CHAPTER 3.

NEW PROVIDENCE GROUP

Name and Limits. The name New Providence, from New Providence, Clarke County, Ind., was introduced by Borden[17] in 1874. The formation was defined by him as including the lower 80 to 126 feet of the "Knobstone group" of southern Indiana and adjoining parts of Kentucky.

The New Providence in southern Indiana and nearby parts of Kentucky is bounded below by the New Albany shale (Ohio shale) and above by the Kenwood sandstone of early Keokuk age, giving it very definite upper and lower limits in the general type region. The same lower limit persists throughout southern Kentucky and northeastward to Berea or Irvine, where the Sunbury shale wedges in between the New Providence and the Ohio shale, The upper limiting formation, however, the Kenwood sandstone, extends southward perhaps only to Lebanon Junction, Bullitt County, Ky. In southern and eastern Kentucky the upper boundary is some one of the higher Mississippian formations which come successively into contact with the New Providence northeastward from Marion County, Ky., to Ohio River, between Vanceburg, Ky., and Portsmouth, Ohio.

The New Providence holds its character as a homogeneous unit, although increasing in thickness, from southern Indiana to the vicinity of Lebanon, Ky., where a sandstone is present near the middle. (See section No. 24 of chart and Plate 8.) From Lebanon eastward and northeastward, via Junction City, Brodhead, Irvine, and Morehead, to Ohio River, this sandstone increases in thickness and make up more or less of the upper half of the New Providence (which, in the northeastern counties is four times the thickness of the entire formation in southern Indiana), while the lower half maintains more nearly the lithologic facies of the New Providence at its type locality. The New Providence thus in its northeastern development becomes a group, being separable into two distinct lithologic divisions, which in

[17] Borden, W. W., Ind. Dept. Geol. & Nat. Res., Fifth Ann. Rept., p. 161, 1874.

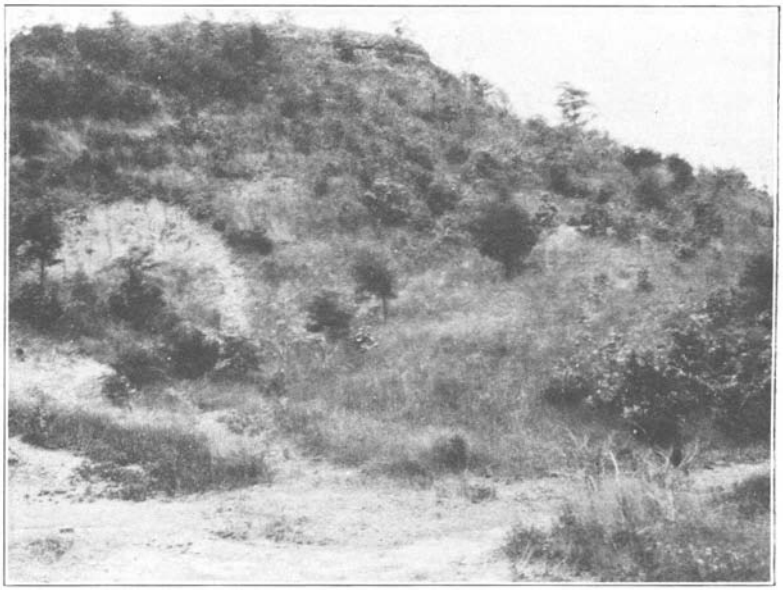

Plate 8. Knob about two miles southeast of Lebanon, Marion County, capped by shelly sandstone. Represents southwestern edge of Logan sandstone of Ohio. Slumped typical New Providence shale below sandstone, 140 feet thick. Black shale at base. Looking southeast.

Ohio are recognized as of formational rank. These two divisions correspond to the Cuyahoga formation of Hyde below and the Logan formation of Hyde[18] above, each with subordinate members.

For the convenience of general treatment, under a single head, of these equivalent facies of rocks characterized from top to bottom by the New Providence fauna, and apparently included within the same time and stratigraphic limits, the name is here modified to New Providence group.

Distribution. The New Providence rocks extend from Jefferson County, Ky., southward to the escarpment known as Muldraugh's Hill, facing the Bluegrass region. Along this escarpment they outcrop in a broad belt around the Bluegrass country to Ohio River. From Muldraugh's Hill southward they extend beneath the cover of younger rocks and are probably present beneath most of southern-central Kentucky nearly

[18] Hyde, J. E., Jour. Geol., Vol. 23, pp. 657-682, 757-779, 1915.

to the state line. There are areas, though, where the New Providence is known to be absent, as along Barren River, between Barren and Allen counties, and the head of Marrowbone Creek, in Cumberland County. In southern Allen County, however, to the south of Petrolia, a small area is known in outcrop, but its geographic extent beneath the overlying rocks is not known. It is generally not present in northern Tennessee, as in Overton County, although there are outliers, one of which is known on Roaring River in Overton County, about 2 miles east of the Jackson-0verton County line. In eastern Kentucky the New Providence outcrops along the western face of Pine Mountain

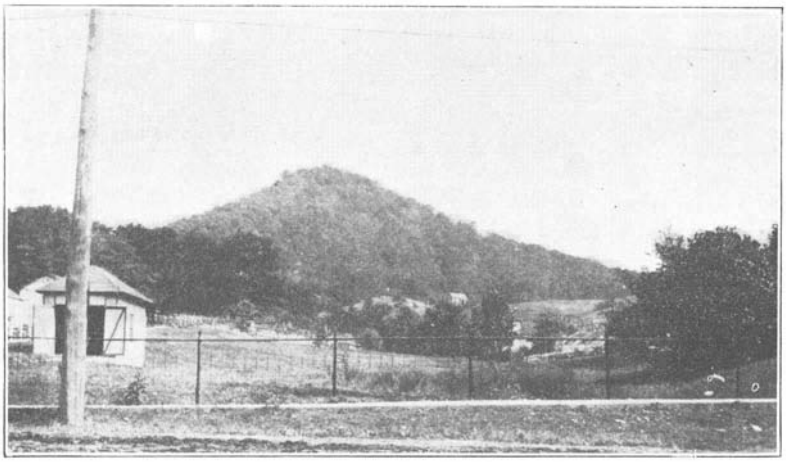

Plate 9. View of Minerva Mountain. Irvine. Ky. Looking east. Slopes occupied by New Providence; summit capped by basal yellow layers of St. Louis limestone. Foreground on Ohio shale. Typical knob of the Knobs region of Kentucky.

from the Breaks of Sandy to Jellico, Tenn., and it also outcrops along the east face of the Cumberland escarpment from Cumberland Gap on the south as far north as Russell County, Va., where its outcrop is faulted out. In this eastern region the New Providence equivalent is represented in the Grainger shale. It certainly underlies the entire area of the eastern coal fields of Kentucky, as proven by hundreds of oil-well borings. The top 20 feet or so of the shale at Pineville, Bell county, where it is overlain by the St. Louis limestone, is shown in Plate 55.

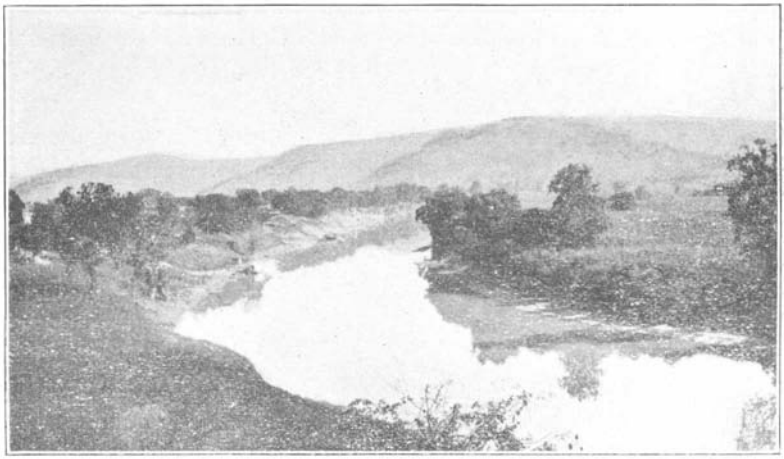

Plate 10. View looking east from Irvine, Ky. River flats about coincident with the "Corniferous" limestone of Onandaga age and with the Ohio shale in the distance. Escarpment on New Providence group. (Cuyahoga and Logan formations of Hyde). Gasper oolite and Ste. Genevieve at brow overlain by the Pottsville. Escarpment is the N. E. continuation of Muldraugh's Hill.

Most of the knobs of the knob region of Kentucky are carved out of the New Providence, and it forms the face of Muldraugh "Hill" or equivalent escarpment facing west toward the Bluegrass region. One of the knobs is illustrated in Plate 9 and the west-facing escarpment at Irvine is shown in Plate 10.

Character. The New Providence has considerable diversity of lithologic character in different areas of its geographic extent. In its type region it is usually a soft green shale which weathers to a green clay. Its weathered aspect is perfectly displayed in the washes one-half mile west of Junction City, Boyle County. This exposure is in the immediate vicinity of Linietta Springs, from which Foerste[19] gave, provisionally, the name "Linietta clay" to those beds, before their identity with the New Providence was determined. In some localities this facies of the New Providence includes thin layers of limestone composed almost entirely of crinoid plates. At such places fossils are usually abundant; from such the greater part of the known New Providence fauna has been collected. Buttonmould Knob,

[19] Foerste, A. F., Ky. Geol. Survey Bull. 5. pp. 143-178, 1905.

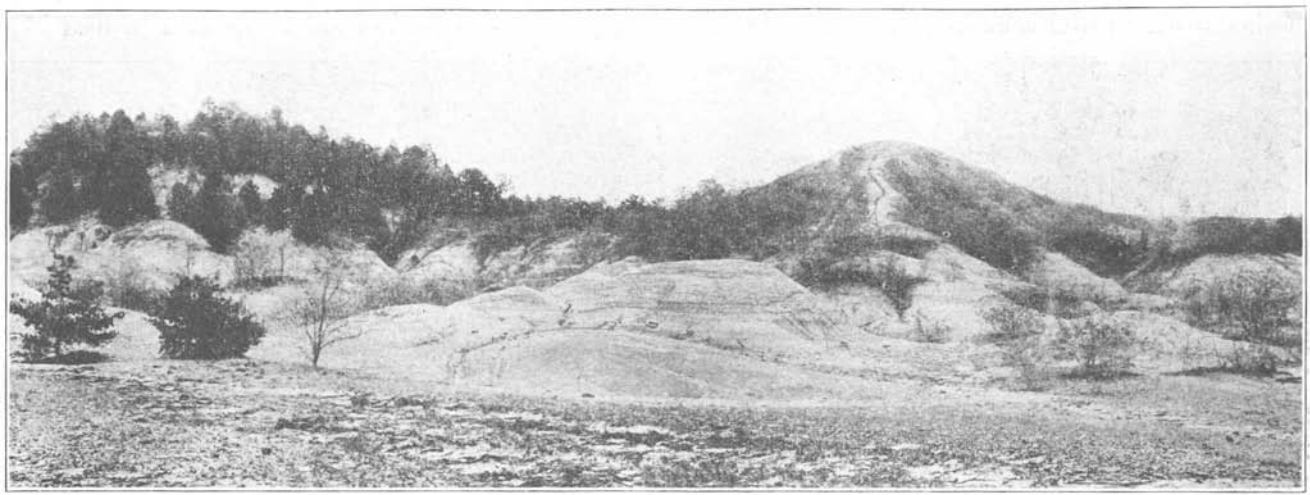

Plate 11. View of denuded area of New Providence shale about one-half mile west of Junction City, Ky. Looking east. Black shale and phosphate nodules containing fossil wood, crustacean remains, and *Lingula,* in level space in foreground. The surface weathers to a green clay.

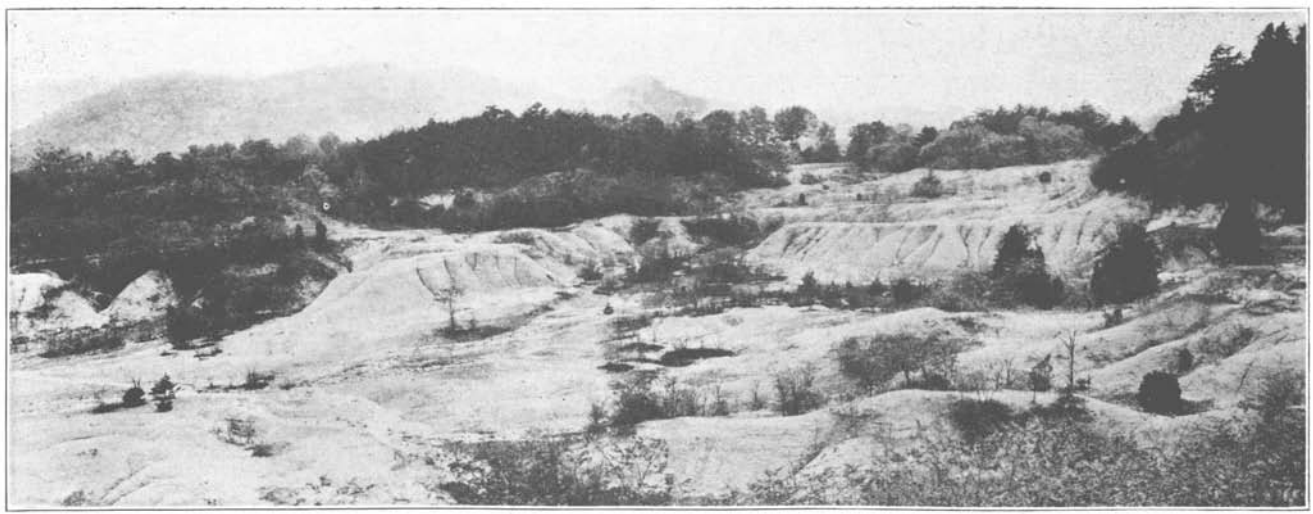

Plate 12. Same subject and locality as in Plate 11. Looking west from top of knob shown in Plate 11. The exhibition of the New Providence and its characteristic weathering at this locality is the best known. The Logan sandstone comes in at the top of the escarpment shown in the distance.

12 miles south of Louisville, is the most prolific and famous of these localities. Here the limestone layers extend through most of the lower half of the formation which is 150 feet thick. The north end and west side of Kenwood Hill, 5 miles south of Louisville, is another locality. There the limestone layers occupy a thiner zone near the middle of the formation. Another is on the east side of Fishing Creek, on the Jamestown road, 5 miles west of Somerset. Still another is a mile south of Petrolia, Allen County. Here the limestone is thicker and notably cross-bedded. (See Plate 13) The conditions at Buttonmould

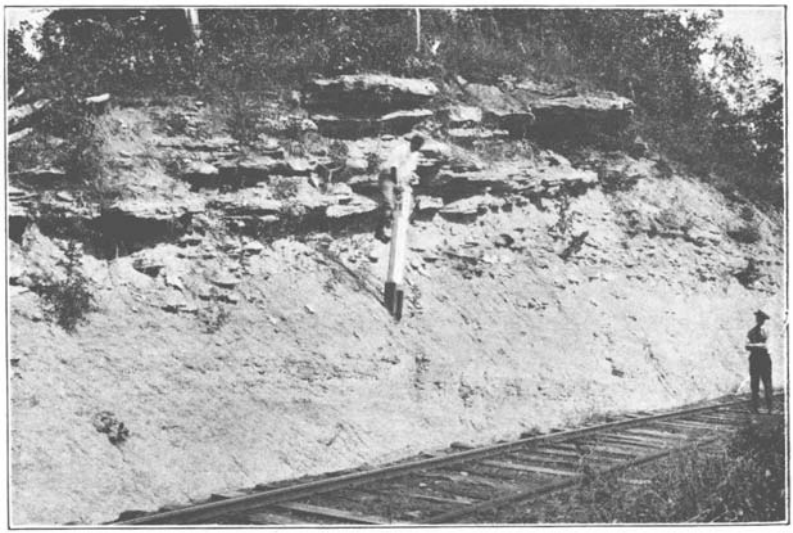

Plate 13. Local irregularity in bedding in the New Providence shale. Louisville & Nashville Railroad about 1 mile south of Petrolia, Allen County. Looking southeast.

Knob and on Fishing Creek are shown in Nos. 7 and 21 of the Chart of sections.

A notable feature of these limestone deposits is their small geographic extent. Exposures of the same horizon within a mile or two of Buttonmould Knob reveal the entire absence of such limestone layers. Near the south end of Kenwood Hill, one-half mile distant from the point on the north end where the prolific fossiliferous limestone is present, not a trace of the limestone is to be seen in a complete exposure of the full thickness of the

New Providence. Another notable feature of this soft shale facies of the New Providence is the abundant and widely prevalent nodules composed of carbonate of lime and iron. In freshly-made exposures these preserve their form as nodules projecting from the clay or shale, but on weathered surfaces they commonly exfoliate and break up into thin, shelly, ferruginous curving chips, which strew the surface of the exposure.

The predominant soft green shale facies of the New Providence extends throughout the south-central counties as far east perhaps as Rockcastle County, as shown in section No. 29 of the section chart.

In the vicinity of Lebanon, Marion County, a sandstone is introduced into the midst of the New Providence, by which its homogeneous character prevailing westward and southward is broken up. The sandstone is about 15 feet thick, and is underlain by 141 feet and overlain by 102 feet of typical New Providence shale. (See section No. 24 of the section chart and Plate 8.) The sandstone is more or less shelly and is fossiliferous. A fossil of especial significance is *Taonurus caudi galli* (See Pl. 23), which has not been seen by the writer west or south of Lebanon, but which is increasingly common in and entirely confined to and characteristic of the sandy facies of the New Providence northeastward to Ohio and eastward to Virginia.

Eastward from Lebanon the sandstone thickens, and in the vicinity of Junction City, as shown in section No. 28 of section chart, is at least 75 feet thick to the top of the highest knob. Here the sandstone is underlain by shale typical of the New Providence, as exhibited in Plates 11 and 12. Neither its top nor the top of the New Providence is reached, so the full thickness of the sandstone is not known, nor is it known whether it is overlain by typical New Providence shale, as in the vicinity of Lebanon. Farther east, in the section from about 2 miles west of Brodhead to Brodhead, (section No. 29 of section chart), the lower 135 feet of the New Providence includes a notable amount of sandstone or sandy layers, the top 25 feet of the 135 feet being a shelly sandstone full of Taonurus. Above this is 50 feet of typical New Providence green clay shale. This is succeeded by 40 feet of slightly sandy, moderately stiff shale with abundant iron nodules. The upper

100 feet includes a large proportion of shelly sandstone. These upper beds with shelly sandstone probably are equivalent to the sandstone at Lebanon and Junction City, but the lower sandstone beds seem to have no counterpart elsewhere in the New Providence except in Lewis County, as described farther on in this report. From about the latitude of Berea northward to the part of Lewis County referred to in the last sentence, the shale and the sandstone facies of the New Providence are clearly separated near the middle of the formation, the lower part of which is predominantly shale approximating the typical New Providence in character, and the upper part is predominantly

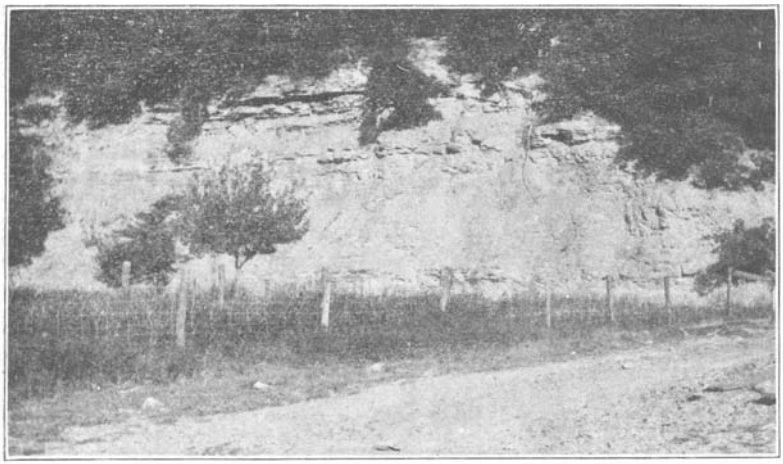

Plate 14. View of bluff near Owsley Branch about 7 miles east of Berea, showing the transition of Cuyahoga shale into the Logan sandstone of Hyde. Looking east.

shelly sandstone full of *Taonurus*. The general character, limits, and relative thickness of these two general components of the New Providence of this part of Kentucky are fully illustrated by sections Nos. 24 to 28 and 33 to 44 of the chart of sections. The transition between these two components of the New Providence group is illustrated by Plate 14.

CUYAHOGA AND LOGAN FORMATIONS OF HYDE.

General Character. The lower subdivision of the New Providence group corresponds to the Cuyahoga formation of Hyde and the upper subdivision to the Logan formation of

Hyde's classification of the Ohio rocks, and it will be possible to discriminate and map these two units in Kentucky, at least as far south as the latitude of Berea. In Lewis County, as intimated on p. 37, the lower subdivision (Cuyahoga of Hyde) of the New Providence takes on a sandstone facies, as shown in secs. 42 and 43 of the section chart. The sandstone, however, is quite different from that of the upper subdivision (Logan of Hyde.) The lower sandstone is more firmly cemented and makes coherent layers which do not break down into fragments on weathering. The layers are evenly bedded and uniform in thickness, as shown in Plate 15. This sandstone facies has been

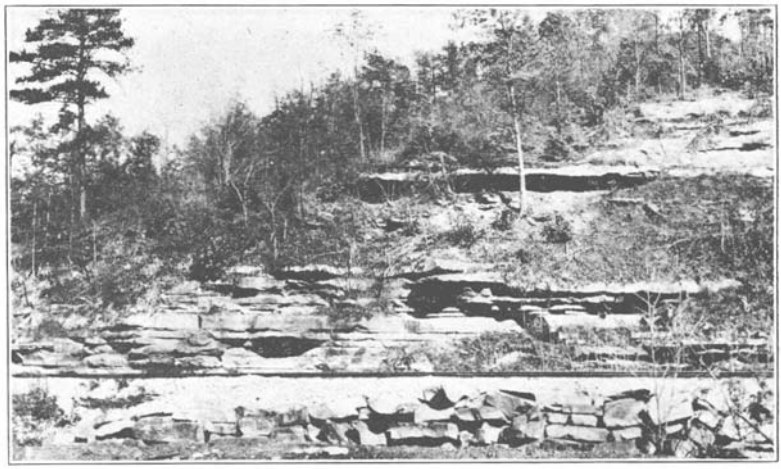

Plate 15. "Vanceburg facies" of the Cuyahoga. The tendency to the even bedding so completely attained by the Buena Vista member shown in Plate 18 is apparent. These layers are probably about 100 feet above the bottom of the Cuyahoga. Kinniconick Branch of Chesapeake & Ohio R. R., nine miles west of Carter. Looking north.

called the "Vanceburg sandstone facies" by Hyde,[20] because well-developed at Vanceburg, Ky. It is known to extend across Lewis County and is well developed and displayed along the Kinniconick Branch of the Chesapeake & Ohio Railroad from about 1 mile southeast of Tannery to the vicinity of Ruggles, near which station lies the boundary between the two subdivisions of the New Providence. The north-south extent of this

[20] Hyde, J. E., Stratigraphy of the Waverly formation of southern and central Ohio. Jour. Geol., Vol. 23, pp. 655-682, 1915.

sandstone facies, however, has not been determined, but it is known that it does not extend as far south as Morehead nor as far north as Portsmouth. At Morehead thin even layers of sandstone in shale extending 50 feet or so above the Buena Vista sandstone member, described below, is the beginning of this sandstone facies. Within the lower 50 feet of the New Providence from Stanton to Ohio River is a sandstone member characterized by remarkably even bedding. This is the Buena Vista sandstone member of the Cuyahoga formation. The "Vanceburg facies" of Hyde is an upward extension of the Buena Vista type of sandstone.

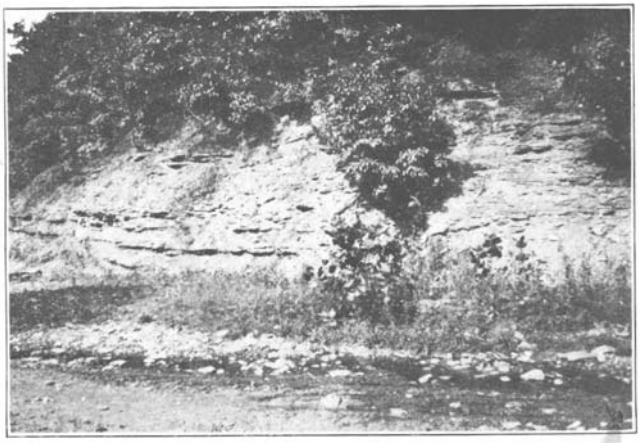

Plate 16. Exposure of Logan sandstone showing characteristic diagonally cleaving sandstone. Breaks down into small irregular plates. Rothwell, Ky. Looking northwest.

At Portsmouth the lower half of the New Providence is made up mainly of shale of its characteristic type, including, however, in the lower 50 feet or so, scattered, even layers of sandstone.

The sandstone of the upper, Logan, division of the New Providence is distinguished by its soft, incoherent, shelly character. It is affected throughout by diagonal cleavage, due to which, on weathering, it breaks down in to relatively small pieces with sharp edges and irregular surface. This peculiarity is well illustrated by the photograph plates 16 and 17. It is character-

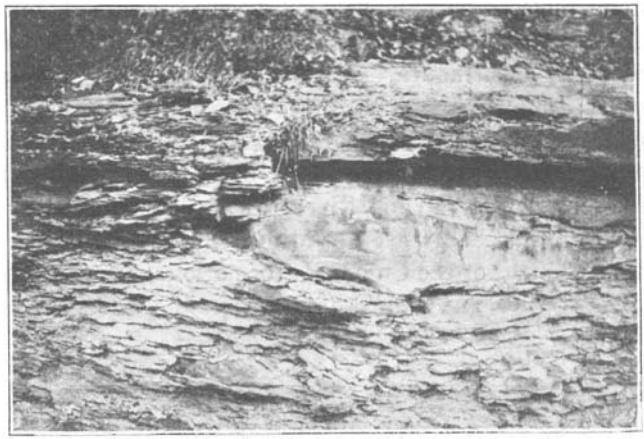

Plate 17. View of Logan sandstone showing diagonal cleavage into small pieces characteristic of the sandstone. Cut on Kinniconick Branch of Chesapeake & Ohio R. R., about 4½ miles west of Carter, Ky.

istic of this sandstone throughout its extent from Lebanon, Kentucky to Ohio. At Cumberland Gap the New Providence includes layers of a more finely shelly sandstone in shale, and farther north, as at Big Stone Gap, Va., and Jenkins, Ky., thick and more coherent layers of sandstone occur.

The New Providence is variously described in many well logs in eastern Kentucky. Perhaps the following two logs are fairly representatives: quoted from Jillson, Oil and Gas Resources of Ky., pp. 404 and 406.

Log No. 1. F. R. Bussey Farm, Busseyville, Lawrence Co., Ky.

	Feet
Chester, etc.:	
Big lime	100
New Providence:	
Slate and shells	215
White slate	255
Total New Providence	470
Sunbury:	
Black slate	20

Log No. 2. O'Neal Farm, near Busseyville

	Feet
Chester, etc.:	
Big lime	150

New Providence:		
Sand	15	
White shale	10	
White sand	25	
Slate and shells	300	
White slate	133	
Total New Providence		483
Sunbury:		
Brown shale		20

A fairly full description of the New Providence as a whole having been given, it remains to describe three subdivisions of some importance. These are the Buena Vista sandstone member of the Cuyahoga formation, near the bottom, the Beaver Creek oil "sand," probably at a higher horizon in the Cuyahoga, and the Morris Mountain shaly member of the Logan formation at the top of the New Providence.

Buena Vista Sandstone Member. This member was named from Buena Vista, Ohio, a town on Ohio River between Vanceburg and Garrison, Ky. At that place the sandstone was formerly quarried for use in Cincinnati and elsewhere. The Buena Vista is a remarkably even-bedded rock, of very uniform grain, of a pleasing bluish gray color, of medium hardness. It is a very free working stone and easily dressed or sawed to required dimensions. The layers, too, are separated, at least where the writer has examined the stone, by shale partings which facilities quarrying. (See Plate 18.) The bottom layer of the Buena Vista is known as the "city ledge," supposedly on account of the fact that this layer was most extensively quarried at Buena Vista for use in Cincinnati. The Buena Vista is separated from the Sunbury shale by from 5 to 20 feet of shale, usually of soft, green, marly character, like the typical New Providence, but in Lewis County, near Tannery station on the Chesapeake & Ohio Railroad, some red shale occurs. This shale below the Buena Vista has been called by Hyde[21] the Henley shale member of the Cuyahoga.

[21] Loc. cit.

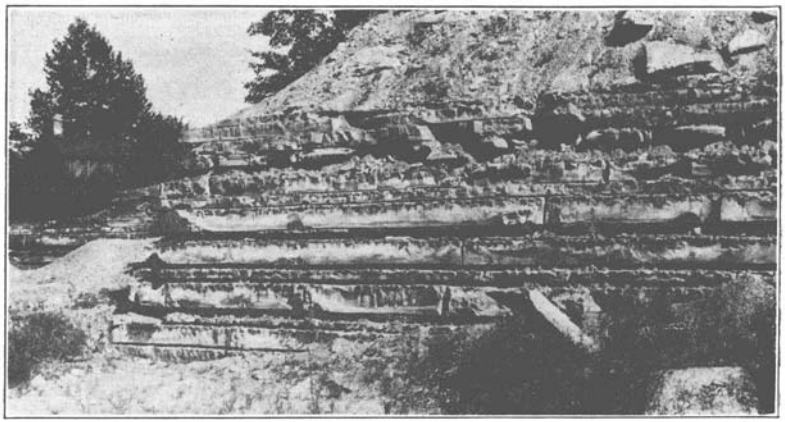

Plate 18. Buena Vista sandstone member of Cuyahoga in Bluestone quarry at Rockville on the Chesapeake & Ohio Railroad, 5 miles southwest of Morehead. Looking east.

The Buena Vista, probably the "city ledge," makes its southern appearance in the New Providence in the vicinity of Stanton, Powell county, about 2 miles north of which it was observed. It is there separated from the Sunbury by about 5 feet of shale. Northward the Beuna Vista member thickens, it is supposed gradually, by the introduction of successively higher layers, until at Bluestone quarry at Rockville, 5 miles southwest of Morehead, it is 18 feet 5 inches thick. Below is a detailed section:

Section of the Buena Vista Sandstone Member at Bluestone Quarry, Near Rockville, 5 Miles Southwest of Morehead, Rowan Co. This Section is Shown in Plate 18.

	Feet	Inches
Top of spur		
Soil	4	
Sandstone		8
Shale	3	
Sandstone		4
Shale	5	
Sandstone	1	
Shale	7	
	21	

Buena Vista sandstone member:		
Sandstone, top layer of quarry rock		11
Shale		2
Sandstone		10½
Shale		2
Sandstone		10
Shale		10
Sandstone	1	4
Shale		1
Sandstone		9
Shale		1
Sandstone	1	8
Sandstone red		3
Shale marly green		3
Sandstone red		2
Sandstone	1	7
Shale		5
Sandstone		7½
Shale		4½
Sandstone	1	9
Shale marly		8
Sandstone		4
Shale		3
Sandstone	1	4
Shale		2½
Sandstone ("City ledge")	2	6
Total Buena Vista member	18	5
Henley shale member of Hyde:		
Not exposed } Ten feet thick, all shale a mile or two northeast.		16
Shale green }		3
		19
Sunbury shale:		
Shale black		17
Berea sandstone		absent
Bedford shale:		
Clay, gray, indurated		20
Ohio shale:		
Shale, black (top 5 ft. or so exposed). Thickness unknown		

Although formerly extensively quarried for building stone at Buena Vista, Ohio, and at Tannery, in Lewis county, Ky., it is now, so far as known to the writer, quarried only in Ken-

tucky at Bluestone and at Farmers a few miles southwest of Bluestone. The rock quarried at Bluestone is mostly used for making cells in which to seal up coffins.

A specimen of a sponge, probably *Physospongia dawsoni,* was found by Prof. A. M. Miller in Lexington in sandstone of Buena Vista character from Rowan county. This fossil is known elsewhere only, at Crawfordsville, Ind., where it occurs in beds referred to the Keokuk horizon.

Beaver Creek Oil "Sand." The Beaver Creek oil "sand" is a rather massively bedded limestone, from 5 feet to 40 feet

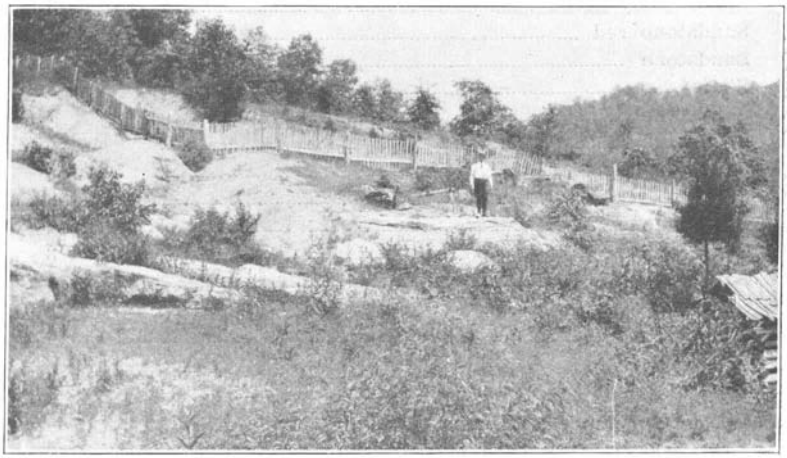

Plate 19. Beaver Creek oil "sand" in the midst of typical New Providence shale weathering to clay. Beaver Creek road, two miles southwest of Parnell in the Monticello quadrangle, Wayne County. Base of Fort Payne about edge of woods. Looking East.

above the bottom of the New Providence in Wayne County. It was named from Beaver Creek, on which it outcrops 3 miles southwest of Parnell and about 7 miles west of Monticello. This stratum is of especial importance as the oil reservoir of the Wayne County oil fields.

Where outcropping 1 3-4 miles southwest of Parnell it is 30 feet above the top of the black Chattanooga shale, the intervening rock being soft green shale, typical of the New Providence. It is overlain by about 60 feet of similar shale with thin fossiliferous limestone layers, from which a considerable

New Providence fauna has been collected. Its position in the New Providence shale is shown in Plate 19. The fossils are listed in list No. 6 beyond.

The distance of the Beaver Creek "sand" above the Chattanooga shale is not constant. About one mile southwest of its outcrop on Beaver Creek, just described, it is only 5 feet above the Chattanooga, the intervening rock being soft green shale. The immediately overlying beds, too, are very different, being mostly unfossiliferous limestone. This same variation in the position of the Beaver Creek "sand" relative to the black shale

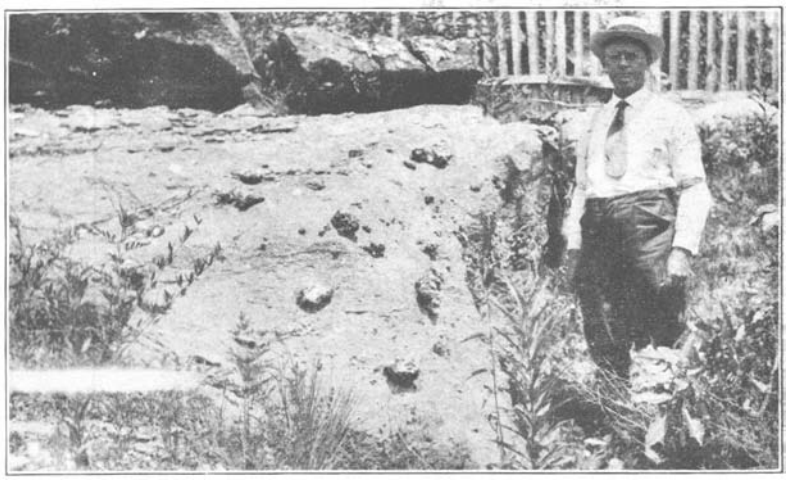

Plate 20. Nearer view of Beaver Creek oil "sand" showing quartz that apparently formed in cavities in the limestone. Same locality as No. 19.

has been demonstrated by drilling throughout the oil fields of Wayne County. (See sections 15, 16 and 18 of the section chart.)

The geographic extent of the Beaver Creek "sand" has not been determined, but it is known beneath a large part of Wayne County.

Where outcropping the Beaver Creek "sand" is a rather dense, bluish limestone, weathering yellow or brown owing to the presence of considerable iron. In places it has inclusions of drusy or cavernous quartz several inches in diameter. (See Plate 20.) Wherever the limestone has been found to be oil-

bearing it is cavernous or porous, a condition that doubtless accounts for the presence of the oil, which presumably was derived from the underlying petroliferous black shale.

Where exposed on Beaver Creek it is about 6 feet thick. On Cumberland River north of Monticello it is 4 feet thick. In the oil wells throughout Wayne County, as reported by

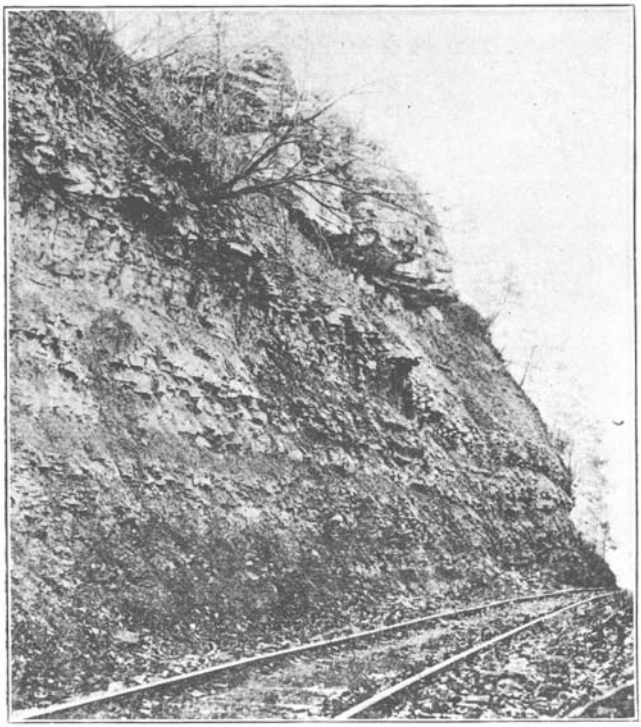

Plate 21. Deep cut on Kiniconick Branch, Chesapeake & Ohio R. R., four miles west of Carter, Carter County. Looking west. Morris Mountain member of the Logan formation, 40 feet thick, overlain by Ste. Genevieve limestone.

Munn,[22] it has been found to range from 1 to 25 feet thick, the prevailing range being about 8 to 18 feet. The Beaver Creek "sand" is sparingly fossiliferous. (See list No. 6.)

Morris Mountain Shaly Member of the Logan Formation.

The Morris Mountain shaly member is here named from Morris

[22] Munn, M. G., Oil fields of Wayne County, Ky. U. S. Geol. Survey Bull. No. 579.

Mountain, about 4 miles north of Stanton, Powell County, Ky., in the Beattyville quadrangle. It is composed mostly of shale, but includes subordinate amounts of sandstone and limestone or calcareous and fossiliferous layers. At Carter, Carter County, and at Deep Cut, 4 miles west of Carter, it has a bed of red shale at the top. Its general character is well displayed at Deep Cut, and Plate 21 is a photograph of this exposure. It is the topmost member of the Logan formation in eastern Kentucky. On Morris Mountain it is overlain by the St. Louis limestone and underlain by shelly sandstone of the Logan formation. Along most of its outcrop it varies in thickness from 40 to 100 feet, the prevailing thickness being about 50 to 60 feet. At Morehead it is only 15 feet thick. It is known in outcrop all the way from the latitude of Berea to that of Carter, in Carter County. Being a rather soft bed, it has yielded a soil free from stones and also has been so enriched by the wash from the overlying limestone that its area, a narrow belt extending along the steep hillsides, is extensively cleared and cultivated. This fact is well exhibited on Morris Mountain as shown in Plate 22.

The Morris Mountain member is probably the same as the Rushville group of Andrews in Ohio, but proof of this correlation is lacking. The greatest importance geologically of this member, however, is the fact that it carries the New Providence fauna from Berea to well across Lewis County, and doubtless includes the horizon as it does a large representation of the New Providence fauna of Kings Mountain. (See List No. 3.) This fact, combined with its physical continuity from a region where the New Providence is only about 300 feet thick to one in which it is 600 feet thick, proves conclusively the New Providence age of the full section between the Sunbury shale and the Maxville limestone of Ohio and northeast Kentucky, unless, as possible but not known, there are beds in the lower part of the section in northeast Kentucky older than typical New Providence.

Thickness of New Providence Group. In Jefferson County, Ky., the New Providence is 150 to 160 feet thick. It seems to hold this thickness south to Lebanon Junction and southeast to Fishing Creek, west of Somerset. On Beaver Creek, in Wayne County, its thickness is about 100 feet. On Meshack Creek, in

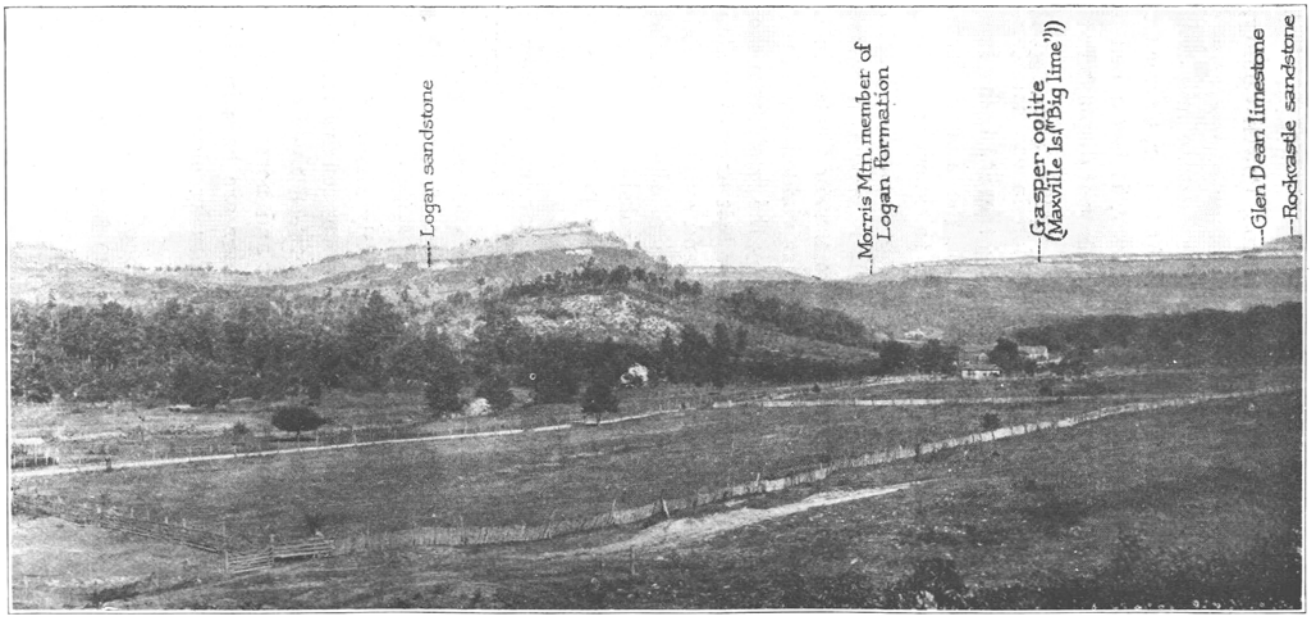

Plate 22. View of Morris Mountain, four miles north of Stanton, Ky. Looking north. Gasper oolite and Ste. Genevieve at top. Cleared and cultivated space on Morris Mountain member of Logan formation. Wooded slope on Logan and Cuyahoga formations. In center, and on left, top of Logan sandstone shows in woods below Morris Mountain member.

Monroe County, it is 60 feet thick. In the vicinity of Lebanon, Marion County, it is 258 feet thick. At Kings Mountain, in Lincoln County, it is about 300 feet thick, and at Brodhead it is practically the same. In the knobs east of Berea it is 400 feet thick and increases northward to a thickness of 600 feet in Lewis County. At Cumberland Gap, Va., it is about 300 feet, and at Jenkins, Letcher County, it is about 400 feet thick. Beneath the eastern Kentucky coal field the thickness of the New Providence is given in the oil-well logs in various counties as follows: Clay, 600 feet; Floyd, 400 to 450; Johnson, 365-445; Lawrence, 365-445; Knox, 300 to 350; Martin, 484; Menifee, nearly 600; Morgan, 456-535; Pike, 430; Wolfe, 500.* An eastward thinning of the New Providence is revealed by these figures in agreement with the results of observations on the outcrop on the western escarpment of Pine fountain and on the Cumberland escarpment in Virginia from Cumberland Gap to Russell County, Va. In general the maximum rate of thickening of the New Providence is in a northeast direction from southern Indiana. It thickens at a smaller rate eastward. The increase is coincident with the increase in arenaceous matter. The northeastward increase in thickness and in proportion of arenaceous sediment continues into central Pennsylvania, where the equivalent Pocono formation is, in Broad Top Mountain, 1400 feet thick and predominantly sandstone.

ECONOMIC PRODUCTS

The building stone of the Buena Vista member has already been described. In the vicinity of Louisville the clay shale of the New Providence, mixed with some more arenaceous layers, is utilized for brick. The brick, however, are subject to developing a white coating on weathering due to the efflorescence of soluble sulphates such as sodium or potassium sulphate from the soda and potash in the shale, of which analyses show about 1 per cent. of the former and nearly 5 per cent. of the latter.

Another product of even greater importance is petroleum. The Beaver Creek oil "sand" of Wayne County has already been described. In eastern Kentucky the Big Injun and Wier

*Jillson, W. R., Oil and Gas Resources of Ky. Ky. Geol. Survey, Series V., Bull. I., 1919.

sands are in the New Providence. In West Virginia and southwestern Pennsylvania the Big Injun sand has been one of the most productive oil reservoirs of the eastern United States.

AGE AND CORRELATION.

By the following lists of fossils it is proven that the New Providence shale, and with it the equivalent Cuyahoga and Logan formations of Ohio, is of the age of the Fern Glen formation of Missouri and southern Illinois or at the most that the New Providence does not include beds higher than lower Burlington.

This correlation is not a discovery of or original with the present author, but has been maintained by Ulrich, as is evidenced by many annotated labels accompanying the collections in the U. S. National Museum. Weller has expressed the same view. (Bull. G. S. A., 1910.) It is probable though that the lower Burlington is also represented in the New Providence, as attested by such forms as *Productus burlingtonensis* and *Spiriferella?* The present author's main contribution to the correlation of the New Providence is the proving that it is the equivalent of the rocks in Ohio lying between the Sunbury shale below and the Maxville limestone above, and as the equivalence of those formations with the Pocono formation of Pennsylvania is reasonably well supported by several lines of evidence, it follows that the Pocono of Pennsylvania, Maryland, Virginia and West Virginia, including the Big Injun oil sand, is also of the age of the New Providence and Fern Glen, and probably of the lower Burlington. The Fern Glen has been classed by Weller[23] as Kinderhook, but Ulrich[24] includes it in the Osage group as the basal formation, and Girty[25] seems inclined to the same view. From the Pocono on the east to the Fern Glen and lower Burlington on the west there seems clearly to be a continuous delta-like body of sediment diminishing rather uniformly in thickness and undergoing a change of facies through distribution of finer and finer sediment with increasing distance from

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[23] Weller. Stuart, Mississippian brachiopoda Mon. I, Illinois State Geol. Survey, p. 15, 1914.

[24] Ulrich, E. O., Revision of the Paleozoic systems. Bull. Geol. Soc. Am. Correlation chart of Mississippian series, 1911.

[25] Butts. Chas., Geology of Jefferson County, Ky. Ky. Geol. Survey Rept., pp. 114-145, 1915.

the eastern shore until at the western extreme the deposition was largely limestone. It is not improbable that the upper one-third to one-half of the Pocono, consisting of sandstone and conglomerate without marine invertebrates but with plants, is a fresh water deposit, only the lower part of the formation carrying marine fossils as in Broad Top Mountain, Pa.

List No. 2 gives the fossils occurring in the typical New Providence in the vicinity of Louisville, where the fossiliferous beds do not extend above the middle of the formation and at Buttonmould Knob go down nearly to the bottom. The material of list No. 9 is from exactly the same zone 100 miles southeast of Louisville. On the other hand, list No. 3 is of material from the very top of the New Providence where it is about 300 feet thick. The substantial identity of the faunas of lists Nos. 2 and 3 is evident from a comparison of the two lists. This proves the New Providence age of the beds at Kings Mountain. The fossils of list No. 10 carry the Kings Mountain horizon to a point 30 miles still farther northeast. Here the New Providence is at least 400 feet thick. Here also the Morris Mountain shaly member of the Logan, which carries this New Providence fauna, is well-defined, and from here it can be traced continuously along its outcrop by its topography, culture, stratigraphic relations, and fossils, to Deep Cut, on the Kinniconick Branch of the Chesapeake & Ohio Railroad 4 miles west of Carter, in Carter County. Lists 11 to 14 are of fossils from this member and other collections were made but are not listed. At Deep Cut the Morris Mountain member is about 600 feet above the bottom of the New Providence.

LIST NO.2.

Section No.7 of Section Chart.

List of Fossils From the New Providence Shale at Kenwood Hill, 5 miles south of Louisville, and at Buttonmould Knob, 12 miles south of Louisville, Kentucky, within the Typical Region of the New Providence.

Amplexus fragilis White and St. John.
Cyathaxonia arcuata Weller.
Cyathaxonia bordeni Greene.
Cyathaxonia cynodon Rafinesque and Clifford.
Cyathaxonia parva Greene.

Favosites valmeyerensis Weller.
Monilipora crassa McCoy
Monilipora gracilis Keyes?
Monilipora longi Rowley?
Striatopora carbonaria White.
Striatopora n. sp. Same in Burlington limestone.
Trachypora 2 species, 1 species at Kings Mountain.
Triplophyllum cliffordana E. & H.
Triplophyllum? declinis Miller
Triplophyllum? wortheni Weller
Trochophyllum verneuilliana E. & H.
Actinocrinus sp.?
Agaricocrinus sp.
Amphoracrinus sp.?
Barycrinus 3 sp.
Cactocrinus sp.?
Catillocrinus tennesseae (Troost) Shumard.
Cyathocrinus 7 sp.
Eretmocrinus yandelli (Shumard).
Gilbertsocrinus cf. tenuiradiatus Hall.
Halysiocrinus perplexus (Shumard).
Megistocrinus sp.?
Mespillocrinus 2 sp.
Metichthyocrinus tiaraeformis Springer.
Orophocrinus sp.
Platycrinus, discoid form, 2 sp. Discoid forms characteristically lower Burlington.
Platycrinus elongate form, 6 sp.
Poteriocrinus sp.?
Scaphiocrinus sp.
Schizoblastus decussatus (Shumard).
Schizoblastus granulosus (Roemer).
Stemmatocrinus trautscholdi Wachsmuth and Springer.
Synbathocrinus robustus Shumard.
Synbathocrinus angularis Miller and Gurley
Wachsmuthocrinus spinulosus (Miller and Gurley).
Anisotrypa hexagonalis Ulrich.
Cliotrypa ramosa new gen. and sp. Ulrich, Ms.
Cystodictya americana Ulrich.
Cystodictya lineata Ulrich.
Dendrotrypa pustulosa Ulrich. Ms.
Eridotrypa protensa Ulrich. Ms.
Fenestella albida var. richfieldensis Ulrich.
Fenestella compressa Ulrich.
Fenestella compressa var. nododorsalis Ulrich.
Fenestella exserta n. sp. Ulrich. Ms.

Fenestella meekana Ulrich.
Fenestella herrickana Ulrich.
Fenestella regalis Ulrich.
Fenestella triserialis Ulrich.
Fistulipora sigillata Ulrich Ms.
Leioclema floreale Ulrich. Ms.
Leioclema porosum Ulrich. Ms.
Leioclema sublimatum Ulrich. Ms.
Rhombopora exigua Ulrich.
Rhombopora incrassata Ulrich.
Stenopora scabra Ulrich. Ms.
Streblotrypa major Ulrich.
Streblotrypa spiralis Ulrich.
Vinella n. sp.
Hederella sp.
Brachythyris suborbicularis (Hall).
Chonetes shumardanus De Koninck.
Chonetes shumardanus var. 1.
C*honetes shumardanus* var. 2.
Chonetes shumardanus var. 3.
Delthyris novamexicana (Miller).
Orthotetes lens White?
Productus fernglenensis (Weller).
Pustula n. sp.?
Rhipidomella oweni Hall and Clarke.
Spirifer floydensis Weller.
Spirifer imbrex Hall?
Spiriferina subelliptica McChesney.
Myalina sp.?
Igoceras sp.? cf. *pabulocrinus* (Owen).
Platyceras equilaterae Hall.

LIST NO. 3.

Section No. 22 of Section Chart.

List of Fossils from Kings Mountain Tunnel, Lincoln County.

Amplexus fragilis White and St. John?
Cyathaxonia sp.?
Cyathaxonia cynodon Rafinesque and Clifford
Monilopora crassa McCoy.
Monilopora gracilis Keyes?
Monilopora longi Rowley?
Striatopora sp. like *S. carbonaria* but somewhat smaller.
Striatopora smaller than above.
Trachypora sp. No. 1. Same at Buttonmould Knob.
Triplophyllum (Zaphrentis) cliffordana (E. & H.)

Trochophyllum verneuiliana (E. & H.)
Zaphrentis spinulose var.
Bythoporoid bryozoan. Same at Buttonmould Knob.
Cliotrypa ramosa Ulrich. Ms.
Cystodictya americana Ulrich.
Cystodictya lineata Ulrich.
Cystodictya pustulosa Ulrich.
Cystodictya cf. C. ziczac Ulrich.
Dendrotrypa pustulosa Ulrich Ms.
Evactinopora radiata Meek and Worthen.
Fenestella compressa Ulrich.
Fenestella compressa var. *nododorsalis* Ulrich.
Fenestella germana Ulrich Ms.
Fenestella multispinosa Ulrich.
Fenestella regalis Ulrich.
Fenestella near *rudis* Ulrich.
Fenestella triserialis Ulrich.
Leioclema sublimatum Ulrich Ms.
Meekopora aperta Ulrich.
Rhombopora angustata Ulrich.
Rhombopora exigua Ulrich.
Rhombopora gracilis Ulrich.
Rhombopora incrassata Ulrich
Stenopora scabra Ulrich. Ms.
Streblotrypa major Ulrich.
Streblotrypa spiralis Ulrich.
Thamiscus divaricans Ulrich.
Thamiscus polyporides Ulrich.
Thamiscus sculptilis Ulrich.
Brachythyris suborbicularis (Hall)
Chonetes shumardanus De Koninck
Cliothyridina glenparkensis Weller.
Cyrtina sp.
Delthyris novamexicana (Miller.)
Orthotetes crenistria Phillips?
Productus fernglenensis Weller.
Pustula alternata Norwood and Pratten?
Rhipidomella oweni (Hall and Clarke).
Spirifer imbrex Hall?
Spiriferella plena (Hall)?
Platyceras equilaterale Hall.

LIST NO. 4.

List of Fossils from Railroad Cut, about one mile south of Petrolia, Allen County.

Plate No. 13.

Cyathaxonia cynodon R. & C.
Cyathaxonia sp.?
Monilipora (Cladochonus) gracilis Keyes.
Triplophyllum cliffordana E. & H.
Trochopyllum verneuiliana E. & H.
Zaphrentis cannonensis Winchell
Cystodictya lineata Ulrich.
Fenestella compressa Ulrich.
Leioclema sublimatum Ulrich.
Rhombopora exigua Ulrich.
Rhombopora incrassata Ulrich.
Stenopora scabra Ulrich Ms.
Streblotrypa spiralis Ulrich.
Athyris lamellosa L'Eveille
Brachythyris suborbicularis (Hall).
Chonetes shumardanus De Koninck.
Rhipidomella oweni Hall and Clarke.
Spirifer imbrex Hall?
Igoceras cf. *pabulocrinus* (Owen.)

LIST NO.5.

List of Fossils from Meshack Creek, Monroe County, about 10 miles east of Tompkinsville. From 50 feet of beds next above Chattanooga Shale.

Section No. 14, Section Chart.

Cyathaxonia bordeni Greene.
Monilopora crassa McCoy.
Agaricocrinus. Undescribed sp. of Burlington affinities.
Crinoid with stem plates with wide thin flanges. Same on Beaver Creek.
Stemmatocrinus trautscholdi Wachsmuth and Springer
Fenestella regalis Ulrich?
Pinnatopora flexuosa Ulrich.
Rhipidomella oweni Hall and Clarke
Igoceras cf. *pabulocrinus* (Owen.)

LIST NO. 6.

List of Fossils from Beaver Creek, in road 1¾ miles southwest of Parnell, Wayne County, Ky., in Monticello Quadrangle. From 60 feet of Shale between the Beaver Creek Oil "Sand" (Limestone) below and the Base of the Fort Payne Formation above, and from the Beaver Creek "Sand" 30 feet above Chattanooga Shale, and separated therefrom by Soft Green Shale weathering to clay.

Section No. 15 of Section Chart.

Crinoid with stem plates with wide thin flanges. Same on Meshack Creek.
Monilopora crassa McCoy.
Monilopora longi (Rowley)?
Trachypora sp.? cells in range nearer together than in T. sp. No. 1 from Kenwood Hill and Kings Mt.
Triplophyllum cliffordana (E. & H.)
Cystodictya americana Ulrich.
Cystodictya lineata Ulrich.
Fenestella compressa Ulrich.
Pinnatopora flexuosa Ulrich.
Pinnatopora vinei Ulrich.
Pinnatopora sp.
Stenopora scabra Ul. Ms.
Streblotrypa major Ulrich?
Brachythyris suborbicularis (Hall)
Spiriferina depressa Herrick.
Cypricardinia scitula Herrick?
Igoceras sp.? large.

From Beaver Creek oil "sand" (limestone).

Actinocrinus, Keokuk form.
Agaricocrinus undes sp. Burlington type.
Cystodictya americana Ulrich.
Cystodictya lineata Ulrich.
Ptilopora cylindrica Ulrich?
Ambocoelia.
Athyris lamellosa L'Eveille?
Cyrtina.
Reticularia.
Spirifer.
Spiriferina depressa Herrick?

LIST NO. 7.

List of Fossils from Beaver Creek, 1¼ miles southwest of Parnell, Wayne County, Ky., in the Monticello Quadrangle. Top of New Providence Shale here about 100 feet above the Chattanooga Shale.

Section No. 16 of Section Chart.

Cystodictya lineata Ulrich.
Fenestella albida Hall?
Fenestella compressa Ulrich?
Fenestella germana Ulrich Ms.
Fenestella herrickanna Ulrich?
Fenestella meekana Ulrich.
Fenestella near *multispinosa* Ulrich.
Fenestella regalis Ulrich.
Fenestella near *serratula* Ulrich.
Fenestella triserialis Ulrich.
Fenestella, several other species.
Pinnatopora flexuosa Ulrich.
Pinnatopora youngi Ulrich.
Polypora sp. 1.
Polypora sp. 2.
Streblotrypa spiralis Ulrich.
Chonetes sp. 1. Same on Fishing Creek.
Chonetes sp. 2. Coarser than sp. 1.
Cliothyridina sp.?
Nucleospira barrisi White?
Orthotetes lens (White)?
Productus semireticulatus Martin.
Productella concentrica Hall?
Spiriferina depressa Herrick.
Cypricardinia scitula Herrick.
Goniatites?
Phaethonides spinosus Herrick.
Ostracod like *Primitia.*

LIST NO. 8.

List of Fossils from West Bluff of Fishing Creek, about 5 miles west of Somerset, Pulaski County, Ky., on Columbia Pike. From the Top of the New Providence Shale.

Section No. 21, Section Chart.

Cystodictya lineata Ulrich.
Fenestella aperta Hall?
Fenestella germana Ulrich Ms.

Fenestella near *herrickana* Ulrich.
Fenestella meekana. Ulrich.
Fenestella regalis Ulrich.
Fenestella near *serratula* Ulrich.
Meekopora aperta Ulrich.
Pinnatopora flexuosa Ulrich.
Pinnatopora youngi Ulrich.
Polypora sp.
Brachythyris suborbicularis (Hall).
Chonetes sp.? same on Beaver Creek.
Cyrtina sp.? cf. Herrick Bull., Denison Univ., Vol. 3, p. 47, pl. 8, fig. 18
Delthyris novamexicana (Miller).
Nucleospira?
Orthotetes lens (White)?
Productus semireticulatus Martin?
Pseudosyrinx gigas Weller
Spirifer floydensis Weller.
Spiriferina depressa Herrick.
Aviculopecten much like *A. duplicatus* of the Chemung of western New York.
Goniophora like G. *truncata* of the Hamilton of New York.
Macrodon like *M. hamiltoniae.*
Proetus near *ellipticus* Meek-Worthen.

LIST NO. 9.

Columbia Pike, Pulaski Co., Ky., abandoned site of road on east side of Fishing Creek. Basal 50 feet of New Providence Shale.

Section No. 21, Section Chart.

Cyathaxonia arcuata Weller.
Cyathaxonia bordeni Greene.
Cyathaxonia cynodon Edwards and Haime.
Cyathaxonia parva Greene.
Favosites valmeyerensis Weller.
Monilipora crassa McCoy.
Monilipora gracilis (Keyes)?
Triplophyllum cliffordana (E. & H.)
Trochophyllum verneuiliana E. & H
Rhombopora angustata Ulrich?
Rhombopora exigua Ulrich.
Rhombopora gracilis Ulrich?
Streblotrypa major Ulrich.
Streblotrypa sp.?
Brachythyris suborbicularis (Hall).
Chonetes shumardanus De Koninck. Typical.

Delthyris novamexicana (Miller).
Orthotetes lens (White)?
Productus semireticulatus Martin?
Rhipidomella oweni Hall and Clarke
Spirifer floydensis Weller.
Spiriferina depressa Herrick?
Cypricardinia scitulus Herrick?
Igoceras sp.

LIST NO. 10.

List of Fossils from about 60 feet of Beds between 40 and 100 feet below the top of the New Providence Shale. Thin, impure, Limestones in the Lower Half. Near top of Ridge, on north side, crossed by the road from Red Lick to Owsley Branch, about 8 miles east of Berea, Madison Co., Ky. Morris Mountain Shaly Member of Logan Formation.

Section No. 36, Section Chart.

Cyathaxonia arcuata Weller.
Cyathaxonia bordeni Greene.
Monilopora crassa McCoy.
Triplophyllum cliffordana (E. & H.)
Trochophyllum verneuiliana (E. & H.)
Schizoblastus aff. *sayi* Shumard.
Cystodictya lineata Ulrich.
Evactinopora radiata M. & W.
Fenestella near *serratula* Ulrich.
Fenestella regalis Ulrich.
Leioclema n. sp.?
Rhombopora angustata Ulrich.
Rhombopora exigua Ulrich.
Rhombopora gracilis Ulrich.
Streblotrypa major Ulrich.
Athyris lamellosa L'Eveille.
Camarotoechia marshallensis Winchell?
Chonetes shumardanus De Koninck.
Cyrtina n. sp.
Cyrtina sp.?
Nucleospira?
Orthotetes crenistria Phillips.
Productus semireticulatus Martin.
Productus fernglenensis Weller.
Productus, undet. small species.
Pustula alternatus Norwood and Pratten.
Reticularia cooperensis Weller?

Rhipidomella diminutiva Rowley.
Spirifer milleranus n. sp. Butts.
Spirifer imbrex Hall?
Spirifer floydensis Weller?
Spiriferella?
Spiriferina depressa Herrick.
Crenipecten cancellatus Meek.
Cypricardinia scitulus Herrick.
Igoceras sp.?
Platyceras cf. *paralius* White and Whitfield.

LIST NO. 11.

List of Fossils from Rothwell, Menifee County, about 100 feet below St. Louis Limestone.

Section No. 39, Section Chart.

Amplexus cf. *fragilis.* White and St. John.
Trochophyllum verneuilana (E. & H.)?
Zaphrentis sp.?
Cyrtina sp.?
Dielasma sp.?
Orthotetes crenistria Phillips?
Productus aff. *arcuatus* Hall. Larger, coarser ribs.
Productus burlingtonensis Hall.
Productus sampsoni Weller.
Productus small non costate sp. with concentric wrinkles like *productella.*
Spirifer milleranus n. sp. Butts.
Spirifer biplicatus Meek (Not Hall).
Spiriferina depressa Herrick,
Conularia.

LIST NO. 12.

List of Fossils from Highway about 2½ miles west of Frenchburg, Menifee County, Ky., 20 feet below St. Louis Limestone.
Morris Mountain Shaly Member of Logan Formation.

Section No. 39, Section Chart.

Athyris lamellosa L'Eveille,
Camarotoechia marshallensis Winchell?
Chonetes shumardanus De Koninck.
Orthotetes crenistria Phillips.
Productus burlingtonensis Hall.
Productus near *sampsoni* Weller.
Spirifer imbrex Hall?
Spirifer milleranus n. sp. Butts.
Crenipecten sp.?
Paleoneilo sulcatina Winchell.

LIST NO. 13.

List of fossils from Carter and Olive Hill, Greenup Co., Ky., just under Ste. Genevieve limestone.

Section No. 41, Section Chart.

Calathospongia?
Palaecis?
Zaphrentis or *triplophyllum.*
Camarotoechia aff. *sappho* H.
Chonetes shumardanus, sulcate var. slightly coarser *costae* than type. Probably a new species.
Orthotetes crenistria Phillips?
Ptychospira sexplicata White and Whitfield?
Productus sampsoni Weller.
Reticularia sp.
Rhipidomella diminutiva Rowley?
Spirifer n. sp.=Sp. *biplicatus* Herrick not Hall.

LIST NO. 14.

List of fossils from Deep Cut on Kinniconnick Branch of Chesapeake and Ohio Railroad, 4 miles west of Carter, Carter County, Ky. From within 40 feet below the bottom of the Ste. Genevieve limestone.

Morris Mountain Shaly Member of Logan Formation.

Section No. 43, Section Chart.

Athyris lamellosa L'Eveille.
Camarotoechia sp.
Chonetes shumardanus De Koninck, sulcate var.
Dielasma sp.
Leptaena.
Orthotetes crenistria Phillips?
Productus burlingtonensis Hall.
Productus near *sampsoni* Weller.
Productus concentricus Herrick?
Spirifer imbrex Hall?
Spiriferella plena Hall?

LIST NO. 15.

List of fossils from farm of John R. Lewis, one-half mile about east of Tannery Station, on Kinniconick branch of the Chesapeake and Ohio Railroad, Lewis Co., Ky., Cuyahoga Formation of Hyde, 150 feet above Sunbury shale.

Section No. 43 Section Chart.

Calathospongia redfieldi Hall?
Ptilopora sp.?
Ambocoelia sp.

Camarotoechia aff. *saphho* Hall. Common Waverly form.
Chonetes shumardanus, var. with shallow sinus in ventral valve and 5 costae to 1 mm. Probably new species.
Cyrtina sp. same as figured by Herrick, Bull. Denison University, Vol. 3, p. 47, Pl. 48, Fig. 18.
Leptaena.
Orthotetes crenistria Phillips.
Productella near P. *sublaevis* Weller.
Productus arcuatus Herrick, possibly not Hall.
Productus arcuatus type but larger and with angular instead of rounded ribs.
Productus cf. *shumardanus* Herrick.
Rhipidomella diminutiva Rowley?
Spirifer biplicatus Herrick not Hall.
Spirifer osagensis Swallow?
Spirifer striatiformis Meek.
Spiriferina depressa Herrick.
Aviculopecten sp.
Cypriicardinia scitula Herrick.

Besides the fossils listed a few others should be mentioned and comments on a few new forms should be made.

A considerable collection was obtained from the top of the New Providence on a knob just northwest of Lebanon Junction, Bullitt county, Ky. This collection contains, in addition to many of the common forms, a small *Rhipidomella* probably *R. diminutiva, a Mesoblastus, Paleacis cavernosa,* Miller, and *Ptychospira sexplicata,* White and Whitfield. From the thin sandstone near the middle of the New Providence about 2 miles southeast of Lebanon (see p. 36, and Pl. 8) a small new species of *Chonetes, Delthyris novamexicana* (Miller), *Productus semireticulatus,* Martin, *Spirifer floydensis,* Weller, were collected. At Sciotoville, Ohio, at water level on Ohio River, *Productus raricostatus* Herrick and *Spirifer striatiformis* occur probably in and near the base of the sandstone of the Logan formation. *Spirifer striatiformis* occurs also in Jackson County, Ky., presumably at about the same horizon. Some fine specimens from Jackson County are in the collection of the University of Kentucky and were kindly loaned to the writer by Prof. A. M. Miller for identification. Besides the specimen of *Calathospongia* of list No. 15, a good specimen was found in sandstone float in the bed of the stream just north of Morehead.

A number of Pelecypods have been collected, particularly from the sandstone facies on Minerva Mountain and Sweet Lick Knob at Irvine. Species of *Allorisma,* pectenoid shells, *Leptodesma,* and *Paleoneilo,* hardly good enough for specific identification were collected.

One of the most common fossils, although confined to the sandstone facies of the New Providence, is *Taonurus*. (See Pl. 23.) This is present in nearly every foot of the wholly sandstone facies of the New Providence in Lewis County, from the very basal layer (the "City ledge") of the Buena Vista mem-

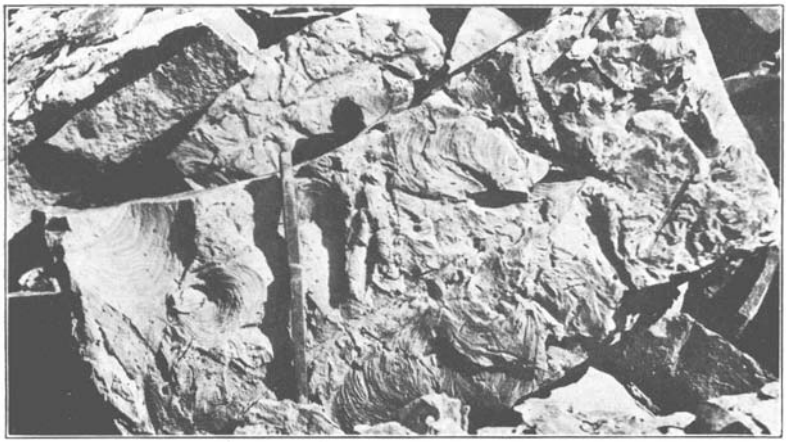

Plate 23. Block of sandstone of the Buena Vista member of the Cuyahoga formation, showing *Taonurus.* Bluestone quarry at Rockville on the Chesapeake & Ohio Railroad, five miles southwest of Morehead.

ber to the top of the Morris Mountain member in Deep Cut, on the railroad 4 miles west of Carter. It is universally present in the sandstone of the New Providence throughout Kentucky. It is believed to have been made by a big worm burrowing in the sand. It is entirely characteristic of the New Providence, the writer never having seen a specimen in the higher Mississippian formations of Kentucky or Tennessee. Another form of burrow is shown in plate 24, possibly made by the same worm as that which made the *Taonurus* markings.

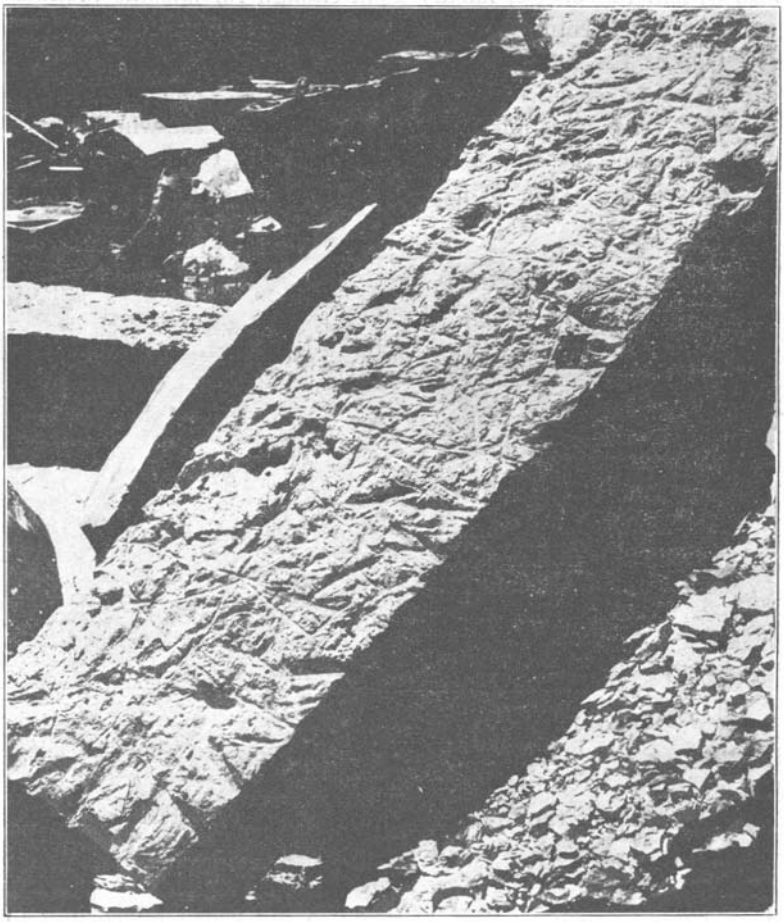

Plate 24. Block of sandstone of Buena Vista member showing worm trails. Bluestone quarry at Rockville, five miles southwest of Morehead.

NOTES ON NEW AND OLD SPECIES OF SPIRIFER

SPIRIFER MILLERANUS, N. SP., BUTTS

Plate 25, Figs. 1-3 and Plate 26, Figs. 3 and 4.

Dimensions. Seventy-five mm. long, about 100 mm. broad, and 44 mm. thick.

Pedicle valve most convex near the middle whence it curves more gently both to the front margin and nearly to the posterior margin. Curves abruptly to the lateral margins but flattens slightly near the cardinal extremities. Area of mould relatively low, about 12 mm. high at the beaks and apparently holding nearly the same width well out toward the extremities of the hinge line. Sinus shallow, with indefinite lateral boundaries. Costae coarse, 10 to 12, in 25 mm. near the front, adjacent to the sinus. So far as preserved, which is on the front two-thirds of both values, the costae do not bifurcate but increase in width toward the front. Muscle scar lozenge shaped, 1 inch long by three-fourths of an inch broad.

Brachial valve curves gently, the curvature increasing gently toward the front, apparently abruptly deflected at the beak to the margin of the very narrow area. Fold raised but slightly above the surface of the rest of the valve in the posterior two-thirds but is fairly prominent in front, not sufficiently so, however, to form a nasute extremity. The crest of the fold apparently straight from the posterior deflection to the front extremity. Costae the same as on the pedicle valve.

The surface ornamentation of both valves as shown in Figs. 3 and 4, Plate 26, consists of radial striae, of which there are about 12 to 14 to each rib in the specimen figured in Fig. 3, and as many as 18 to a rib in the specimen figured in Fig. 4. As shown in Fig. 4, there are also very much finer transverse striae.

This species is apparently closely related to Spirifer logani of the Keokuk. It differs in having coarser costae, 10 to 12 in 25 mm. where Sp. logani has 14 to 16, a much more shallow sinus in the pedicle valve and a less prominent fold on the brachial valve. The shape of the muscle scar is different from that of Sp. logani. The relative proportions of the shell are about the same and the ornamentation seems to be exactly the same.

Horizon and Locality. Sandstone in Logan formation and Morris Mountain shaly member of Logan.

Hill south of Redlick Creek, 8 miles east of Berea; head of Owsley Creek; Morris Mountain 4 miles north of Stanton; Rothwell. The specimen figured as the type, Plate 25, is reported to have been obtained in Bath County. It is an internal mould posteriorly but the front part seems to be a pseudomorph of the shell in iron oxide. Its exact horizon is unknown, but it must be in the New Providence group and probably in the Logan formation. The specimen belongs to the collection of the University of Kentucky and was kindly loaned by Prof. A. M. Miller after whom it is named. A specimen of this species has recently been obtained at Dump Creek, Russell county, Virginia, from the top of the Grainger shale, which is in part of the age of the New Providence group, in beds that may represent the Logan formation.

SPIRIFER IMBREX HALL?

A common Spirifer in the New Providence group has a shell marked with strong, closely spaced, traverse lines, made by imbricating lamellae the margins of which, arching forward upon the costae give the shell a wave-marked appearance which at once attracts the attention. No perfect specimen of this species has been obtained but fragmentary material is common and widely distributed.

The species seems to be about 2 to 3 1-2 times as broad as long. The specimen shown in Fig. 2, Plate 27, is 30 mm. long and 75 mm. broad to the extremities of the mucronate extensions of the hinge. One specimen is 100 mm. broad and the pedicle valve shown in Figs. 1 and 2, Plate 26, indicates an individual of equal or even greater breadth. The thickness of the larger individuals seems to be about 25 mm.

The pedicle valve has a rather broad sinus of moderate depth and with well-defined boundaries. The area of the pedicle valve at the beak seems to be about one-sixth as high as long. It decreases in height slowly for a distance from the beak and then holds the same height for a distance, then tapers to the cardinal angles. The brachial valve has a rather high and angular fold. Both sinus and fold have from 8 to 12 costae.

The ribs number about 24 in 25 mm. Besides the transverse wavy edges of the lamellae, the surface is marked by fine radial striae and by still finer transverse striae which seem to be crowded upon the central part of each lamella.

This shell seems to be more like Spirifer imbrex than any other described species. It agrees in most respects with specimens in the National Museum from the Lake Valley limestone of New Mexico, that have been identified as Spirifer imbrex. The type of the species is a single brachial valve from the Burlington limestone of Iowa. No pedicle valve from the Burlington limestone is known. In view of the lack of material for comparison it seems best to refer this species with some doubt to Spirifer imbrex, although it may later be found to be a distinct species.

Horizon and Locality. Lower half of New Providence shale, Buttonmould Knob. Top of New Providence, Lebanon Junction, Bullitt County; and Kings Mountain, Lincoln County. Morris Mountain shaly member of the Logan formation, south of Redlick Creek 8 miles east of Berea; Frenchburg, Menifee County; and Deep Cut 4 miles west of Carter, Carter County; also top of the Grainger shale, Dump Creek, Russell County, Va.

SPIRIFER OSAGENSIS SWALLOW.

The specimen identified as *S. osagensis* collected at Tannery, Lewis County, from about 150 feet above the Sunbury shale, although not preserving the entire outline of the shell, does preserve the ornamentation perfectly, which agrees with that described by Weller as characterizing that species. This form, if really the *osagensis,* indicates a Kinderhook horizon and suggests the possibility that the beds here may be somewhat older than the base of the typical New Providence. The *Productella* near *sublaevis* and *Productus arcuatus* of the list point in the same direction.

As indicated at the beginning of this section the nearly complete equivalence of the New Providence and Fern Glen is indicated by the fossils listed. In support of this conclusion list No. 16 of identical species from the Fern Glen is given.

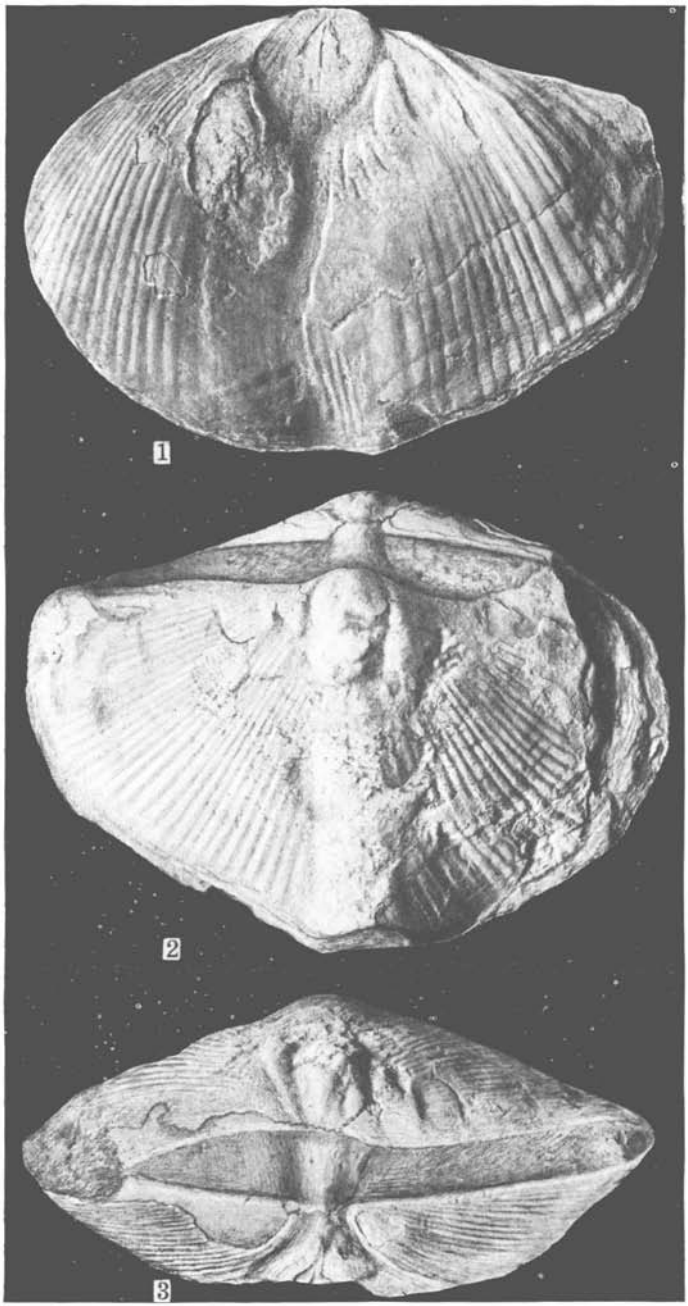

PLATE 25.

Spirifer milleranus, n. sp., Butts.

Figs. 1-3. Pedicle, brachial, and posterior views of a specimen which is an internal mould posteriorly but apparently a pseudomorph in iron oxide anteriorly. Slightly reduced. New Providence formation, Bath County.

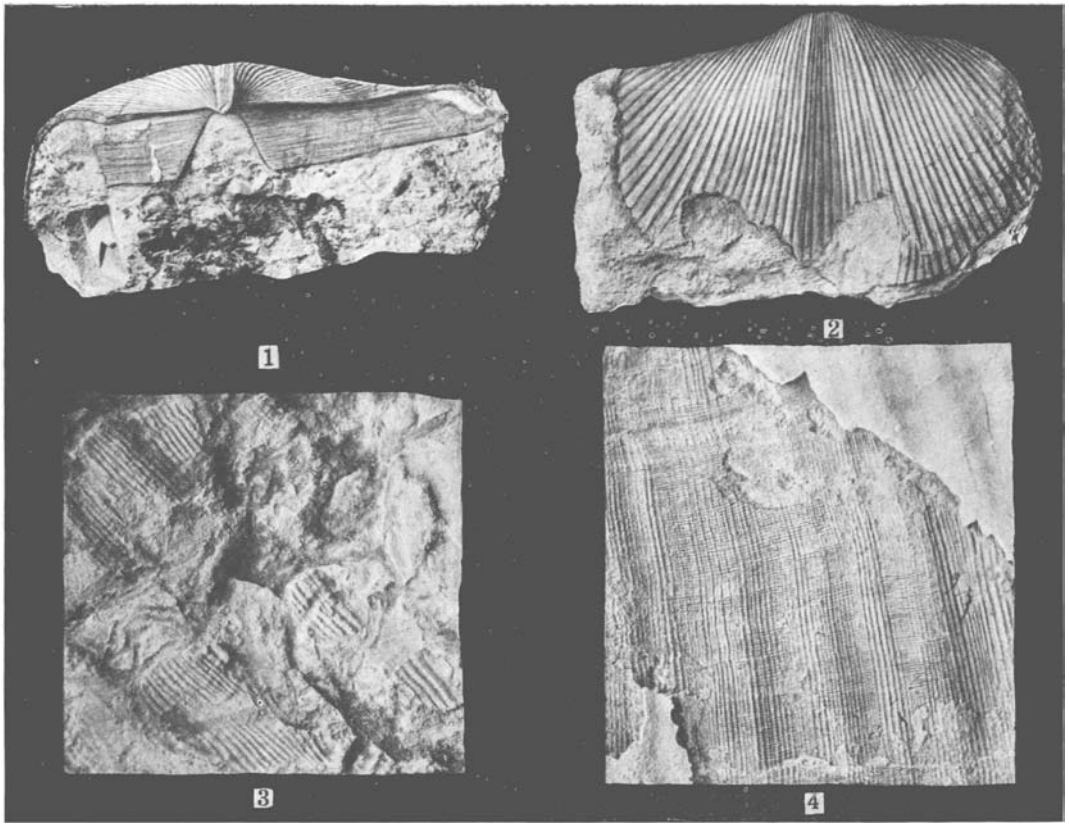

PLATE 26. Figs. 1-2. Spirifer imbrex, Hall? Pedicle and posterior views, slightly reduced. Top of New Providence, King's Mountain, Lincoln County. Figs. 3-4 x 5½. Spirifer milleranus n. sp. Enlarged views showing the surface ornamentation. Fig. 3. Part of surface of brachial valve shown in Plate XXV, Fig. 4. Part of surface of another specimen. Morris Mountain shaly member of Logan formation.

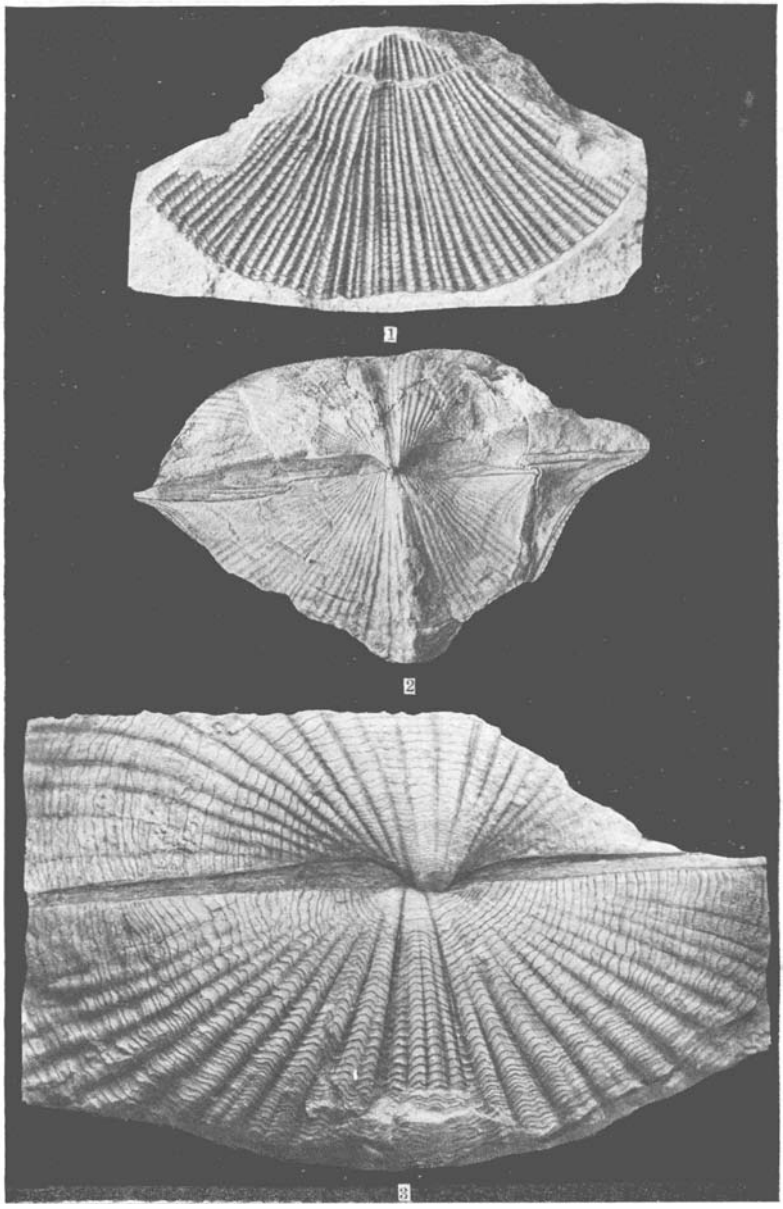

PLATE 27. Spirifer imbrex, Hall? Fig. 1 x: 1¾. Enlarged view of natural mould of brachial valve showing ornamentation. Fig. 2. Brachial valve of imperfect specimen, slightly reduced. Top of New Providence. King's Mountain, Lincoln County. Fig. 3 x: 3½. Enlarged posterior view of a specimen preserving the shell and ornamentation. Top of New Providence, Lebanon Junction, Bullitt County.

LIST NO. 16.

List of Fossils from the Fern Glen Formation of eastern Missouri and southern Illinois, and from contemporaneous beds in the St. Joe limestone member of Boone limestone at War Eagle, Arkansas, and elsewhere in Arkansas and Missouri, that occur also in the New Providence shale. Partly from material in the U. S. National Museum collected and identified by Ulrich and partly from Weller, Bull. G. S. A., Vol. 20, pp. 235-332, Pls. 10-15, 1909

Cladochonus (Monilopora?) americana Weller.
Cyathaxonia arcuata Weller.
Favosites valmeyerensis Weller.
Monilopora crassa McCoy.
Trachypora sp. 2.
Triplophyllum cliffordana E. & H.
Zaphrentis (Triplophyllum) wortheni Weller.
Schizoblastus (Pentremites) decussatus Shumard.
Cystodictya lineata Ulrich.
Cystodictya n. sp. same at Kings Mountain.
Dendrotrypa pustulosa Ulrich Ms.
Evactinopora sexradiata Meek and Worthen.
Fenestella albida Hall var. *richfieldenses* Ulrich.
Fenestella compressa var. *nododorsalis.*
Rhombopora angustata Ulrich.
Rhombopora incrassata Ulrich.
Athyris lamellosa L'Eveille.
Delthyris novamericana (Miller).
Leptaena
Productus fernglenensis Weller.
Productus sampsoni Weller.
Ptychospira sexplicata White and Whitfield.

The list includes 22 species, all of which except *Evactinopora sexradiata,* are common to the New Providence. The genus Evactinopora, represented in the New Providence at Kings Mountain by *E. radiata,* is so rare and peculiar that any member of the genus is about as good evidence as an identical species.

UNCONFORMITY AT TOP OF NEW PROVIDENCE GROUP

The New Providence is succeeded in different areas by formations of different ages, ranging' from the Fort Payne, of Keokuk age, in southern Kentucky, to the Ste. Genevieve limestone or the Pottsville formation in northern Kentucky. The nearest approach to a complete sequence is in central Kentucky,

where rocks of Keokuk age succeed the New Providence. Even here, however, there may be a break in the sequence, due to the absence of the upper part of the Burlington limestone, no evidence for the presence of which has been found in Kentucky. In localities where the New Providence is succeeded by the Pottsville, as south Portsmouth, the break is much greater, being represented by the full thickness of the Fort Payne and the Meramec and Chester groups of the Mississippian and by whatever lower part of the Pottsville may be absent. The combined thicknesses of the absent formations would amount at the least to over 2,000 feet. (See fig. 2 p. 183.)

The simplest explanation of this condition is that the absence of the formations from their place in the general stratigraphic succession is the result of dry land, or of very shallow water so that no sediments were transported to the areas where the formations are now absent, or that, during the time of the deposition of these formations elsewhere, deposition in the areas of absence was prevented by currents. Another explanation is that the absent rocks were deposited and subsequently the areas where they are now absent were elevated above sea level and the formations were removed by erosion before the formation now overlying the New Providence in any area was deposited. As a matter of fact the present conditions are probably the result of a succession of oscillations producing also minor unconformities in the mass of limestone overlying the New Providence. These conditions are much too complicated for an attempt at their detailed description to be made in this place.