CHAPTER 4.

ROCKS OF KEOKUK AGE

The rocks included under this head are so treated on account of their regional variability, as will appear from their description. In Jefferson County and the surrounding region of Kentucky they include the following units in ascending order: The Kenwood sandstone, the Rosewood shale and the Holtsclaw sandstone. In southern Kentucky they are included in the Fort Payne formation.

Limits. The bottom of the rocks of Keokuk age is usually well enough defined, since in most of their extent they lie upon quite different kinds of rock, as the green shale of the New Providence or the black Ohio shale. In places the unconformity at the base of the Keokuk rocks is manifested by a slight discordance of bedding. Such a locality is on the railroad 1 mile south of Petrolia, Allen County, where the contact of the Fort Payne on the New Providence is exposed. The slight angular unconformity is plainly shown in the photograph, Plate 28. The top of the Keokuk is in places less satisfactorily determinable. This is particularly true of the region south of Louisville. Here the writer in 1914 placed the top of the Keokuk at the top of the Holtsclaw sandstone. This horizon is marked locally by either a layer of oolite 2 feet thick or by a glauconitic green clay. Recently, however, it has been ascertained that there is in that general region south of Louisville, above the oolite and glauconite, 30 to 60 feet of limestone rather more like the Keokuk than the Warsaw and also carrying a few fossils elsewhere assigned to the Keokuk. This discovery has cast some doubt as to the correctness of the location of the boundary at the top of the Holtsclaw. However, since the presence of the oolite and glauconitic clay may indicate a slight break, and since there is a glauconitic layer of rather wide geographic extent at apparently the same stratigraphic horizon in Rockcastle, Madison, and Jackson counties, and as a thin layer of such rock serves excellently as a boundary, it has been decided to adhere to the upper limit of the Keokuk as adopted in the Jefferson County report referred to and include the doubtful beds in the War-

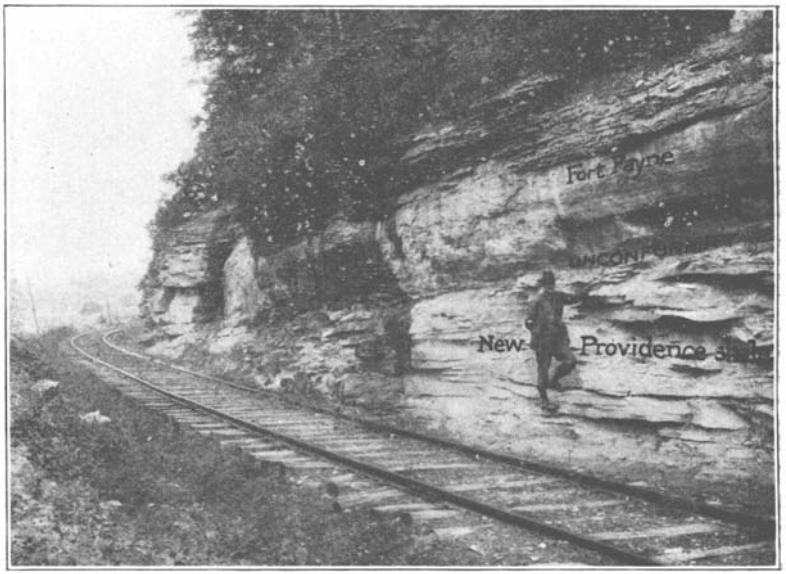

Plate 28. Contact of New Providence and Fort Payne formations showing a slight angular unconformity. Prof. Arthur M. Miller holds hammer on contact. Top of New Providence here limestone with partings of characteristic green shale.

saw formation. This boundary will be further discussed in the section on age and correlation and in the description of the Warsaw formation.

Distribution. The Keokuk rocks underlie all of Kentucky west of the "Knobs" region of Jefferson and Bullitt counties and south of the crest of the north facing escarpment (Muldraughs Hill), bounding the Bluegrass region on the south. In southeastern Kentucky they extend north to a limit approximately represented by a line drawn from a point a few miles north of Mount Vernon, in Rockcastle County, to a point unknown but probably only a short distance north of Cumberland Gap at the southeast corner of the state. About 5 miles northeast of Mt. Vernon the Keokuk is represented by about 2 feet of limestone between the New Providence and the Warsaw and at Cumberland Gap by 15 feet of chert between the New Providence and the Ste. Genevieve. This chert is of typical Fort Payne character. At Pineville the

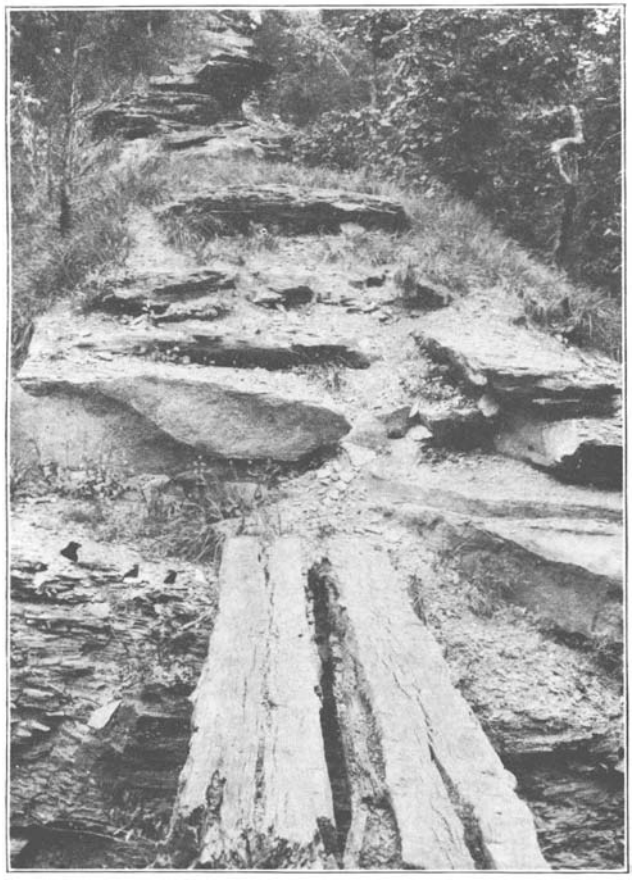

Plate 29. View of comb on Beaver Creek where closely approached by Long Run, two miles due south of Parnell in the Monticello quadrangle, Wayne County. Looking east. Shows prevailing character of Fort Payne formation in region. This is the Rosewood facies of the Fort Payne characterizing it in the "Knobstone group" of Jefferson County, Ky., and in southern Indiana. Stiff calcareous shale breaking down into chips on extreme weathering.

Keokuk is absent. Its approximate northeast limit is shown on the key map on the section chart.

Character. Throughout the part of Kentucky east of the western Kentucky coal field the Keokuk rocks are predominantly clastic, their main component being a siliceous, argillaceous, and probably slightly calcareous rock breaking down into shale on weathering. This character is well displayed in

Plate 29. In Jefferson County the rocks of Keokuk age are divisible into three formations, the Kenwood sandstone below, the Rosewood shale in the middle, and the Holtsclaw sandstone above. These formations are here briefly described.

Kenwood Sandstone.[26] The Kenwood sandstone, named from Kenwood Hill, 5 miles south of Louisville, is a hard, rather even-bedded sandstone, usually interbedded with shale. On Kenwood Hill and on Jacobs Park Hill, one mile northwest, the lower part of the Kenwood, which only is present, is thick-bedded, the layers reaching a thickness of over 2 feet. On Buttonmould Knob, 12 miles south of Louisville, it is 20 feet thick and massive; southwest of Huber, still farther south, it is rather thick-bedded but thinner as a whole; and at Lebanon Junction it has dwindled to a soft shelly sandstone hardly distinguishable from the overlying Rosewood shale. (See sections Nos. 4, 7, 8, 9, 10 of section chart.) The Kenwood is included in the Keokuk because of its lithologic character and because it carries *Productus wortheni,* a Keokuk fossil. This is the only fossil found in the Kenwood, and it is very rare.

Rosewood Shale.[26] The Rosewood shale is identical in character with the shaly facies and components of the Fort Payne of southern Kentucky and middle Tennessee, already referred to and to be described. It includes a few thin layers of limestone a little distance above the middle. It is 190 feet thick.

Holtsclaw Sandstone.[26] The Holtsclaw is a soft sandstone about 20 feet thick in Jefferson County, Ky. It does not extend south of Jefferson County, and is absent in the southwest part of that county. At Borden, Clark County, Indiana, the upper 100 feet or so of the Keokuk rocks is sandstone, of which the upper 20 feet is rather massive and probably represents the Holtsclaw, while the lower 80 feet probably represents the upper part of the Rosewood shale and may be the same as the Riverside sandstone of Indiana reports. The Holtsclaw carries a fairly abundant Keokuk fauna which is listed in the report on Jefferson County cited.

Fort Payne Formation. South of Muldraugh's "Hill," in

[26] Butts, Charles, Geology of Jefferson Co., Ky. Ky. Geol. Survey, 1915.

all the counties where they are exposed, from Barren County on the west to Wayne County on the east, and in the counties of northern-middle Tennessee as far south as Overton County, the rocks of Keokuk age are predominantly a stiff shale of the Rosewood type, but include limestone of varying degrees of purity in beds of varying thickness and extent. The prevailing proportion is roughly estimated at two-thirds shale and one-third limestone. In that region the name Fort Payne formation has usually been applied to these rocks by stratigraphers, but their Keokuk age has always been recognized by paleontologists. Lithologically they are neither the same as the typical Fort Payne, which is predominantly a chert, on the outcrop at least, nor the typical Rosewood, which is all shale, nor like the typical Keokuk, which is all limestone. Having been traced by mapping nearly continuously into the typical Fort Payne, however, and there being no doubt of their approximate equivalence, the use of the name Fort Payne formation will be continued here for southern and eastern Kentucky and middle Tennessee. The name was introduced by Hayes[27] in 1890 from Fort Payne, Ala.

While generally in northern middle Tennessee and southern Kentucky the Fort Payne is nearly all shales it may change in a comparatively short distance to nearly all limestone. An example of such a change of facies is to be seen in Overton County, Tenn., in the Standingstone quadrangle, between the Dry Fork of Mill Creek west of Hilham and Roaring River at Crawford Mill, about 8 miles southeast of Hilham. On Dry Fork the Fort Payne is practically all shale; at Crawford Mill nearly the whole of the lower 140 feet is solid limestone. A photograph of this exposure is published in Bulletin 24, Part II-A of the Tennessee Geological Survey Annual Report for 1919. Another example fully as impressive is found on Beaver Creek, Wayne County, Ky., 1 to 2 miles southwest of Parnell. Here within one-half mile the lower half of the Fort Payne changes from thick-bedded, gray, coarse limestone to practically all shale. See sections 15 and 16 of section chart.

[27] Hayes, C. W., Geol. Soc. Am. Bull., Vol. 2, p. 143, 1891. Read December 29, 1800.

The shale of the Keokuk, including the Fort Payne, is dark to dark gray, or even, in a few localities, greenish in the lower part. The shale is not evenly fissile, like the Ohio shale, with thin, smooth surfaced laminae of paper-like thinness, but tends to cleave diagonally to the bedding into small, uneven surfaced, sharp-edged chips.

Judging from analyses of the Rosewood shale, the shale of the Fort Payne is high in silica and some of it carries a small percentage of calcium carbonate. Four samples of the Rosewood shale distributed through the thickness of the formation, 1 mile west of Brooks, Bullitt county, Ky., ranged in percentage of major constituents as follows: Silica 63.56 to 68.36 per cent; Alumina 13.19 to 18.81 per cent; calcium oxide .25 to 3.10 per cent. Only one sample showed 3.10 per cent calcium oxide, equivalent to 5.53 per cent carbonate; the other three samples showed less than one per cent calcium oxide. The other constituents were water, iron oxide, sodium oxide (soda) and potassium oxide (potash). (See table of analyses, Jefferson county report by author referred to, p. 236.)

The limestone is of two kinds, one of which is thick-bedded, coarse, light or bluish gray, highly crinoidal, being a mass of crinoid stem plates; and the other fine-grained, unfossiliferous, bluish gray and medium thick-bedded. This kind of limestone is highly siliceous and doubtless the shale of the formation in many localities is derived from such rock by the solution and leaching of the limy content as the limestone weathers on the outcrop. The general appearance of this kind of limestone is shown in Plate 30, that of the coarse-grained fossiliferous limestone in Plate 31. The siliceous layers commonly become completely silicified to brittle chert on weathering. An example of such chert is shown in Plate 32. It is from such limestone that the completely chertified beds of the typical Fort Payne chert of Alabama is derived. Considerable thicknesses of such limestone, comparatively fresh, are exposed in the vicinity of Blount Springs, Ala. Such silicified limestone layers are exceedingly hard and a great hindrance to oil-well drillers, many hours, or even days, being consumed in penetrating a few feet. In some localities, as in Barren County, Ky., and Overton County, Tenn., certain layers on the

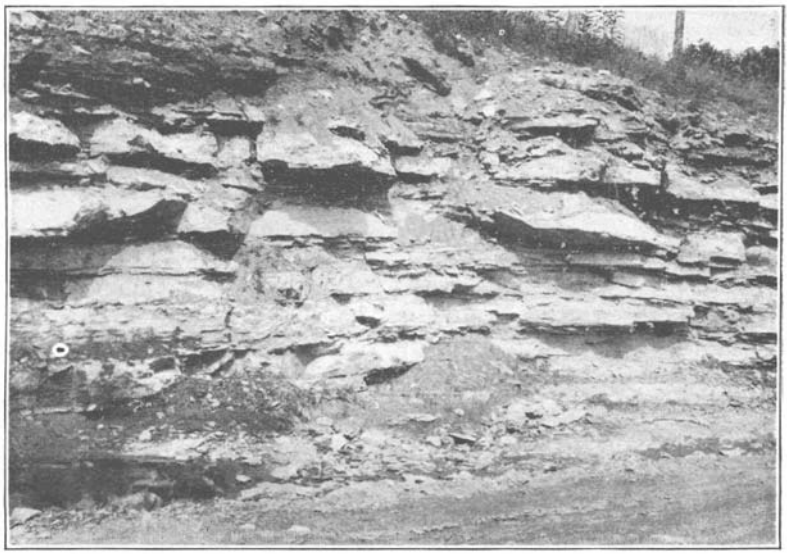

Plate 30. Siliceous limestone with shale partings typical of the Fort Payne chert. Road cut on Tompkinsville pike near Skaggs Creek about one mile south of Temple Hill, Barren County, Ky. Looking southwest. Such limestone silicifies to chert. Example shown in Plate 32.

Plate 31. Basal, coarse, gray limestone of the Fort Payne resting on New Providence shale. Columbia pike on west bluff of Fishing Creek, five to six miles west of Somerset. Looking south. Fossils of list No.8 were collected from the New Providence shale, just beneath this limestone.

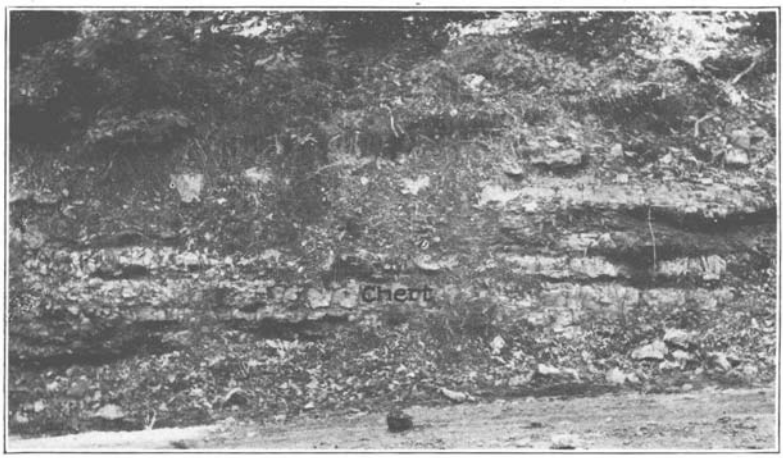

Plate 32. Typical Fort Payne chert. Columbia pike on west bluff of Fishing Creek, five to six mi1es west of Somerset, Ky. Looking east.

weathered outcrop have the appearance of brown sandstone. This is highly porous or spongy and is doubtless the result of the leaching of the calcium carbonate from layers more coarsely siliceous than the layers that weather to shale.

Throughout all of southern-central Kentucky and northern-middle Tennessee the beds of coarse, gray, crinoidal limestone occur at most any horizon in the Fort Payne. In Barren County, Ky., two such beds, at about 30 feet and 80 feet below the top, appear to be fairly persistent. In a few localities an unusual thickness of very coarse, massive, in some places cavernous limestone 10 to 50 feet thick makes the bottom of the Fort Payne, resting either upon the New Providence shale or, where that is absent, upon the Chattanooga shale. The thick limestone on Beaver Creek, 1¼ miles southwest of Parnell, shown in section No. 16 of the section chart, is an example of such development. Another such is on Meshack Creek, Monroe county. These developments are lenticular and of small areal extent. In Meshack Creek, a section at the edge of one of those lenses is exposed. In this section masses of the limestone are scattered on the surface of a point of a spur below its horizon, but it is not present in place in the side gullies in clearly-exposed sections from well up in the Fort Payne down to the Chattanooga. Just

across a ravine, possibly one-eighth of a mile distant, and across the main valley perhaps one-half mile distant, the massive limestone, 20 feet or more thick, outcrops as a ledge that persists for a long distance along the bluffs of the creek. This ledge is at exactly the level of the contact of the Fort Payne and New Providence in the exposed section where the massive limestone is absent between them, but the masses on the slopes below the contact show that its edge lay against the exposed beds at their contact on the point of the spur. Another locality of this limestone, but not so thick as usual, is at the head of Marrowbone Creek, in Cumberland County.

On Roaring River, Overton County, Tenn., in the Standingstone quadrangle, is an instructive section showing, by the fossils collected, the Keokuk age of this massive limestone. Beginning at Browns Ford, 5 miles south of Hilham, the Chattanooga shale is overlain by a few feet of crinoidal limestone, and the limestone is followed above by nearly unbroken shale, about 200 feet thick, of the ordinary Rosewood type. On the bluff one-half mile west of Browns Ford the limestone, there also immediately overlying the black shale, appears to be at least 40 feet thick, coarse and massive. One-half mile farther west the same limestone is 40 to 50 feet thick, but there is between it and the Chattanooga shale 25 to 40 feet of thin-bedded or laminated, partly reddish limestone interbedded with green shale, as shown in the following section:

Section of the basal (Fort Payne Beds) and the New Providence formation on Roaring River, Overton County, Tenn., 1 mile west of Browns Ford and 2 miles east of the Jackson County Line.

	Feet
Fort Payne Formation:	
Limestone, coarse, massive, crinoidal	50
New Providence formation:	
Limestone and shale, limestone thin-layered, reddish	13
Shale, green	9
Limestone in shale with bryozoa	3½
Shale, green with phosphatic nodues	1
Chattanooga:	
Shale, black	20
Ordovician:	
Limestone	

From the slope on the shale and limestone, of the New Providence, the following species of fossils were collected:

Cyathaxonia sp.?
Monilopora crassa McCoy.
Agaricocrinus americanus Hall?
Alloprosallocrinus conicus Lyon.
Cattillocrinus tennesseeae Shumard.
Eretmocrinus ramulosus Hall.
Stemmatocrinus trautscholdi Wachsmuth and Springer.

The crinoids were identified by Mr. Springer, all without question except the Agaricocrinus, which, however, he felt fairly sure is the species named. The *Agaricocrinus, Alloprosallocrinus,* and *Eretmocrinus* are all, according to Springer, strictly Keokuk forms; the other species named are as distinctly New Providence forms. It is plain, therefore, that both Keokuk and New Providence rocks are present, and that the mixture of the fossils came about through the Keokuk forms rolling down the slope upon the outcrop of the New Providence shale which yields the New Providence fossils. Since the heavy basal limestone of the Fort Payne extends to the top of the bluff, the source of the Keokuk crinoids could not have been above, so must have been in that limestone which is crowded with crinoidal remains.

The importance of this determination is that it proves the Keokuk age of the limestone under discussion, which is widely distributed in middle Tennessee and Kentucky, although it is in all cases a lenticular development and nowhere of great areal extent. Judging from the circumstances, the New Providence at this point on Roaring River is a residual body of small extent from the erosion taking place in the time represented in the unconformity at the top of the New Providence.

The farthest northeastern development of coarse limestone in the Keokuk that has been observed is in vicinity of Calvary, about 4 miles south of Lebanon, Ky. Here is a highly fossiliferous, bluish, coarse limestone, of importance because of carrying a considerable suite of characteristic Keokuk fossils, which come in immediately above shale with characteristic New Providence fossils. This limestone, however, is not so coarse, massive, or thick as that referred to on Meshack Creek or Roaring River,

Tenn. On Fishing Creek, 5 miles west of Somerset, and at Kings Mountain, in Lincoln County, the Fort Payne is predominantly limestone and chert and only about one-half as thick as the shaly facies of the formation farther west and southwest. On the Louisville & Nashville Railroad midway between Maretburg and Brodhead, Rockcastle County, about 5 feet of siliceous shale with thin, apparently slightly calcareous, nodular layers immediately overlying sandy shale with *Taonurus*, is doubtfully regarded as Fort Payne. On Town Branch, about 3 miles northeast of Mt. Vernon, and at Hummel station, about 1 mile farther northeast, about 2 feet of limestone with a few poorly preserved fossils referred to the Fort Payne, is the extreme northeastern observed representative of the Fort Payne. At Pineville, the Fort Payne is absent, but at Jellico, Tennessee, and at Cumberland Gap it is represented by about 15 feet of thin-bedded chert of typical Fort Payne character.

Thickness. The thickness of the Keokuk rocks, including the Fort Payne, is 250 feet in Jefferson County; 200 feet in Barren and Wayne counties; apparently not over 75 feet on Fishing Creek, Pulaski County, and at Kings Mountain, Lincoln County; less than 75 feet in the vicinity of Junction City, Boyle County; 5 feet or less in Rockcastle County; and 15 feet at Cumberland Gap.

Age and Correlation. The Keokuk age of the rocks described in this section is well enough proven by the fossils listed and cited beyond, as well as by their stratigraphic position below the Warsaw. So far as the writer's experience goes in the study of collections from central Kentucky and northern-middle Tennessee, only one species of brachiopod, *Brachythyris suborbicularis,* and only the long-ranging *Cystodictyas* continue from the New Providence into and through the Keokuk rocks. At the very base of these rocks south of Lebanon, Ky., (sec. No. 24 of section chart), the fossils of list No. 17 were collected, and those of list No. 18 were collected just above. Typical New Providence green shale, with a few New Providence fossils, immediately underlies the limestone carrying the fossils of list No. 17. With the few exceptions noted above, none of these forms are recorded from rocks below the Keokuk. From the heavy basal limestone lenses in southern Kentucky and northern

Tennessee a spirifer very like *Sp. montgomeryensis,* if not that species, occurs, and several unlisted crinoids which Springer regards as Keokuk forms could only have come from this bed. On the head of Marrowbone Creek, in Cumberland County, many new species of bryozoa, mainly of *Fenestella* occur, which are apparently without exception different from any in the top of the New Providence from a slightly lower horizon on Beaver Creek in Wayne County. (List No. 7.) In the Jefferson county area, the Kenwood sandstone carries *Productus wortheni,* a Keokuk form, and the higher formations of the Keokuk there carry such characteristic Keokuk forms as *Orthotetes keokuk, Rhynchopora beecheri, Spirifer crawfordsvillensis, Sp. keokuk, Sp. montgomeryensis, Sp. rostellatus,* and *Syringothyris textus.* Most of these are from the Holtsclaw sandstone, at the top. The Keokuk fauna therefore ranges all through the rocks described under this head from bottom to top. Some of the Keokuk forms pass up into the Warsaw, which, however, has species in its bottom layers that do not occur in the Keokuk. The nearly complete change of fossils in crossing the boundary upward from the New Providence to the Keokuk is explained by the unconformity and time break between them. While fossils are not abundantly distributed through all these rocks of Keokuk age in central Kentucky, the purer limestone lenses are generally well stocked with them. In the siliceous limestone beds and in the shales, fossils are usually scarce but in places at some horizons they become fairly plentiful, especially Bryozoa. The following lists include a fairly complete representation of the fauna. As appears in these lists a good number of undescribed species are present.

LIST NO. 17.

One mile northwest of Calvary, Marion Co., Ky., old quarry of reservoir of Lebanon waterworks. Basal limestone of Fort Payne formation,

Section No. 24, Section Chart.

Agaricocrinus sp.?
Monilopora beecheri Grabau.
Triplophyllum (Zaphrentis) dalei E. & H.
Triplophyllun (Zaphrentis) centralis Meek and Worthen
Lophophyllum, sessile form. New species?

Archimedes negligens Ulrich.
Cystodictya americana Ulrich.
Cystodictya lineata Ulrich.
Cystodictya pustulosa Ulrich.
Cystodictya sp. —much branching.
Cyclopora fungia Prout.
Fenestella rudis Ulrich?
Fenestella cf. *cingulata* Ulrich.
Glyptopora keyserlingi Ulrich.
Hemitrypa proutana Ulrich.
Leioclema punctatum (Hall).
Phractopora megastoma Ulrich.
Phractopora (Prismopora) trifolia (Rominger).
Polypora retrorsa Ulrich.
Proutella discoidea (Prout).
Streblotrypa major Ulrich.
Taenoidictya ramulosa Ulrich.
Worthenopora spinosa Ulrich.
Cliothyridina parvirostris Meek and Worthen.
Dielasma sp.?
Eumetria?
Orthotetes keokuk?
Reticularia pseudolineata (Hall).
Rhipidomella near *dubia* (Hall).
Spirifer tenuicostatus Hall.
Spiriferina cf. *salemensis* Weller.
Syringothryris?
Tetracamera cf. *subcuneata* (Hall).
Platyceras sp.?

LIST NO. 18.

Bluff below Lebanon water supply reservoir, about 3 miles south of Lebanon, Ky. Fort Payne formation near bottom.

Section No. 24, Section Chart.

Amplexus sp.?
Hemitrypa proutana Ulrich.
Brachythyris suborbicularis (Hall).
Cliothyridina parvirostris (Meek and Worthen).
Chonetes illinoisensis Worthen.
Cyrtina sp.?
Productella n. sp.?
Pseudosyrinx sp.?
Pustula alternata Norwood and Pratten.
Reticularia pseudolineata (Hall).

Spirifer (n. sp.)? cf. sp. *logani* Hall.
Spirifer tenuicostatus Hall.
Spiriferina sp.?

LIST NO 19.

Cut at south end of railroad tunnel short distance north of Spurlington, Taylor County. Ky., about 20 feet below top of Fort Payne formation.

Athyris cf. *densa*, proportionally longer.
Brachythyris suborbicularis (Hall).
Chonetes illinoisensis Worthen.
Orthotetes keokuk (Hall).
Productella sp.?
Rhipidomella dubia (Hall).
Spirifer keokuk Hall.
Spirifer n. sp. Resembles S. *crawfordsvillensis* Weller. Has the same number but finer ribs, strongly striated radially, transverse striae as in Sp. *crawfordsvillensis.*
Spirifer, n. sp. General type of Sp. *mundulus* Rowley, but proportionally broader, more plications and stronger transverse striae.
Spirifer tenuicostatus Hall.
Spiriferina n. sp. Like sp. *spinosa* in general form and number of ribs but more finely punctate.
Syringothyris n. sp.
Aviculopecten amplus. M & W.

LIST NO. 20.

King Mountain Lincoln County, Ky. From material from cut at south end of railroad tunnel. Seems to be from near top of Fort Payne formation but may be mixed.

Section No. 22, Section Chart.

Zaphrentis big form.
Taonurus? a fragment suggesting that form.
Brachythyris suborbicularis (Hall).
Productus n. sp.
Pustula alternata (Norwood and Pratten).
Spirifer aff. *montgomeryensis* Weller.
Loxonema?
Straparollus?
Conularia sp.?

LIST NO. 21.

Meshack Creek, Monroe County, Ky. Base of Fort Payne formation.

Section No. 14, Section Chart.

Agaricocrinus americanus Hall.
Eretmocrinus magnificus Lyon and Casseday.
Productus ovatus Hall?
Pseudosyrinx?
Schizophoria sp.?
Spirifer montgomeryensis Weller.
Spirifer aff. *montgomeryensis.*
Igoceras?

LIST NO. 22.

Road between Mitchell Creek and Ward, Overton County, Tenn., in the Standingstone quadrangle. Top of Fort Payne formation.

Monilopora beecheri Grabau.
Batocrinus?
Cystodictya americana Ulrich.
Cystodictya lineata Ulrich.
Cyclopora fungia Prout.
Fenestella multispinosa Ulrich.
Fenestella rudis Ulrich.
Fenestella serrulata Ulrich.
Leioclema gracillum Ulrich.
Polypora near *biseriata* Ulrich.
Polypora halliana Ulrich.
Rhombopora or *Batostomella.*
Vermipora sp.?
Worthenopora spinosa Ulrich.
Orthotetes sp.?
Spirifer sp.?
Spiriferina sp.?

LIST NO. 23.

Two miles about due north of Nobob, Barren Co., Ky. About 50 feet below top of Fort Payne formation.

Hadrophyllum n. sp.
Triplophyllum 2 sp.
Brachythyris suborbicularis (Hall).
Cliothyridina obmaxima (McChesney).
Pseudosyrinx sp.?
Spirifer keokuk Hall?
Spirifer sp.?

LIST NO. 24.

Bruce, Barren Co., Ky.

Gray limestone about 30 feet below top of Fort Payne formation.

Brachythyris brucenis n. sp. cf. Plate 61, fig. 8 Weller, Mon. Miss Brachiopoda.
Brachythyris suborbicularis (Hall).
Orthotetes keokuk (Hall).
Productella sp.?
Productus cf. *setigera* (Hall).
Spirifer keokuk Hall?
Spirifer montgomeryensis Weller.
Spirifer aff. *montgomeryensis.* Finer ribs and less well defined sinus. Transverse striae obscure.