.
22. Bob, Decatur County.

## POST-DIXON FORMATIONS.

Along the western flank of the Cincinnati axis the Silurian rocks following the Waldron shale are known as the Louisville limestone. In West Tennessee the same interval is occupied by several limestone and shale formations which have been named by Foerste, in ascending order, the Lego limestone, Dixon bed, Brownsport bed, and Gant bed. The Brownsport and Gant beds are the special subjects of this paper.

The term Brownsport was loosely defined. In fact, the name could hardly be considered as defined at all, since practically the only description of these strata given by the author of the name is to the effect that the name Brownsport bed is applied to the richly fossiliferous section overlying the Dixon red clay and containing the fauna studied by Roemer during his visit to Decatur County, Tennessee. In this sense the name would have reference mainly to the crinoid, brachiopod, and coral beds, so conspicuously shown in the section at Brownsport Furnace. Apparently the name was instituted only for convenience of reference, and not as a formational name. In the same article (p. 576) rocks now known to be equivalent to the brachiopod beds of the Brownsport Furnace section are named the Gant bed. The recognition of either or both of these names as formations is thus made questionable, and we were in doubt whether (1) to apply the name Brownsport as a group term to the post-Dixon Niagaran strata as exposed at Brownsport Furnace, (2) to extend the term so as to include all the Niagaran rocks following the Dixon, or (3) to restrict and redefine the formation entirely. After a consideration of all the sections, the first course seemed the wisest.

In the post-Dixon Niagaran interval four well-marked divisions can, we believe, be recognized. The lowest is a series of rather widely distributed, very fossiliferous white clays and thin-bedded limestones furnishing most of the crinoids afforded by the glades; argillaceous limestones and shales, quite similar lithologically to the Dixon but of more local distribution, succeed these white strata, and are overlaid in turn by blue shales bearing great numbers of brachiopods; just above the brachiopod beds are blue shales and cherty limestones in which the great coral fauna so well developed at Louisville, Kentucky, is likewise abundantly represented. In exposures of these strata in Tennessee the corals are sometimes so numerous that the ground is entirely hidden by the specimens. These three formations constitute the Brownsport group as here recognized. Finally, the Niagaran of West Tennessee is closed by a massive white, coarsely crystalline limestone, 70 or more feet thick, which seems to be of considerable extent, especially in the northern half of the area.

## BEECH RIVER FORMATION.

As indicated previously, the lowest beds of the Brownsport group furnish most of the erinoids of the late Niagaran of West Tennessee. To this formation the name Beech River is applied from the conspicuous exposures along Beech River in Decatur County. The weathering of these beds gives rise to the most conspicuous of the West Tennessee glades. Their strata are almost exclusively fine shales of a gray, yellow, or bluish color, but weathering into a white clay. These shales are generally present where their proper place in the section is exposed; indeed, they form the most widely spread division of the late Niagaran. Their fauna is also the best known of any of the Niagaran divisions, probably because most of the well-known erinoids and blastoids from West Tennessee are derived from them. *Coccoerinus bacca*, *Troostocrinus reinwardti*, and *Eucalyptocrinus milliganae* are particularly abundant, and each was found to be characteristic of a certain zone. Numerous outcrops of these shales may be seen in the general area between Perryville and Clifton, but particularly fine exposures are found at Brownsport Furnace, thence northward to Perryville, and at numerous localities along Beech River. The Brownsport Furnace section has been given on a preceding page; the sections along Beech River are essentially the same, but the best exposed and most clearly defined section of the Beech River formation is found at the large glade about 2 miles south of Perryville.

*Section two miles south of Perryville, Decatur County, Tennessee.*

	Feet.
Decatur limestone. In large boulders covering formation below-----	—
Beech River formation.	
Eucalyptocrinus zone.	
Fine bluish fossiliferous shales in the lower part and yellow shales increasing in their yellow color and fossiliferous character toward the top. <i>Eucalyptocrinus milliganae</i> is not uncommon, while <i>Lampteroerinus tennesseensis</i> , <i>Callicrinus ramifer</i> , <i>Eucalyptocrinus ventricosus</i> , <i>Marsupioerinus tennesseensis</i> , and many other species of the same class are occasionally found. <i>Troostocrinus</i> is a rare fossil and the specimens are larger and more slender than the typical <i>T. reinwardti</i> of the beds below.	20
Troostocrinus zone.	
Yellowish shales with numerous typical <i>Troostocrinus reinwardti</i> and <i>Caryocrinus bulbulus</i> less common-----	10
Gray, shaly limestone forming a bench on the glade-----	1-3
Very fossiliferous, bluish, and whitish shales, becoming tinged with yellow toward the top-----	11
Coccoerinus zone.	
Rather shaly limestone, much more resisting than shales above and below. This limestone forms a well-marked bench separating the Coccoerinus zone below and the Troostocrinus zone above -----	3

	Feet.
White and gray shaly limestones and shales which rapidly disintegrate into a white clay upon exposure. <i>Coccoerinus bacca</i> found throughout this division but most abundant near the middle.....	19
Gray, shaly, rather infossiliferous limestones.....	5
Hard white limestone with a purplish tinge upon fresh fracture.....	1
White or greenish-white clay containing numerous dwarfed specimens of <i>Bilobites</i> , <i>Plectambonites</i> , <i>Pisocrinus</i> , etc.....	2
Dixon formation. Red and purple shales and shaly limestone.....	—

*Astrasporgia meniscus* is a very abundant and characteristic fossil of the Beech River, although not restricted to this formation. Specimens of this sponge in the later divisions of the Niagaran are rare. *Spirifer oligoptychus*, *Orthis ? fissiplica*, *Dalmanella arcuaria*, *Fistulipora hemispherica*, *Fenestella acuticosta*, *Astylomanon cratera* and varieties, *Caryomanon inciso-lobatum* and *C. stellatum-sulcatum*, are likewise abundant and range throughout the three beds.

The three subdivisions of the Beech River formation are, as a rule, quite similar lithologically and they are instituted mainly because of faunal differences. Mr. Springer's work upon the Crinoidea will illustrate this portion of the fauna in detail. The most abundant crinoid fauna has been found in the upper or Eucalyptocrinus zone, where Mr. Pate collected *Callicrinus ramifer*, *Lampterocrinus tennesseensis*, *L.*, new species; *Eucalyptocrinus milliganae*, *E. ventricosus*, *Alloerinus typus*, and three or four new species; *Marsupiocrinus tennesseensis*, *M. striatus*, *Lecanocrinus pisiformis*, *Herpetocrinus gorbyi*, *Calceocrinus*, two new species; *Pisocrinus milliganae*, *P. gemmiformis*, *Thalamocrinus oratus*, *T. cylindricus*, *Thysanocrinus milliganae*, *Sagenocrinus*, new species, as well as other undescribed forms.

#### BOB FORMATION.

Just below Bob Landing, along the west bank, the Tennessee River has exposed a section of red limestone and shales so similar in lithology to the Dixon formation that at first sight one would not hesitate to so refer them. A closer investigation of these strata shows that they overlie the Eucalyptocrinus zone of the Beech River formation, with its numerous characteristic fossils, and are succeeded by the brachiopod beds described below as the Dictyonella zone. Red strata holding the same position can be traced through the southern part of Decatur County and through Hardin and Wayne counties as far south as Indian Creek, so that these red rocks are known to occupy at least this limited area. These strata vary in thickness from 5 or 6 feet in their southern outcrop along Indian Creek at a bridge about half way between Olive Hill and the mouth of the creek to 20 feet or more at Bob. Large examples of *Uncinulus stricklandi* are quite common in this division, so, for convenience of reference, these strata may be called the *Uncinulus* bed or zone.



Following these red beds are shales and limestones holding an abundance of brachiopods. A discussion of these strata follows.

In the discussion of the Lower Helderberg rocks, Safford, in his *Geology of Tennessee*, described a locality near Esq. A. B. Gant's home, on Indian Creek, in Wayne County, 14 miles from Waynesboro and 22 from Savannah, where a bed of limestone, holding a fauna of more or less mixed character, was presented immediately below the Black shale and above the Meniscus layers. The section here, as given by Professor Safford, is as follows:

	Feet.
(4) Black Shale Group, represented by its lowest member—the sandstone.	
(3) A layer of gray limestone, containing the fossils of column C, which are silicified-----	10
(2) <i>Space</i> . rocks not seen-----	8
(1) Argillaceous limestone at the foot of the hill, which may be referable to the Meniscus formation-----	5

The list (column C) mentioned in the section was of brachiopods about equally divided between the Niagaran and "Lower Helderberg" species. The bed was, therefore, apparently transitional and of considerable interest in an area where the Niagaran and Helderbergian were elsewhere unconformable.

Doctor Foerste included this locality in his studies and found that a considerable stratigraphic interval separated layer 3 of Professor Safford's section from the Hardin sandstone (layer 4). He also proposed that "for purposes of discussion it will be found convenient to apply the name *Gant limestone* to the coarse sandy limestone under discussion [layer 3], and the term *Gant bed* to the top of Silurian section, including the Gant limestone at its base." At the Gant locality he found the "Gant limestone" to contain *Spirifer saffordi*, *Dictyonella gibbosa*, *Nucleospira concentrica*, *Wilsonia saffordi*, *Uncinulus stricklandi*, and *Schuchertella (Orthotheses) subplanus*. At other localities in the vicinity the "Gant limestone" was found to contain *Meristina maria-roemeri* and *Gypidula roemeri*, in addition to the brachiopods already mentioned, and beneath this limestone were found whitish clays and soft limestone containing sponges, brachiopods, and erinoids characteristic of the Glade exposures of the Beech River formation.

The following section, which has been compiled from Foerste's remarks upon this subject, is rather characteristic of his "Gant bed" in apparently the only area where it has hitherto been recognized.

*Section on hillside just northeast of Martin's mill, Tennessee.*

Bob formation.

	Feet.
Layer C. Much weathered and poorly exposed limestone with <i>Astylospongia praemorsa</i> , <i>Caryomanon stellatum-sulcatum</i> , <i>Meristina maria-roemeri</i> , and <i>Wilsonia saffordi</i> -----	14

	Feet.
Layer B. Bluish limestone, partly fine grained and partly crinoidal, with <i>Wilsonia saffordi</i> , <i>Ucinulus stricklandi</i> , <i>Schuchertella subplanus</i> , <i>Gypidula roemeri</i> , <i>Camartocchia neglecta</i> , <i>Nucleospira concentrica</i> , and <i>Meristina maria-roemeri</i> -----	9
Layer A. Sandy "Gant limestone" forming a projecting ledge-----	5
Beech River formation.	
Whitish clays and soft limestone, with sponges, brachiopods, and crinoids-----	57
Dixon formation. Red shale and shaly limestone.	

Foerste did not recognize his "Gant bed" in any but a small area along Indian Creek in the vicinity of Martin's mill and the Gant homestead. We have found limestones and shales, carrying great numbers of brachiopods of the species listed by Foerste, succeeding the Beech River formation and extending from a point just south of Decaturville continuously eastward and southward through the area drained by the Tennessee River and Indian Creek. At Brownsport Furnace these brachiopod beds are 25 feet in thickness, and it is strange that the similarity of their fauna to that of the "Gant limestone" was not noticed hitherto. One-half mile below Bob, on the west bank of the Tennessee River, the red limestones and shales are succeeded by about 42 feet of limestones and shales abounding in brachiopods. The section here is as follows:

*Section one-half mile below Bob, Decatur County, Tennessee.*

	Feet.
Lobelville formation-----	—
Bob formation.	
(f) Hard grayish clay at top, soft yellow clay in middle part, and soft blue clay at the base with brachiopod fauna listed below (under (c))-----	12
(e) Hard buff limestone, blue upon fresh exposure-----	1-2
(d) Soft blue clay with brachiopod fauna of bed below-----	2
(c) Yellow argillaceous limestone layers, two to three inches thick, alternating with soft yellow clay. Brachiopods numerous, <i>Gypidula roemeri</i> , <i>Meristina maria-roemeri</i> , <i>Nucleospira concentrica</i> , <i>Dictyonella gibbosa</i> , <i>Ucinulus tennesseensis</i> , and <i>Wilsonia saffordi</i> , being particularly abundant-----	14
(b) Rather massive white limestone in 8 to 12 inch courses. <i>Ucinulus stricklandi</i> not uncommon-----	10
(a) Red limestones and shales to water's edge. Large <i>Ucinulus stricklandi</i> quite abundant-----	20

As noted in the above section, all of these brachiopod bearing strata are grouped together in the Bob formation, this name being selected on account of the excellent exposure at Bob Landing, Decatur County, Tennessee.

The Bob formation is likewise found at a number of points north of the general area just described, and here the limestone part of the strata seems better developed. At Lady's Bluff, 16 feet of limestone

and 5 of shale were noted in the section. It is possible that the original distribution of the formation was equivalent to that of the underlying Beech River, and that erosion preceding the advance of the sea in which the succeeding formation—the most widespread of all—was laid down, has removed these strata, particularly in the more northern areas.

Although we might have adopted the term "Gant formation" for these limestones and shales with an abundant and characteristic brachiopod fauna, we came to the conclusion that the name had better not be employed. At present there is scarcely any exposure at the original Gant locality, and in a few years vegetation will have completely covered the rocks here. The place is found with great difficulty, and, moreover, Gant no longer lives there. The term is not a geographical one, and, in addition, the entire section is not developed there. An excellent exposure of these strata occurs about 1 mile from Swift on the Swallow Bluff road where the shales and limestones hold fine specimens of the brachiopods. Here the limestone layers, usually present at the base of the formation, have disintegrated in shaly material and the large *Uncinulus stricklandi* noted in this particular bed occur free.

Typical "Gant" limestone and clays are also well exposed on the west side of Buffalo River in Perry County, at Beardstown. The section along the Tennessee River in the vicinity of Bob is by far the most complete and conspicuous, and it seemed most fitting, as stated above, to apply this new name to the formation.

The uppermost division of the Bob formation is of nodular, cherty limestone or hard shale in which brachiopods of the genus *Conchidium* are the most characteristic fossils. On the east side of the Tennessee River this zone, to which we have applied the name *Conchidium*, is well shown in the Lady's Bluff section, while west of the river good exposures are found at Brownsport Furnace.

#### LOBELVILLE FORMATION.

The third formation here recognized is characterized paleontologically by a fauna of corals so abundant in species and specimens that the identification of the beds is attended with little difficulty. These corals are most abundant in the upper half of the formation, and wherever their strata are well exposed many fine specimens may be had. *Halysites catenulatus*, so abundant at Louisville, Kentucky, in the late Niagaran, is represented in the West Tennessee strata, with the exception of the Clinton, only at this horizon. The same occurrence in the late Niagaran only, holds true for almost all of the following species, likewise very characteristic of the Louisville coral bed: *Alveolites louisvillensis*, *A. niagarensis*, *Amplexus shumardi*, *Cladopora complanata*, *C. reticulata*, *Coenites verticillata*,

*Favosites cristatus*, *F. cristatus-major*, *F. discus*, *F. favosus*, *F. louisillensis*, *F. niagarensis*, *F. spongilla*, *Heliolites subtubulata*, *H. interstinctus*, *Plasmopora follis*, *Calveola tennesseensis*, *Thecia major*, and *T. minor*. Short Creek, near Linden, Tennessee, is a famous locality for these corals, and most of the West Tennessee specimens in paleontological collections were procured here. The strata, however, are exposed in Perry County from Linden to a point about 2 miles north of Lobelville, and, as the two faunal divisions which we recognize in the formation are well shown in the vicinity of the latter place, the name Lobelville is proposed for this formation. West of the Tennessee River the Lobelville formation is widely distributed, but is not so continuously exposed. Its presence in the Brownsport Furnace section has been indicated on a previous page, and other localities where the formation is well shown, especially in the southern half of Decatur County, might be named.

Red, purple, and blue shales, holding many bryozoa and a number of the corals noted above, follow the Conchidium limestone of the Bob formation and are succeeded by the strata in which the coral fauna is so well developed. These strata, for which we employ the subdivision Bryozoan zone, seem to be but 9 feet thick in the Mousetail section. At Lady's Bluff, where a more detailed section was made (page 426), a thickness of 22 feet was noted. Peeler's Pond, a locality 1 mile northwest of Whitfield, in Hickman County, shows a section of red shales at the bottom closely resembling the Dixon lithologically, and of blue shales at the top. These red shales are without doubt not Dixon, but are the bryozoan beds noted at Mousetail and Webb's Mill. The bryozoa of these beds are mainly of new species. Several species of *Fistulipora* and a new *Nicholsonella* are particularly abundant. The occurrence of these red strata at the base of the Lobelville formation, as well as similar red rocks at the same position in the Bob formation, is believed to be very significant in indicating previous land conditions.

*Section at Peeler's Pond, Hickman County, Tennessee.*

	Feet.
Devonian.	
Chattanooga black shale-----	—
Silurian.	
Decatur limestone.	
Massive white limestone-----	6
Lobelville formation.	
Coral zone. Shales and thin bedded limestone with an abundance of <i>Favosites</i> , etc-----	27
Bryozoan zone.	
Soft blue shale with many bryozoa and a few corals-----	23
Red clayey shales, greatly resembling Dixon formation, but containing characteristic Lobelville bryozoa and corals----	8+
Bottom not exposed.	

A section very similar to the above is exposed at the Webb or Rise Mill, just south of Linden. The formations and thicknesses exposed here are as follows:

*Section at Webb or Rise Mill, near Linden, Tennessee.*

	Feet.
Devonian.	
Chattanooga black shale-----	—
Silurian.	
Decatur limestone-----	16
Lobelville formation.	
Coral zone-----	40
Bryozoan zone.	
Blue shales with bryozoa and corals-----	18
Red clay shales with base not observed-----	11

A columnar section of this locality was given by Foerste <sup>a</sup> in which the basal red shales are referred to the Dixon. In his text this reference is made doubtful, and he notes that the exposures around Linden are peculiar in not displaying the great wealth of brachiopods and sponges characteristic of more southern exposures. If our studies are correct, these peculiarities are readily explained by the position of the strata above the brachiopod (Bob) and sponge (Beech River) beds. To us the most striking feature of this and other localities near Linden is the great resemblance of the coral beds to the late Niagaran section at Louisville, Kentucky.

The upper zone of the Lobelville formation is so well characterized by its prolific coral fauna that no difficulty should be experienced in its recognition. The strata are usually whitish shales so prolific in fossils that their disintegration upon hillsides leaves the ground fairly covered by the specimens. A particularly fine example of a glade formed by the weathering of these coral beds is the Graveyard Glade, 1½ miles west of Bob. The section here extends from probably the top of the Beech River formation to the Decatur limestone occurring in boulders on the top of the hill, but the corals from the coral beds have so covered the underlying strata that the succession could not be determined with accuracy in the time available. The corals, determined from a preliminary study of the fauna in this horizon at the Graveyard Glade, are listed below. Every one of these species occurs in the uppermost Niagaran strata at Louisville, Kentucky, and we do not know of a clearer case of equivalent rocks, judged by faunal evidence.

<sup>a</sup> Journal of Geology, XI, 1903, p. 578.



*Corals at Graveyard Glade, 1½ miles west of Bob, Tennessee.*

<i>Thecia major</i> Rominger.	<i>Eridophyllum dividum</i> Davis.
<i>Thecia minor</i> Rominger.	<i>Cladopora reticulata</i> Hall.
<i>Heliolites interstinctus</i> Linnaeus.	<i>Cladopora complanata</i> Davis.
<i>Heliolites subtubulatus</i> McCoy.	<i>Omphyma verrucosa</i> Rafinesque and Clifford.
<i>Plasmodopora foliis</i> Edwards and Haime.	<i>Alveolites niagarensis</i> Rominger.
<i>Amplexus shumardi</i> (Edwards and Haime).	<i>Alveolites louisvillensis</i> Davis.
<i>Favosites discus</i> Davis.	<i>Cystiphyllum niagarensis</i> (Hall).
<i>Favosites spongilla</i> Rominger.	<i>Cystiphyllum granilincatum</i> Hall.
<i>Favosites favosus</i> Goldfuss.	<i>Heliophyllum dentilincatum</i> Hall.
<i>Favosites niagarensis</i> Hall.	<i>Heliophyllum gemmiferum</i> Hall.
<i>Favosites cristatus</i> Edwards and Haime.	<i>Heliophyllum radícula</i> (Rominger).
<i>Favosites cristatus major</i> Davis.	<i>Halyssites calenulatus</i> Linnaeus.
<i>Favosites louisvillensis</i> Davis.	<i>Halyssites nexus</i> Davis.
<i>Favosites venustus</i> Hall.	<i>Striatopora huronensis</i> Rominger.
<i>Romingeria vanula</i> Davis.	<i>Cocinites verticillata</i> Davis.

Localities affording good exposures of the coral zone have been noted in several of the sections already presented, but the Graveyard Glade, Brownsport Furnace, Peeler's Pond, Lobelville, and Jacks Branch, near Linden, are worthy of special mention.

## DECATUR FORMATION.

The closing member of the Niagaran in West Tennessee is a massive, white crinoidal limestone with some magnesian beds, sometimes reaching a thickness of 70 or more feet. This has been noted in several sections given on previous pages as the Decatur limestone. In the immediate vicinity of Decaturville this limestone is represented mainly by residual boulders, but at Tuck's Mill, 1½ miles north of Decaturville, the formation is well exposed. The section at the latter place may be considered as typical for the formation, but its occurrence at many places in Decatur County has given rise to the name. At the bridge crossing Beech River, 1½ miles north of Decaturville on the road to Parsons, the white, coarse-grained Decatur limestone rests unconformably upon the Eucalyptocrinus beds of the Beech River formation, a short distance above the level of the river. The section continues up the hill back of the mill, and altogether about 70 feet are exposed. Fossils are apparently not abundant, but *Uncinulus stricklandi*, *Wilsonia saffordi*, *Pachydietya crassa*, *Penniretepora* sp., and other Niagaran fossils were observed. It will be noted that all of these fossils have an extended range, so that the characteristic fossils of the Decatur limestone can not yet be given. Toward the top of the Tuck's Mill section this limestone becomes slightly shaly, and here fossils are found in most abundance.

Along the river bank one-half mile northeast of Perryville a large quarry has been opened in the Decatur limestone and a good exposure of the rocks is presented. Foerste quotes *Astrosporgia meniscus* as occurring in this quarry immediately beneath the Linden limestone. Careful collecting here shows other Niagaran fossils, so that there is little doubt of the correctness of the reference of this limestone to the Decatur.

The section at Lady's Bluff presents the Decatur limestone so well that the following subdivisions can be noted:

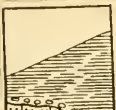

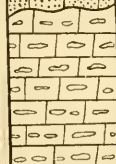

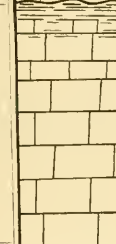
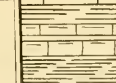

*Decatur limestone at Lady's Bluff, Tennessee.*

	Feet.
Linden formation.....	—
Decatur limestone.	
Yellow, argillaceous limestone.....	2
Massive, white magnesian limestone.....	30
Argillaceous, grayish limestone weathering into shale.....	11
Massive, magnesian limestone, grayish at top and yellowish toward bottom.....	20
Lobelville formation.....	—




Although the three localities mentioned above afford the best sections of the Decatur limestone known to us, still favorable exposures for its study are found at numerous other places in Decatur and Perry counties. Southward this, as well as the underlying Lobelville formation, is usually absent, the Chattanooga black shale or Helderbergian strata resting upon the Bob formation.

The following composite section of the Ordovician-Devonian strata of west Tennessee was prepared from a study of the numerous individual sections studied in this area.

## Composite section of Ordovician-Devonian rocks of west Tennessee.

Period.	Thickness.	Columnar section.	Description.
Devonian.	10'		Chattanooga black shale. Black, fissile, carbonaceous shale, often with a band of phosphatic material at the base and a layer of phosphate nodules at the top.
	10'		Hardin sandstone member. Sandy shales and sandstones containing fish remains.
	50'		Camden chert. Siliceous limestone weathering into beds of angular chert fragments. Fossils of Lower Oriskany age often extremely abundant.
	35'+		Linden formation. Massive crinoidal limestone in lower half and blue shales and thin limestones in upper part. <i>Camarocrinus saffordi</i> is the most conspicuous fossil of the lower limestone (Ross bed of Foerste). The upper shaly beds (Pyburn beds of Foerste) are crowded with fossils of New Scotland age. <i>Striatopora issa</i> , <i>Favosites conicus</i> , <i>Callopora perelegans</i> , <i>Eridotrypa corticosa</i> , and <i>Lioclema cellulosum</i> being particularly abundant.
Silurian (Niagaran).	70'		Deceatur limestone. Massive, white, coarsely crystalline, crinoidal and magnesian limestone becoming yellow and slightly shaly at the top.
			Lobelville formation. Coral zone (45'). Yellow clays and thin clayey limestone crowded with corals. Several species of <i>Favosites</i> , <i>Heliolites</i> , <i>Thecia</i> , <i>Cystiphyllum</i> , <i>Halysites</i> , and <i>Plasmopora</i> are very abundant.
	76'		Bryozoan zone (31'). White to blue shales holding a few corals and many bryozoa in the upper part; red to purple shales and argillaceous limestone with the same fauna making up the lower division.

## Composite section of Ordovician-Devonian rocks of west Tennessee—Continued.

Period.	Thickness.	Columnar section (Lobelville).	Description.
Silurian (Niagaran).	75'		<p>Bob formation.</p> <p>Conchidium zone (15'). Massive crinoidal to argillaceous limestone with few fossils, species of <i>Conchidium</i> being most characteristic.</p> <p>Dictyonella zone (30'). Blue clay and shales crowded with brachiopods. <i>Dictyonella gibbosa</i>, <i>Gypidula rocmeyri</i>, <i>Merista tennesseensis</i>, <i>Uncinulus tennesseensis</i>, and <i>Wilsonia suffordi</i> are among the more common or characteristic forms.</p> <p>Uncinulus zone (30'). Gray massive limestone at top and red shaly strata in lower two thirds. Large examples of <i>Uncinulus stricklandi</i> are numerous and the most noticeable fossils.</p>
	106' 6"		<p>Beech River formation.</p> <p>Eucalyptocrinus zone. Fossiliferous, dark blue shales and thin cherty limestone, becoming yellowish toward top. <i>Eucalyptocrinus milliganae</i> and other crinoids characteristic fossils.</p> <p>Troostocrinus zone. Blue shales with a bed of compact limestone 5 or more feet thick at the base and a similar limestone band developed in the middle part. <i>Troostocrinus reinwardti</i> abundant and characteristic of this division.</p> <p>Coccoerinus zone. Blue to white shales and shaly limestone readily disintegrating into clay. Fossils abundant with <i>Coccoerinus bacca</i> as the diagnostic form.</p>
	44'		<p>Dixon formation. Red to purple shales and clayey limestones with occasional layers of white argillaceous rock. <i>Fistulipora hemispherica</i> the only abundant fossil.</p>

Composite section of Ordovician-Deronian rocks of west Tennessee—Continued.

Period.	Thickness.	Columnar section (Dixon).	Description.
Silurian (Niagaran).	46'		<b>Lego limestone.</b> Compact gray to white argillaceous and subcrystalline limestone with few fossils.
	4'		<b>Waldron shales.</b> White indurated clay and argillaceous limestone, holding the typical Waldron fauna.
	28'		<b>Laurel limestone.</b> Massive, pink to reddish purple argillaceous and crystalline limestone.
	14'		<b>Osgood limestone.</b> Thin bedded, reddish, argillaceous limestone containing <i>Stephanocrinus osgoodensis</i> , <i>Pisocrinus gemmiformis</i> , and typical <i>Carystocrinus ornatus</i> .
	1'		<b>"Clinton" formation.</b> White to light brown crystalline, fossiliferous limestones with greenish brown chert.
Ordovician.	34' 6"		<b>Fernvale formation.</b> Bluish shales in upper half, coarse grained, cross bedded, light colored phosphatic limestone in lower. <i>Rhyuchotrema capax</i> , <i>Devorthis subquadrata</i> , <i>D. proavita</i> , <i>Strophomena planodorsata</i> , and <i>Rhombotrypa quadrata</i> observed.
	3'		<b>Arnheim ("Warren") formation.</b> Coarsely crystalline phosphatic limestone weathering into abundant chert. The lowest layer is of dark conglomeratic material, made up of the casts of <i>Cycloras</i> and containing large and small fragments of the underlying Hermitage limestone.
	70' +		<b>Hermitage ("Saltillo") formation.</b> Bluish gray, compact argillaceous limestone alternating with blue shales. Fossils few but <i>Dalmanella testudinaria</i> var. <i>fertilis</i> , <i>Leptobolus lepis</i> , <i>Trematis punctistriata</i> , <i>Schizocrania rudis</i> , <i>Whiteavesia</i> sp., <i>Zygospira modesta</i> , and <i>Hindia sphaeroidalis</i> are occasionally seen.



## NOTES ON DISTRIBUTION OF THE BROWNSPORT GROUP.

The general distribution of the various late Niagaran formations in the valley of the Tennessee River has been noted briefly in the preceding pages. Leaving this area and proceeding toward the Central Basin of Tennessee, the most eastern exposure of the Brownsport, according to Foerste, is along the Nashville, Chattanooga, and St. Louis Railroad, at the bridge  $1\frac{1}{2}$  miles west of Pegram, about 21 miles east of Dixon, Tennessee. Here, following Foerste's description and section, the base of the Brownsport is a very fossiliferous clay, 8 feet in thickness, directly overlaid by Mesodevonic limestone. The limestones underlying this clay bed are referred by Foerste<sup>a</sup> to the Dixon and Lego, the latter formation being made the equivalent of the Louisville. We can not agree with these determinations and believe the sections presented below will prove at least that his so-called basal beds of the Brownsport are the equivalent of the coral beds of the Lobelville formation, while the argillaceous limestone at the base of this section appears to belong to the lower part of the same formation.

*Section at railroad bridge, 1½ miles west of Pegram, Tennessee.*

Devonian.	Feet.
Chattanooga black shale. Lower layers with rather numerous lingu- loids -----	—
Hardin sandstone. Rather massive, sandy shales with <i>Cycloras</i> and <i>linguloids</i> -----	1-2
Mesodevonic limestone:	
(b) Massive, arenaceous limestone with <i>Tropidoleptus carinatus</i> , <i>Ancyrocrinus</i> , etc. (Hamilton) -----	1-2
(a) Coarsely crystalline, massive, crinoidal limestone with <i>Poly- pora shumardi</i> , <i>Cystodictya gilberti</i> , <i>Nucleocrinus ver- neuillianus</i> , etc. (Onondaga) -----	8
Silurian.	
Lobelville formation.	
Fossiliferous blue and yellow shales holding the following spe- cies: <i>Calceola tenuiscensis</i> , <i>Favosites discus</i> , <i>F. farosus</i> , <i>F. reustus</i> , <i>Thracia major</i> , <i>T. minor</i> , <i>Heliolites interstinctus</i> , <i>H. subtubulatus</i> , <i>H. micropora?</i> , <i>Halysites cateulatus</i> , <i>Cladopora reticulata</i> , <i>Atrypa reticularis niagarensis</i> , <i>Spirifer foggi</i> , <i>Un- cinulus stricklandi</i> , <i>Mcristina maria-rocmeyri</i> , <i>Wilsonia saffordi</i> , etc. -----	8
Argillaceous limestone with a few shale layers -----	30+
Fossils few, but several corals of species occurring in the shale above were noted.	

A very instructive Niagaran section is exposed in the quarry 3 miles west of Newsom, Tennessee, at the end of a short spur from the Nashville, Chattanooga, and St. Louis Railroad. At the time the section at this locality was made the quarry face was so steep that

<sup>a</sup> Journal of Geology, XI, 1903, p. 577.

it was almost impossible to collect from the various strata in place, but enough paleontologic evidence was secured to indicate the correctness of the correlations indicated.

*Section at quarry, 3 miles west of Newsom, Tennessee.*

	Feet.
Devonian (Chattanooga) black shale.....	—
Devonian limestone (Onondaga).....	6
Silurian.	
Lobelville formation.	
Yellow shales with the coral fauna of the Lobelville formation..	½
Massive, argillaceous limestone in upper part and more crystalline toward bottom. Probably equivalent to lower part of Lobelville formation.....	15
Waldron shale.	
Fossiliferous blue shales and limestones holding the typical Waldron fauna.	
(d) Blue limestone.....	1
(c) Blue shale.....	¼
(b) Massive limestone.....	3
(a) Typical Waldron shales, dark blue in color and very fossiliferous.....	4-5
Laurel limestone (to base of section).	
Massive gray and pinkish crystalline limestone.....	—

Proceeding northeastward from the West Tennessee geanticline, no strata older than the Mississippian are encountered until the Wells Creek Basin, just southwest of Cumberland City on the Cumberland River, is reached. Here a local uplift exposes strata as old as earliest Ordovician. Foerste has studied this area and the following section is compiled from his notes.<sup>a</sup> In this the identification of the Dixon and Brownsport limestones is of particular interest, and the general section is apparently that prevailing in the Tennessee River Valley.

*Section at Wells Creek Basin, Tennessee.*

	Feet.
Devonian black shale.....	—
Helderbergian (Linden) limestone.....	—
Brownsport limestone. <i>Astracospongia meniscus</i> found near base.....	?170
Dixon formation. Dark, red brick clay rock.....	32
"Glenkirk" limestone (Laurel, Waldron, and Lego combined).....	—
Osgood limestone. Red clayey shales and limestones.....	21
"Clinton" limestone. Massive white limestone; cherty in upper part....	22
Ordovician ("Saltillo") limestone.....	—

In East Tennessee and in the Appalachian in general, Niagaran strata proper are wanting, with the exception of several small areas near Sneedville, Hancock County, Tennessee. In his *Geology of Tennessee*, Professor Safford described the occurrence of the *Meniscus* limestone, giving it the special name Sneedville limestone, in the

<sup>a</sup> *Journal of Geology*, XI, 1903, p. 690.

Powell Mountain group of ridges in East Tennessee, and publishes a section <sup>a</sup> in which the Meniscus limestone is identified between the Dyestone (Rockwood) group and the Black Shale. *Halysites catenulatus* and other fossils were noted. We have not visited this locality, but specimens in the U. S. National Museum collections indicate the probable equivalence of this limestone with the coral beds of the Lobelville formation in West Tennessee. This identification is in keeping with the facts concerning the wide extension of this coral zone, but the section here must be restudied before a definite correlation can be made. Professor Safford notes a locality 4 miles south-east of the salt works in Anderson County where a cherty bed in contact with the black shale is well charged with corals. The fauna in the U. S. National Museum collections noted from Sneedville are *Halysites catenulatus* (large and small mesh), *H.* near *nexus*, *Favosites farosus*, *F. venustus*, *Heliolites* cfr. *micropora*, and several species of large Orthocerata.

In southern Indiana and northern Kentucky the strata of Silurian age between the Waldron shale and the overlying Devonian rocks have been designated the Louisville limestone by Foerste. The publications of Hall, Nettelroth, Lyon, Davis, and others have made known a large fauna from these strata, but, to the best of our knowledge, no detailed account of their stratigraphy has ever been printed. Such an account can not now be furnished, but enough is known to indicate that the Niagaran limestone in the immediate vicinity of Louisville, Kentucky, have representatives of the Coral and possibly the Conchidium beds of West Tennessee. The uppermost 8 feet of the Louisville Silurian section are of argillaceous cherty limestone, holding great numbers of the corals listed on page 437. Beneath these layers are about 30 feet of strata similar lithologically but containing fewer corals. The next lower rocks are exposed along Bear Grass Creek, where the strata are seen to be blue in color and cherty. Here fossils are scarcer, but the prevailing forms are pentameroid brachiopods. The Louisville limestone, therefore, in the immediate vicinity of Louisville is apparently equivalent to our Lobelville formation and not to the entire post-Dixon Niagaran formations of West Tennessee.

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<sup>a</sup> Geology of Tennessee, 1869, p. 294.