THE PALEONTOLOGY OF KENTUCKY

A SYMPOSIUM



The
Kentucky Geological Survey

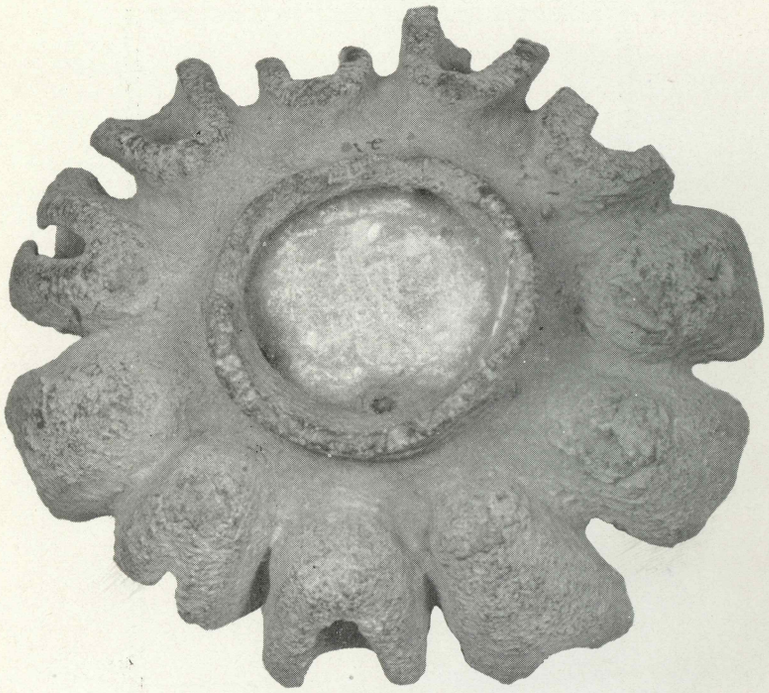
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The Paleontology of Kentucky

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BRACHIOSPONGIA DIGITATA.

A rare Franklin County, Kentucky, Fossil Sponge from the Brannon (Ordovician) limestone. Because of its unusual figure and rarity it is much prized by collectors as a museum piece. Photo by W. R. Jillson, 1927.

THE PALEONTOLOGY OF KENTUCKY

A Symposium outlining systematically, and briefly describing with stratigraphic references the various fossil forms of life indigenous to the rocks of the Commonwealth, arranged and edited

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Illustrated with One Hundred and Thirteen Photographs, Maps and Diagrams

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Dedicated to the

REMARKABLE EARLY SCIENTIFIC IMPULSES

of

M. deLongueil, 1739
Colonel Christopher Gist, 1751
Colonel George Croghan, 1765
Captain Harry Gordon, 1766
Benjamin Franklin, 1768
George Louis LeClerc, Comte de Buffon
General William Henry Harrison, 1795
President Thomas Jefferson, 1797
Doctor William Goforth, 1804
Thomas Ashe, Esquire, 1806
General William Clark, 1807
and John Clifford, 1816
who because of their interest in, collection of and
philosophical writings on the

PLEISTOCENE MAMMALIAN FOSSILS
OF BIG BONE LICK

may be properly accredited with the placement
of the foundation stones of

KENTUCKY PALEONTOLOGY

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An Introduction to Kentucky Paleontology

One lifts with difficulty the drapings of primeval obscurity which envelope the first inquiries into the occurrence of fossils—relics of pre-historic life—in that part of the Ohio valley known as Kentucky. Although the Western Hemisphere was discovered by Columbus during the closing decade of the fifteenth century, and both England and France were soon vigorously attempting settlement at a number of points on the middle Atlantic seaboard of North America, it was not until well past the middle of the seventeenth century that intelligent white Europeans penetrated into the unbroken and savage infested wilderness that marked this part of the continent.

In the year 1669 that dauntless French explorer and adventurer, Sieur de La Salle, plunged into the great forest south of Lake Erie and was gone from the western outposts of civilization, in what is now the United States, for two long years. Following his return he claimed to have discovered the Ohio River, and this claim was substantiated for him by some of his contemporaries, particularly Joliet. Admitting the not entirely unreasonable nature of this contention, at least so far as certain upper reaches of the Ohio are concerned, there are some who stoutly oppose the idea that La Salle ever penetrated as far south as the Falls of the River—where Louisville now is—though he did bring back to the St. Lawrence settlements certain knowledge of the existence of the great Rapids.

Granting that La Salle did actually reach in person the Falls of the Ohio, to him must be given the credit for having discovered the two finest fossil localities in Kentucky—and these before the third quarter of the seventeenth century had yet passed. In dropping down the Ohio he would certainly have been taken the short distance up the waters of Big Bone Creek to the Lick to secure food and salt for the saline springs there were widely known to both forest man and beast—the bison, the deer, the elk and other lesser animals finding their way to this place from unbelievably remote ranges. In the alluviated quagmire surrounding these famous Ordovician salt seepages, La Salle must have seen, and with what interest, a great profusion of bones and fragmentary skeletal parts, some at the surface bleached white by many years exposure to the weather, and others partly protruding from the salty sands and muds of the creek bottem. All in all it was the finest and most extensive assortment of Pleistocene and semi-Recent mammalian fossils in this country. Later, and but a few miles further down the Ohio, at the Falls as he traversed the whitened and flood scoured Silurian and Devonian limestones at and adjoining the Rapids, he stood upon what was later to become recognized as one of the greatest and most celebrated Paleozoic coral reefs in this part of the world.

But if he saw then, the wasting bones of the *Mastodon,* the *Mammoth* and the *Megalonyx* at Big Bone Lick, and the coraline petrefactions of *Zaphrentis prolifica* and *Favosites hemisphericus* at the Falls, there is nothing to show that they made any impression upon him for he returned without either the slenderest report or collection to substantiate their existence. A grand soldier of fortune, this technical oversight on the part of La Salle, granting that he saw these very unusual localities, must not be addressed too seriously in his discredit, for at that time neither of the sciences of geology or paleontology had yet been born, and such occurrences when considered at all were quickly passed over as the *prima facie* evidences of the catastrophic and convulsive activities of nature associated with the very general belief in deluvial phenomina.

Be that as it may, no area so surely to be visited by an able bodied traveller at the time, as was this great salt spring, could long remain undescribed in the literature of the civilized world. So we find that seventy years after the return of La Salle and long after his death, M. de Longueil, an indefatigable French traveller and explorer accompanied by a number of Indians came and camped there in 1739. In his picturesque account he tells of the great number of bones of gigantic animals found scattered about the great salt spring. If not the first, it is certainly one of the earliest written reports of this unique fossil locality. The period was one of quickening interest in the West. That many another white European traversing the wilderness found his way gratefully to this seepage so much admired by the French coureur de bois, the English Indian traders and the aborigines themselves for its plentiful salt and game, rather than its truly remarkable prehistoric remains, must not be doubted. Years passed and in 1751 when Colonel Chrisopher Gist, early western explorer and Indian scout, visited it and made some small collections of proboscidian teeth, it was apparently well known by all who were passing through this part of the Ohio Valley.

In the year 1765 Colonel George Croghan, who had his Colonial base at Fort Pitt, came purposefully to Big Bone Lick and made what must be considered for the time, rather extensive collections some of which were sent to the American seaboard while others were dispatched to England and to France. During the following year Captain Harry Gordon visited and collected fossil bones and teeth at Big Bone Lick and within a year or two the many sided Benjamin Franklin, and Comte de Buffon, the great French naturalist, were both in possession of and describing these unique fossils in Paris. Interest in the great vertebrate fossils of "the West" then became the thing among those who had the time, the money and the impulse to carry forward such investigations. Rudimentary paleontology had taken possession of the public mind. Hundreds certainly, possibly thousands of first class Pleistocene fossil specimens were taken during the next few years from this wonderful locality.

As indicative of the broad and highly intelligent interest which addressed itself to the collection and description of the remains of the large extinct mammals recovered from Big Bone Lick one has only to refer to the very considerable activity of General William Henry Harrison in 1795, President Thomas Jefferson in 1797, Doctor Goforth of Cincinnati in 1804, Thomas Ashe, Esquire of England in 1806, General William Clark in 1807 and John D. Clifford of Lexington in 1816. Throughout the early and middle part of the nineteenth century not less than fifty or sixty papers, and pamphlets were written and published on Big Bone Lick and its truly magnificent assortment of fossil remains. The subject is yet a live one and of very broad interest as may be deduced from the steady increase of writings on the subject. New papers touching some previously unobserved angle are even at this time of frequent appearance. Not the least of these are those with a decidedly paleontological trend, though no new species have been found or referenced to this locality for many years. Literally tons of fossil bones have been taken, first and last from the saline oozes and muds, now largely solidified, of Big Bone Lick. While it is a fact that much of this once splendid material has been lost or allowed to disintegrate beyond repair, it is nevertheless true that many good specimens are today to be seen in a number of the great national museums of England and France as well as America. Unfortunately but a small amount of the material taken from this once overflowing paleontological storehouse, remains today in Kentucky. Furthermore, in spite of all that has been done in the field of descriptive writing and research there is no complete locating checklist of all known specimens taken from this great Kentucky Lick.

Less spectacular than their vertebrate affiliate, the fields of invertebrate paleontology and paleobotany in Kentucky failed to find commanding and wide interest until the middle or latter part of the first quarter of the nineteenth century. This is the indisputable fact, though these branches are now generally recognized as much more important to geology and mineralogy than is vertebrate paleontology. But the reason for the delay is not far to find. Invertebrate investigations are time-consuming and tedious. They require for both systematic and practical results a very specialized training and experience. During the earliest part of the last century an official or State geological survey had not yet come into existence and individuals found it, without some such means of continued support, impossible to carry forward extensive investigations in widely separate areas. Furthermore there were in fact, no really trained geologists or paleontologists in this Commonwealth. The field of invertebrate fossil inquiry was not, however, empty, much less overlooked. From the earliest times men in the "learned professions" were attracted to it. This was the case in this part of the middle west as well as in those States bordering the Atlantic and in parts of England, France, Germany and elsewhere. In Kentucky we find the earliest references made to invertebrate fossils are by men trained for the law or medicine or who were in the fortunate command of leisure.

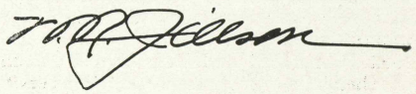
In North America the beginnings of geological and paleontological investigation and writing are firmly rooted in the so-called "Maclurean Era" from 1785 to about 1820. The period is named for that very outstanding natural philosopher, William Maclure, who as the result of extended tours afoot throughout the Eastern United States published his "Observations on the Geology of the United States" with a tri-colored areal geological map in 1809. It is the corner stone of American geology. Interest in this volume among cultivated people with a certain personal independence and flair for nature observations was immediate. John D. Clifford of Philadelphia and Lexington, Kentucky, and his friend the eccentric Professor C. S. Rafinisque of Transylvania University began their observations in Kentucky toward the end of this period. Clifford's first article on the geology of this western country bears the imprint date of 1819.

During the two following decades the first serious work on the invertebrates of Kentucky was undertaken, though it must not be overlooked that Samuel L. Mitchell exhibited on plate three of his, "Observations on the Geology of North America" an "asterite or petrified echinus from Kentucky, said to be frequent in the Great Cavern, near the Green River." This book was published in New York in 1818 and the little fossil so early reproduced from this State was undoubtedly *Pentremites conoidens* a small blastid ranging in this area from the Warsaw to the Ste. Genevieve in the Mississippian, or Lower Carboniferous. Among the earliest investigators to mark their labors by publications was John Lewis of Frankfort who may in truth be said to have been the father of the first geological reconnaissance in Kentucky. This investigation was carried forward as an official engagement by William Williams Mather in 1838 and was published in 1839. Subsequently, both separately and collectively papers appeared under the names of David Dale Owen, Joseph Granville Norwood, Lunsford P. Yandell and Benjamin F. Shumard. Samuel Brown, a professor of chemistry at Transylvania University, was also a leader at this time in the field of geologic research and writing as numerous articles attest. Another outstanding scientific figure of this period was John Lawrence Smith who spent much of his life in Louisville and Kentucky. With the exception of Mather and Lewis, all of these early students of geology and invertebrate paleontology in Kentucky were graduate doctors of medicine. Some of them were active practitioners who found these geological trips afield a genuine pleasure.

Such desultory and sporadic work, however interesting, could not be, even in the aggregate, of more than ordinary importance. Kentucky during the first half of the eighteenth century did little more than stand still in the field of geologic and paleontologic investigation. Though systematic work was progressing in States to the north, the East and the Southeast, the Bluegrass Commonwealth simply marked time until Governor Lazarus W. Powell in 1854 approved a bill organizing the "First" Kentucky Geological Survey and subsequently appointed David Dale Owen as State Geologist. Work in the field of paleontology, particularly the invertebrate and paleobotanical fields then went forward with vigor and system. Besides the name of Owen we soon see that of Leo Lesquereux, Nathaniel Southgate Shaler, J. A. Allen, A. R. Crandall, W. M. Linney, William J. Davis, Henry Nettleroth, John M. Nickles, A. F. Foerste, W. C. Morse, A. M. Miller, Charles Butts, E. O. Ulrich, M. R. Campbell, Stuart Weller, J. M. Weller, A. H. Sutton, E. R. Berry, J. K. Roberts, W. H. Bucher, T. E. Savage, A. C. McFarlan and C. L. Cooper as the gamut of published literature relative to the paleontology of Kentucky is unfolded. Close to the turn of the first century of active geologic work in Kentucky begun in 1838 so auspiciously, the year 1931 now drawing to a close witnesses a rather fulsome coverage of the State's paleontology, though numerous local and some regional problems of significance still remain to be solved. Aside from stratigraphy, wherein a number of notable advances have been made within the last decade in many parts of the Commonwealth, the greatest contribution to invertebrate paleontology in Kentucky has been made within the last few years in the Eastern coal field. This research is of real significance because it is the first contribution to our knowledge in a definite way of the invertebrate forms found in the Pottsville rocks of Eastern Kentucky.

In closing these all too brief remarks relative to the sequence and character of paleontologic activity in Kentucky, it is felt that much has been omitted that might have given better insight and deeper interest in this branch of geologic science. The rather widely ramifying literature on the subject, however, is available to everyone and this coupled with short jaunts into the field to special localities where good collecting is possible should afford an intriguing combination to anyone whose time and interest naturally finds profit in this direction. The writer and his collaborators, each in his separate field, have attempted to so design this volume that it will fulfill the requirements of both the amateur and professional geologist working in Kentucky. It is realized that in the same degree that this becomes an actuality, this book will attain value and importance in the literature pertaining to the geology of Kentucky.

Old State Capitol
Frankfort, Kentucky
September 1, 1931.



Director, Kentucky Geological Survey.

The PALEONTOLOGY *of* KENTUCKY

I

The GEOLOGICAL SUCCESSION of LIFE In KENTUCKY

By

Roy Lee Moodie

THE GEOLOGICAL SUCCESSION OF LIFE IN KENTUCKY

By
Roy L. Moodie

INTRODUCTION

Origin Of The Earth

The origin of the earth, from the viewpoint of geology and astronomy, is best accounted for by the Planetesimal Hypothesis, which is to the effect that the earth, instead of originally being a molten mass, grew to its present form by the accretion of cold bodies from outer space. When the earth had attained about two-thirds its present size it is held that there was enough attractive force to retain a warm blanket of atmosphere. The presence of living things then became possible; simple plants and animals may then have begun to live.

Age Of The Earth

The age of the earth is usually expressed in terms of millions of years, but such statements are largely meaningless since none of us can comprehend the vast stretches of time indicated by even a million years. It will help somewhat to understand the meanings of geological time if we say that the Mammoth Cave, in Edmonson County, had been in existence for many thousands of years when the most ancient Egyptians were first entering the Nile Valley, long before any of the pyramids had been thought of, thousands of years before the city of Babylon was built. Huge mountain chains had arisen and were worn down long before the waters of the earth

had dissolved the first tiny crevice of the colossal cavern. When we realize that solid rock blocks creep down a slope at the rate of about one inch a century, or that a thousand years may bring about almost imperceptible changes in earth's feature, then we gain some concept of the meaning of geological time.

Divisions of Geological Time

The grand divisions of geological time have been made on the basis of the life supposed to have existed at the time. The names are handles for use in discussing past events of geological interest. The most ancient of these times is known as the Archeozoic. This witnessed the accretion of planetesimal bodies to the point where life was possible.

Lowly organized plants have been found in these ancient rocks. The next division of rocks is called the Proterozoic which we think witnessed the development of plants and animals to a very complex state. Bacteria and algae are known (Figure 1) in the limestones from this period and traces of animal life are abundant. Rocks of neither Archeozoic nor Proterozoic age occur within the borders of Kentucky. Following and therefore superimposed upon the Proterozoic is found a great system of rocks, rich in fossils, called the Paleozoic. The first stage of this great period, the Cambrian, with more than one thousand kinds of plants and animals, does not occur at the surface in Kentucky. Succeeding the Paleozoic comes an extensive system of sedimentary rocks with thousands of fossils, known as the Mesozoic. This time witnessed the development of many great and small reptiles, the first birds, many small mammals, and great changes in plant life and the smaller denizens of the seas. The Age of Mammals, called the Cenozoic, witnessed the origin and development of thousands of different kinds of warm-blooded animals. The Quaternary or Holozoic witnessed the last great Ice Age, and includes the Recent, the period in which we are now living.



Fig. 1. The oldest known bacteria from the pre-Cambrian rocks. The chains of *Micrococcus* are associated with marine algae and both are believed to have been influential in the formation of limestone. After *Walcott*.

First Evidences of Plant and Animal Life

The earliest evidences of plant and animal life are found in iron-bearing rocks of the Archeozoic, and in limestones of the Proterozoic. The earliest living things were algae and bacteria which were instrumental in the formation of iron ore and the deposition of limestones. It is difficult to distinguish plant and animal life in these early rocks, for at first there was little to distinguish plants from animals. None of the earliest traces of life are found in Kentucky.

Proterozoic Life

Life in the Proterozoic must have been abundant since the following age, the Paleozoic, started out with a vast array of living things. It is thought that all the geological time preceding the opening of the Paleozoic was much longer than all subsequent time.

DIAGRAMMATIC SECTION OF EARTH'S CRUST

ERAS OF GEOLOGIC TIME WITH CHARACTERISTIC LIFE		CHARACTERISTIC ROCKS WITH MAXIMUM THICKNESS
PSYCHOZOIC ERA (Recent) Age of man		Alluvial deposits in rivers, etc.
CENOZOIC ERA (Modern life) Age of mammals and modern plants	Quaternary-Pleistocene	Shale, sand, and gravel
	Tertiary: Pliocene	5,000 feet clay, shale, gravel, and sandstone
	Tertiary: Miocene	14,000 feet shales, sandstones, and limestone
	Tertiary: Oligocene	6,000 feet shales, sandstone, and limestone
	Tertiary: Eocene	8,000 fect limestone, sandstone, and coal
MESOZOIC ERA (Medieval life) Age of reptiles	Upper Cretaceous	20,000 feet sandstone, shale, limestone, and coal beds
	Lower Cretaceous	20,000 feet limestone, shale, and sandstone
	Jurassic	10,000 feet sandstone and shale
	Triassic	15,000 feet sandstone, shale, and coal beds
PALEOZOIC ERA (Ancient life) Age of higher invertebrate animals	Permian	7,000 feet sandstone and shale
	Pennsylvanian	10,000 feet sandstone, shale, and coal beds
	Mississippian (Waverlian and Tennessean)	4,500 feet shale and limestone
	Devonian	12,000 feet limestone, sandstone, and shale
	Silurian	6,000 feet sandstone, shale, and limestone
	Ordovician	6,000 feet sandstone, limestone, and shale
	Canadian	4,000 feet limestone and shale
	Ozarkian	6,500 feet massive limestone
	Cambrian	18,000 feet quartzite, sandstone, shale, and limestone
PROTEROZOIC ERA (Primitive life) Age of primitive plants (algæ) and invertebrate animals	Keweenawan	30,000 feet conglomerate and sandstone with lava flows
	Animikian	14,000 feet banded slates and cherts with iron ore
	Huronian	10,000 feet glacial conglomerates, quartzite, and limestone
	Sudburian	20,000 feet of white quartzite
ARCHEOZOIC ERA (Primal life) Age of unicellular life	Keewatin / Grenville	100,000 feet sedimentary schist and gneiss with lava flows; slates, conglomerates, and limestone
PRIMITIVE CRUST	Igneous rocks	Granite and other igneous rocks

Fig. 2. Kentucky geological history occupies only the middle part of the geological column shown here.

Cambrian Period

The Cambrian period with its thousand and more kinds of animals and plants is almost unknown in Kentucky, but the nature of the creatures of that time must be briefly discussed before we can understand the life which followed. If we should be able to restore to their living form the animals which are found fossil in Cambrian rocks, we should be greatly surprised to see jellyfishes, quite like those of today; crustaceans like those seen in recent seas; shell fish almost identical to those found on our beaches; and others would resemble somewhat familar creatures, while surprisingly few of them are strange. The unfamilar creatures are the trilobites, a group of animals which lived in abundance during the entire Paleozoic and disappeared at its close.

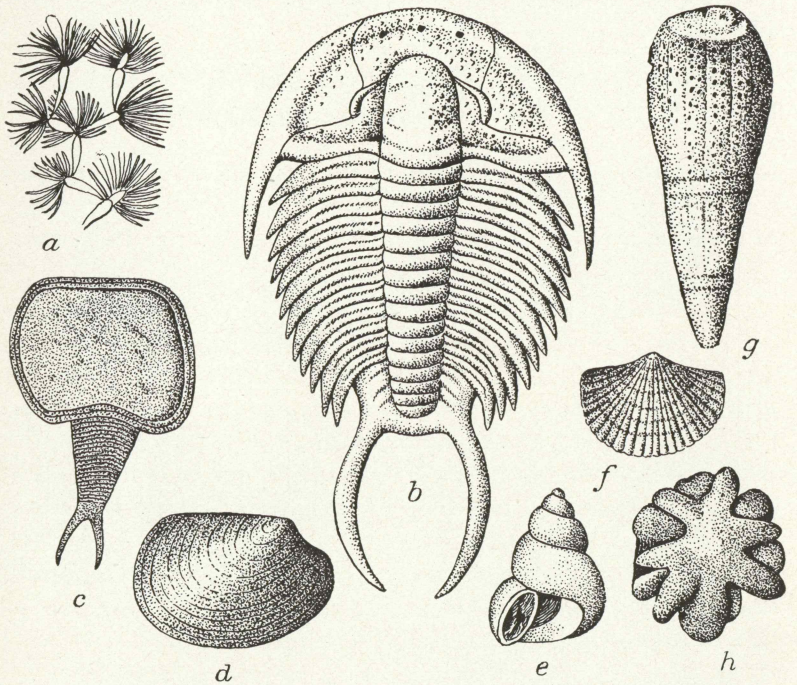


Fig. 3. Life in the Cambrian period. *a*. possibly a fragment of a sea-weed; *b*. a trilobite of the middle Cambrian. Such animals became extinct at the close of the Paleozoic; *c*. a small crustacean—a phyllopod, much like the small creatures seen today in fresh water pools; *d*. a very ancient mussel shell-fish; *e*. a Cambrian snail-like animal; *f*. a hinged brachiopod, like those living in Puget Sound today, from the lower Cambrian rocks; *g*. an early sponge or coral-like growth; and *h*. a cast of a very ancient jelly-fish. From *Chamberlain* and *Salisbury*.

There were no fishes or other backboned creatures during the Cambrian, but in Vermont and in lower Cambrian rocks of Comley in Shropshire, England, are found scales which indicate lowly predecessors of the fishes. If we examine a Cambrian shrimp we see clearly that it is so like modern shrimps that we realize the amazing amount of pre-Cambrian time needed for the development of such an animal. We know little of the changes undergone during this extensive space of time but we can infer much. The Cambrian period is not the beginning of animal and plant life, but a period long past the noonday of the racial life of many creatures. In drilling a deep well for oil and gas in Jessamine County a few years ago the pygidium or tail of Cambrian trilobite was found in the drill cuttings, thus proving the existence of formations of this age beneath the Kentucky Bluegrass.

Records of Cambrian life were made elsewhere than in Kentucky. It will be important, however, to show what enormous advancement life had made at the opening stage of the Paleozoic. Geologists believe that pre-Cambrian time was considerably longer than all succeeding time. Little is known of the early growth of animals and plants in the pre-Paleozoic.

The Geologic Column in Kentucky

The term geologic column is used to indicate the sequence and kind of rocks deposited. The sedimentary record in Kentucky is thus diagrammatically produced in a vertical column. Of course nowhere in the State does such a natural pile of rock actually exist, since as shown by the diagrams, all the Kentucky rocks are tilted showing that they have been disturbed. Moreover, in no one place in the State can the rocks be found exactly as represented in the generalized geologic column due to lack of deposition, erosion and other causes.

Nearly all of the rocks in Kentucky are sedimentary in origin; that is they were laid down under water. Soft mud is often converted, by pressure, into shale, the most satisfactory rock for the preservation of fossils, i. e., leaves, shells and the

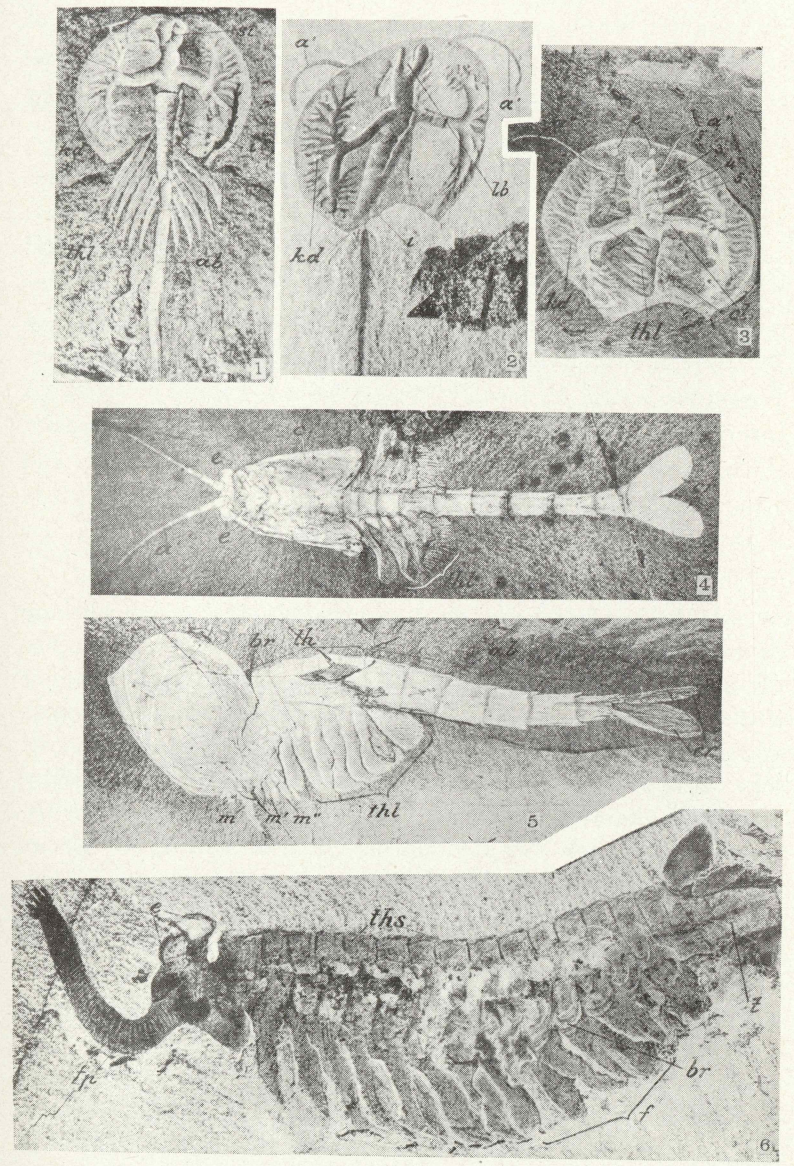


Fig. 4. A number of small crustacea found in rocks of middle Cambrian age. They look very much like modern shrimps. After *Walcott*.

like. Often soft-bodied animals like jelly-fishes, sea cucumbers, shrimps and so on are preserved in shale, greatly flattened of course, in the most exquisite detail. Loose sand and gravel become converted into sandstone and conglomerate which usually preserve fossils very poorly, or not at all.

The third great type of sedimentary rock is limestone, which is precipitated from the sea water by a variety of means; such as by the action of algae, lowly plants, by bacteria, and by animals such as the corals. Coral reefs have a very ancient geological history, and the fossil reef that forms the Falls of the Ohio in the river at Louisville is famous the world over. Limestone is also frequently formed from the shells of dead sea invertebrate animals. These three kinds of sedimentary rocks, shale, sandstone, and limestone, have many varieties each, and all may be changed by pressure, heat and chemical action into a variety of metamorphic rocks. The State exhibits a few igneous rock in place. These are called dikes.

All the hard rocks of Kentucky's geological column belong to the Paleozoic, but lack both a beginning and an ending. The Cambrian elsewhere records the opening of Paleozoic time, but it does not occur at the surface in Kentucky. Likewise rocks of Permian age, closing the Paleozoic are wanting in Kentucky. The periods called Ordovician, Silurian, Devonian, Mississippian and the Pennsylvanian form the principal part of the geological column for the State. The following tabulation shows the records from which the story of the geological succession of life in Kentucky has been read. We will record the oldest period at the bottom in the actual order of deposition.

System	Series	Stage
Silurian	Niagaran	East of Arch
		Alger (East)
		Osgood (West)
	Oswegan	Indian Fields
		Medina

System	Series	Stage
Ordovician	Cincinnatian	Richmond
		Maysville
		Eden
	Champlainian	Cynthiana
		Trenton
		Highbridge

The three remaining systems, the Devonian, the Mississippian and the Pennsylvanian are quite complex, for details of which the reader may consult the publications of the Kentucky Geological Survey in the attached bibliography. Each stage has several substages, all indicated by characteristic fossils.

Life in The Ordovician

Let us imagine ourselves transported backwards millions of years into the Ordovician times, and let us stand on or near the ocean, for we do not know much about the rivers of those far-off times. If we look around us on the land we see no traces of green vegetation, no grasses, trees, shrubs, flowers, ferns, but along the beaches we note a few marine plants. We hear no voice of bird, hum of insect, or call of mammals—there were no land animals at all. It clouds up quickly and the silence is broken by thunder, by the swish of the rain and by the splash of the waves. After the rain all is silence, no fishes leap in the sea. Approaching the shore again we glance into the water and see shell-fish such as brachiopods, clams, and snails. Under the loose rocks we find sponges and corals, while swimming along near the surface of the water, with occasional lunges, are the giants of the Ordovician—the cephalopods. Trilobites creep along the bottom, and out in deeper water are the sea-lillies, which we shall learn to call crinoids. It is indeed a strange world! Fish remains have been found in rocks of supposedly Ordovician age, but geologists now believe them to be Devonian.

The waters of the Ordovician sea—the Cincinnatian and the Champlainian—swarmed with a great variety of invertebrate animals. Hundreds of kinds of moss-like animals, the bryo-

zoans, were great limestone makers, accompanied by at least five hundred kinds of shelled animals—the brachiopods. There were also a host of snail-like creatures, and many corals for the first time showed a tendency to form reefs.

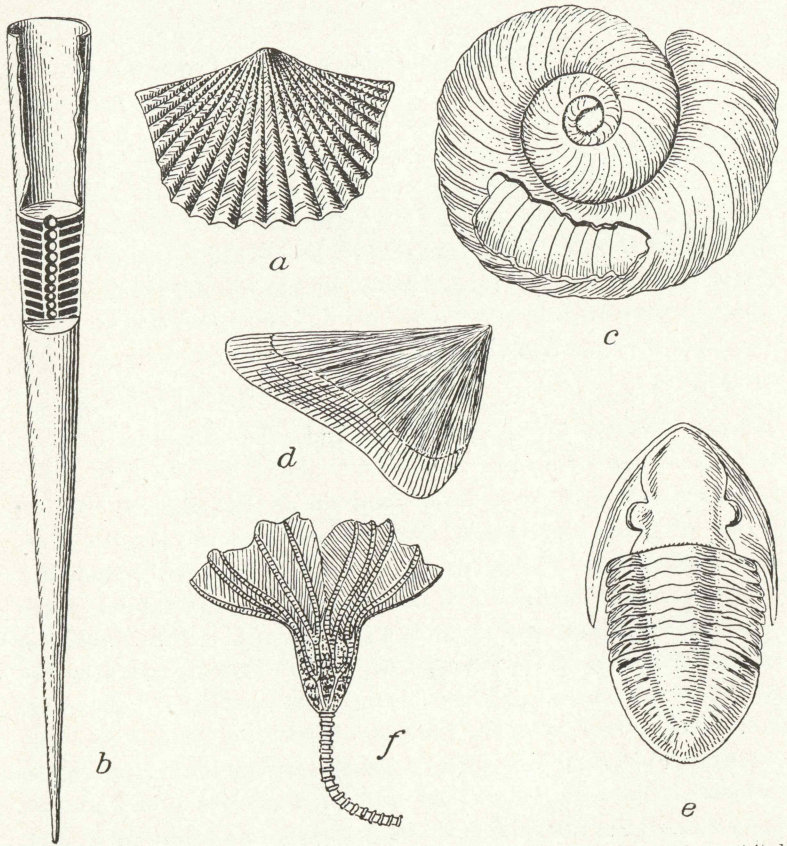


Fig. 5. Some of the sea animals we might have found near the shore had we visited the region of Kentucky during Ordovician times. These creatures were the highest forms of animal life of their time.

a. an Ordovician brachiopod. The brachiopods have existed continuously in the oceans of the world since pre-Cambrian times; *b.* a straight and *c.* a coiled cephalopod, like the nautilus of today. Some of the early Paleozoic straight cephalopods grew to a length of fifteen feet and were giants of their time; *d.* a wing shell, like the butter clams now found in Puget Sound; *e.* an Ordovician trilobite; and *f.* a crinoid or sea-lily. After *Schuchert.*

Life in The Silurian Period

Land plants are not definitely known until after the close of the Silurian. The first three periods of the Paleozoic—the Cambrian, the Ordovician and the Silurian—were the "Dark

Ages" so far as our knowledge of plant life is concerned. During these three periods a thickness of over twenty miles of rock were laid down in various parts of the world, all in salt water, where no land plants would be expected. Over one hundred kinds of sea-weed fossils and impressions have been described, but many of these are probably accidental markings on the rocks and are not plants at all. The algae (sea-weeds) were active in the deposition of limestone. Many of the algae were floating. Some of these ancient sea-weeds were very large, attaining a diameter of two feet and a length of several hundred feet. These algae were later the progenitors of the land plants.

The first fishes and the first air-breathers have been found in rocks of Silurian age, but neither of them in Kentucky. Fishes are known from New York and from Pennsylvania (figure 6). These were fresh-water fishes and are abundant in Silurian rocks of that far-off, northern island of Spitzbergen. The earliest air-breathers were scorpions, between two and three inches long, in structure and appearance very similar to modern scorpions. Related to these early scorpions there lived during the Silurian numerous and often huge, scorpion-like creatures known as eurypterids (figure 6). They lived in brackish water, on the margins of the sea and some times entered the lower waters of the rivers. One kind of these creatures was about nine feet long. They were probably the enemies of the early fishes, all of which were small. Many of the eurypterids were regular demons in appearance.

Corals were abundant in Kentucky, during the Silurian. Coral reefs, especially well-developed at Louisville, were formed. Associated with the corals and coral reefs were many thick-shelled animals like snails, which had developed heavy shells to defend themselves from the heavy waves pounding on the reefs.

Many hundreds of different kinds of invertebrate animals left their remains in the marine deposits of the Silurian, upwards of 2,500 species being known from North America. None of the great groups we found in the Cambrian show much change in the Silurian.

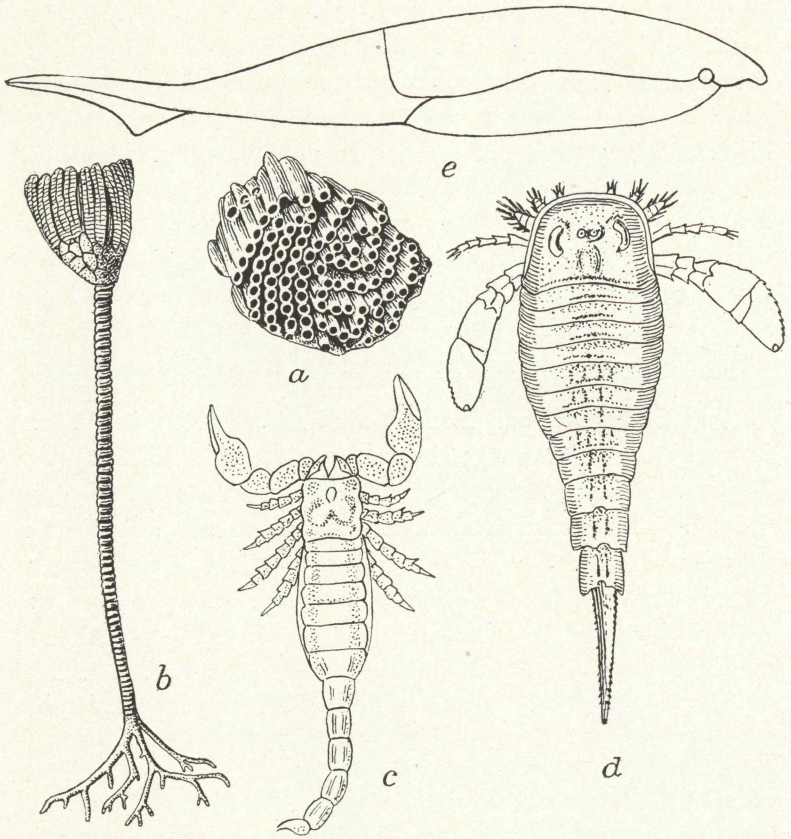


Fig. 6. The wonders of life in the old Silurian rocks. *a.* a fossil chain coral, found in Kentucky coral reefs; *b.* an animal of the star-fish group, a crinoid or stone lily, as it grew in the Silurian sea; *c.* the first air-breather found on land—a true scorpion; *d.* this odd-looking animal, hideous in appearance, had relatives in the Silurian which grew to nine feet in length. The eurypterids, as they are called, died out before the Coal period; *e.* a fish-like animal, *Palaeaspis*, found in Silurian rocks near Kentucky. After *Schuchert* and *Bryant*.

Great deserts are thought to have existed during part of the Silurian, on account of the occurrence of thick deposits of red rocks. Fossiliferous iron ore is abundant in regions near Kentucky, and thick salt deposits of this age are known to the north. Warm seas existed far northward into the Arctic circle, permitting the growth of extensive groups of animals at a place where life is now rare. This is one of the lessons of the rocks.

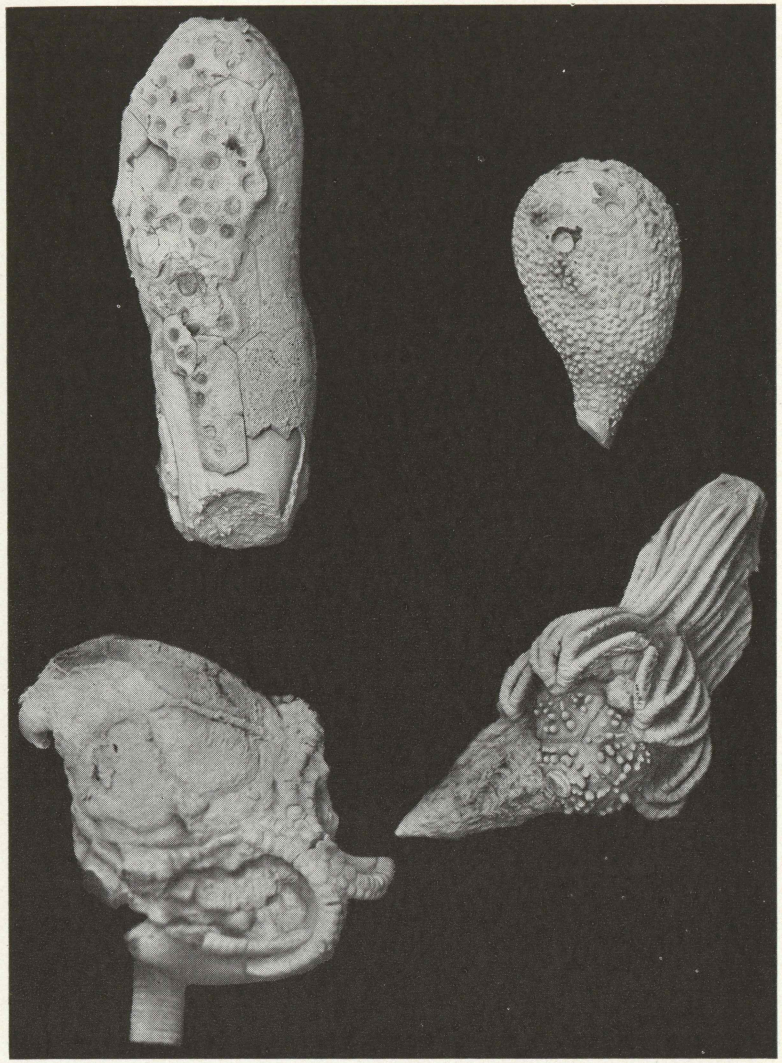


Fig. 7. Dependent life began early in the Paleozoic, as shown by the association of snails and sea lilies in the lower two figures. The upper two figures show evidences of disease.

Life of The Devonian

There is no more significant or picturesque period in the history of the earth than the Devonian. Nowhere in the world

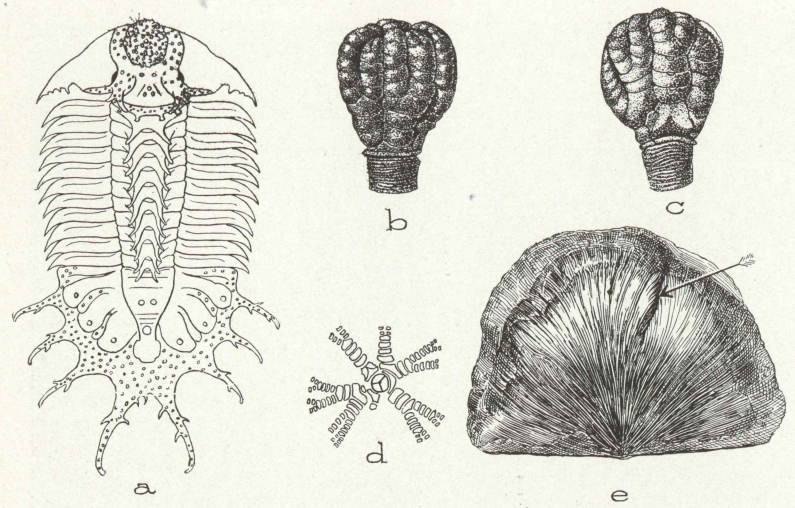


Fig. 8. Paleozoic animals showing evidences of disease. *a.* a large spiny trilobite; *b, c, d.* a crinoid head which has been injured; and *e.* a fractured brachiopod shell.

is found a more complete record of Devonian life than in eastern America. In this record Kentucky plays an important part.

It seems probable that early in the Devonian green plants of a lowly type were to be found along the margins of rivers and fresh-water lakes. These plants spread with relative rapidity over the moist land surfaces, and sedge-like organisms, primitive ferns, and other similar plants became fairly abundant, foreshadowing the enormous expansion of plant life during the great Coal period. One of the most remarkable of these growths was a tree-like seed-fern, whose stumps and roots have been found in place in certain Devonian rocks, actually preserved in the soil in which they grew millions of years ago. The trees were slender and tall, attaining a possible height of forty feet when alive. The discovery of scores of these stumps has led to our knowledge of the oldest petrified forest, a reconstruction of which is shown in figure 11. These odd trees bore seeds in pairs at the ends of modified leaflets, the seed being about one-quarter inch in diameter and enclosed in an outer husk. The first wood is found within the stems of certain of these tall, fern-like trees, as well as in other plants of the

Devonian. No true flowering plants are yet known. Kentucky shares with other states the pride of having grown some of the earliest woody plants which existed on the earth.

Among the animals the great groups of fishes, both fresh-water and marine, constitute the most significant advance in the upward progress of life toward the present. Kentucky seems not to have shared fully in the life of the Devonian, although subsequent discoveries may show unknown fossils. Many of the fishes lived in fresh-water bayous or in rivers into which paleontologists believe they had been chased by the active denizens of the sea, especially by the large and active cephalopods.

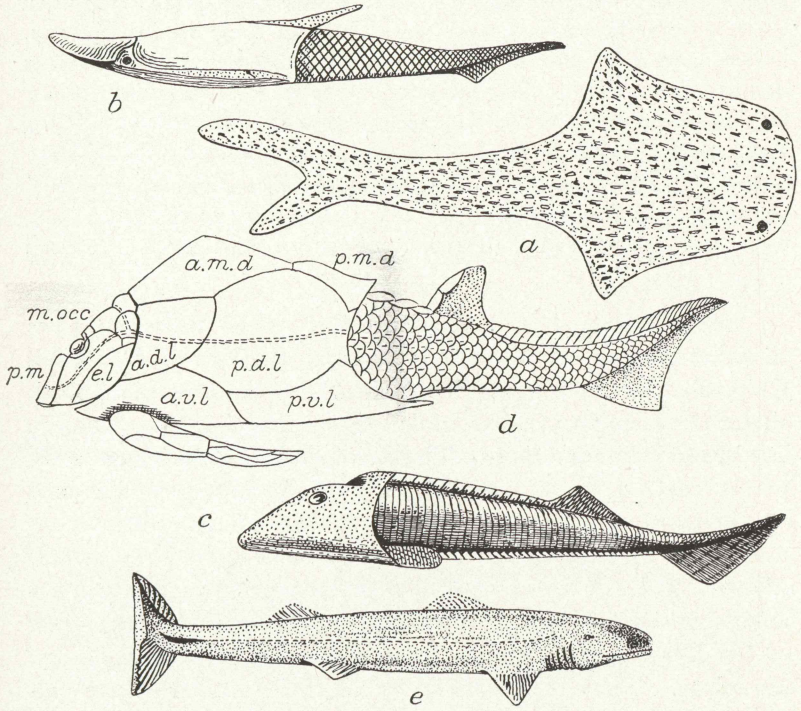


Fig. 9. A group of queer, fishlike animals which lived during the Devonian times, and recorded in the Devonian strata of North America (the eastern states) and Europe. *a.* a soft-bodied, small, fish-like animal, with forward placed eyes and hard scale-like spicules. This creature is flattened out, dorsoventrally, and when seen from the side is quite different in appearance; *b.* a fish-like animal, called *Pteraspis*, from the lower Old Red sandstone of Great Britian; *c.* a fish-like animal related to the lampreys found in Silurian and Devonian rocks of America, Norway, and Spitzbergen. The head shield is most frequently preserved and the form of the brain and nerves can be seen; *d.* an outline of one of the queerest of the early vertebrates. It had no true jaws, no true fins, and a heavy armor. It died out during the Devonian *e.* a primitive, slender shark, sometimes attaining a length of five feet, found in concretions within Devonian shales near Cleveland, Ohio. Figures from *Eastman*.

It will be necessary for us to go outside of the boundaries of Kentucky to find the kinds of animals which filled the place of fishes during this great geological period—the Devonian. The adjacent states of Ohio, Pennsylvania, Iowa, New York, and Canada furnish all the domestic evidences we need, but for comparisons we must cross the seas to Scotland where the stone mason, Hugh Miller, made known the nature of the Devonian vertebrates, and to Norway and Spitzbergen for other kinds of fish-like creatures.

The earliest fishes were so strange that nothing like them is now known. We have no clues as to where they came from, and when we find them they were well along in their racial history. Some seem to have been very soft-bodied creatures without definite fins; the body sparsely covered with minute spines. Others had a part of the body covered with a hard bony armor. Some had an armor-like head shield, and the rest of the body naked or scaled. Some looked curiously like scorpions. All of these diverse looking animals are called ostracoderms. They were the predecessors of the true fishes and lived in fresh and brackish water.

The primitive sharks constitute the earliest representatives of fishes as we know them today. Near the city of Cleveland, Ohio, not far to the north of Kentucky, in Devonian black shales the primitive sharks, called cladoselachians, are found in hard rounded concretions. These sharks are often so perfectly preserved that the minute structure of the muscles and kidney can be seen, under the microscope. None of these sharks exceeded five feet in length. The body was enlongated and rounded, with a blunt snout and eyes placed far forward. *Cladoselache* is the best known of all ancient sharks. Marine sharks of the Devonian are known from scattered teeth and isolated fin-spines. These are usually found in limestones—once calcareous oozes—where they must have fallen at or following the death of the individual.

Other marine, shark-like animals occur abundantly in certain Devonian rocks. These are called Chimaeroids, the dental plates of which are at times found in thousands at certain quarries. This group of fishes has persisted almost unchanged

throughout all subsequent geological time, and are found today, in relatively deep water, along the continental shelves of the Pacific Ocean.

It is surprising to find in the Devonian the earliest representative of the lung-fishes, known today in the muddy rivers of Africa, Australia, and South America. These queer fishes, during the dry season when the waters of the river disappear, coil themselves into a ball of mud and live, quiescent, until the next rains soften their prison, and they swim out. Although they breathe air they have no true lungs and are not related to the land vertebrates.

A group of small to huge fishes of a new and unexpected type arose, lived and perished during the Devonian. These armored fish-like animals are known as Arthrodires, and are unlike any fish now living. We do not at the present time know either their predecessors or their descendants. The largest of them attained a length of nearly twenty feet and in their day were the rulers of the sea. They surpassed the giant cephalopods which in size had ruled the seas for many geological periods. It is thought by some that the arthrodires are related to the sharks; by others to the lung-fishes; and to other groups. The complete bodily form is unknown. The head region was covered with a very heavy bony armor and it is possible that the body back of the pectoral fins was naked, and thus hard to preserve.

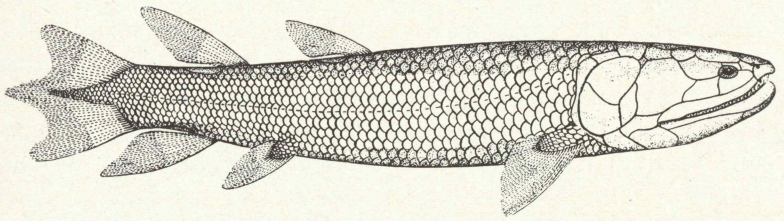


Fig. 10. A restoration of the Devonian crossopterygian fish which is thought to have been an ancestor to later air-breathing vertebrates. After *Bryant*.

A fifth group of fishes, which lived during the Devonian, has been called the Crossopterygii. These fishes looked a great deal like modern fishes (figure 10), but in their structure appear to have been organized like the primitive land vertebrates,

to which they may have been ancestral. The bones of the pectoral fin are arranged much the same as they are in the fore limb of a land vertebrate.

The presence of land vertebrates (amphibians) in the rocks of the Devonian is indicated by a single, imperfect footprint (figure 12) found many years ago in Pennsylvania. The specimen is preserved in the Yale University Museum.

The host of invertebrates which swarmed in the seas of earlier periods persist during the Devonian in slightly changed but undiminished force. These were of the types seen in the Silurian;—corals, brachiopods, bryozoans, starfishes, crinoids, trilobites, blastids, and groups of shell fishes.

Corals were especially wide spread and are found from Louisville to Alaska. Reef formation was common, and the great fossil coral reef in the bend of the Ohio River at Louisville is famous the world over. This Kentucky reef is formed of a number of species of corals; with cup corals over two feet in length and three inches wide, compound colonies eight feet across, associated with many kinds of bryozoans. In the upper Devonian colonies of 'glass' sponges existed, represented by upwards of ninety kinds. In a certain deposit in the Devonian of an eastern state occur more glass sponges than are known from all the rest of the world together. These sponges lived in deep cold water.

Decadence among the numerous trilobites is thought to be indicated by the spiny species existing in Devonian times. Dependent life and the inception of parasites began during this period. Previously all animals had been independent, and disease is thought to have been non-existent. Scars on shells and bones indicate accidents or attacks of the weak by the strong. With the increase of species and numbers of individuals within a species, tragic death of individuals and sudden extinction of species becomes more and more common—a fact truly indicative of the increasing struggle to persist among all organic forms.

Insects may have existed on dry land during the Devonian but they are unknown as fossils. Scorpions and millipeds must

have lived somewhere since they are known in the Silurian. Eurypterids, the huge scorpion-like animals of fresh and brackish water which occurred so abundantly in the continental deposits of the Silurian, persist in the lower Devonian beds; one species attaining a length of six feet. This was their last appearance, and during the somewhat later Pennsylvanian the group became extinct.

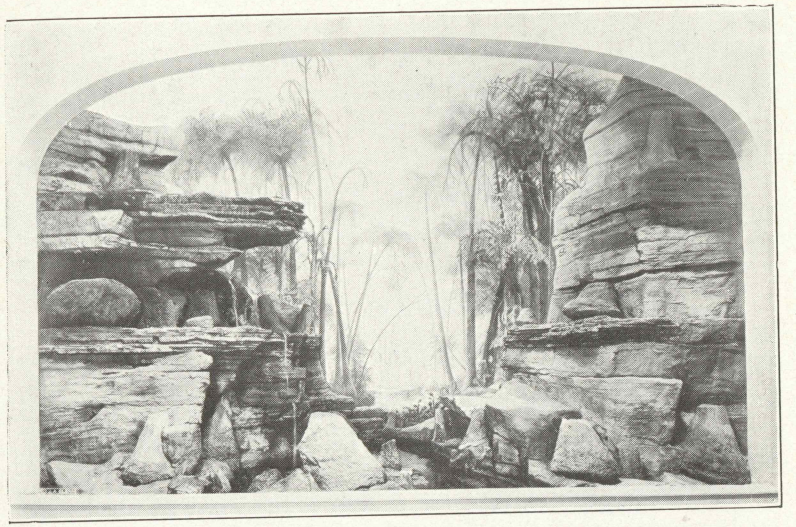


Fig. 11. A restoration of the earliest known petrified forest of tree-like seed ferns, as preserved in the State Museum at Albany, New York. In the foreground is seen an idealized reproduction of the rock section from which the tree stumps were secured at different levels. In the background is a painting of the forest of seed-ferns as it probably looked in the Devonian, with life-size restorations at either side. Trees like these were very abundant later in the Pennsylvanian and furnished a large share of the material for coal.

The climate of the period was warm, and animals and plants lived far north where now there is little life at all. The complete union of North America and Europe, during this time, across Greenland, Spitzbergen, Norway, and Great Britain allowed an unusual intermingling of floras and faunas. Abundant red rock indicates that a part of the period was semi-arid. Devonian coal-beds are thin and of little value, in Kentucky their greatest thickness being occasionally only as much as a fraction of an inch.

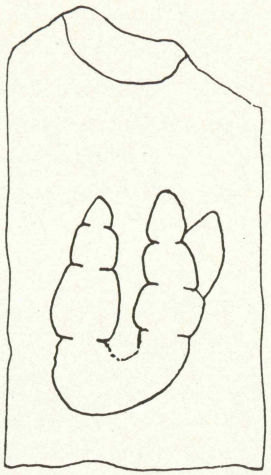


Fig. 12. A Devonian footprint of a land vertebrate, found in Pennsylvania. The original is about three inches long.

The Mississippian Period in Kentucky

The records of the rocks of the Mississippian period all show that the life of the time bears closer relations with immediately subsequent developments, rather than with the preceding life. It marks a great change from early Paleozoic life to that of a later time. This significant relationship is clearly indicated by the inclusion of the Mississippian rocks (lower or sub-Carboniferous) in a common division, the Carboniferous of older geologists, with the Pennsylvanian and the Permian. Mississippian life is more nearly that of the Carboniferous (carbon or coal-bearing) rocks than it is Devonian.

People living in western Kentucky know the rocks of the Tennesseeian division of this period as the producers of numerous caves and sinks, causing the term "the land of ten thousand sink holes" to be applied to much of this area. Mammoth Cave occurs in the rocks of this period. Sink holes from all sizes, as small as a barrel to an area of 3,100 acres occur in western Kentucky up to the number of 60,000 of which 9,000 have been mapped, according to the observations of State Geologist Jillson.

The plants of the Mississippian show a decided advance over those of the Devonian and are much like those of the later Coal period, the Pennsylvanian, and a more exact account of the plant life of the Mississippian will be included under that period, where illustrations of Carboniferous plants will also be given. While coal in irregular lenses does occur in the Mississippian rocks yet the beds are never so productive as those of the Pennsylvanian. The fossil trees of this period in Kentucky show an increase in woody parts, some of them attaining a height of one hundred feet. Most of them did not branch until near the top. Some of the trees were primitive conifers. The several thousand species of fossil plants known from the Carboniferous rocks of the world formed one of the most luxuriant, though not the most varied, floras the world has ever known. It is quite probable that the fossil plants so far known constitute only a part of those which actually existed. Ferns of a wonderful variety abounded. More exact details will be given in the next section.

Curious fossils called conodonts occur abundantly in the Mississippian rocks of Kentucky. The conodonts are minute glistening, brownish or black, tooth or scale-like fossils, of an uncertain nature. They are supposed by some geologists to be teeth and scales of small fishes or fish-like animals. These minute objects occur in extraordinary abundance in some localities where the rocks bear literally thousands of them.

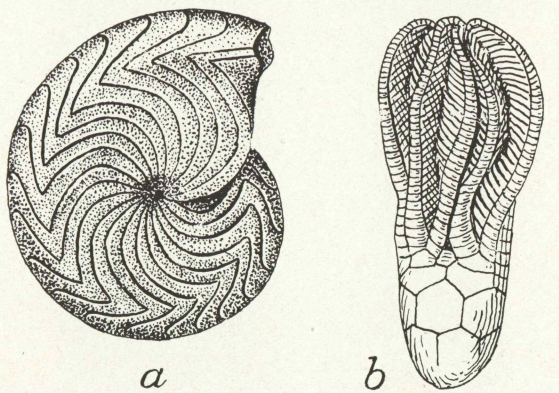


Fig. 13. Two animals from rocks of the Mississippian period. *a.* a beautifully preserved fossil cephalopod; *b.* a fossil stone lily. After *Schuchert.*



Fig. 14. Amphibian footprints found in Mississippian shales. One-third natural size. After *Branson*.

Land vertebrates must have existed somewhere in Kentucky during the Mississippian, but their fossils are yet unknown, not only within the State but throughout the entire Western Hemisphere the only indications of land vertebrates are some fossil footprints (figure 14). Even in Europe the record is scant. The later Coal period, however, bears records of many scores of different kinds of amphibians and reptiles, though principally from outside the State.

A group of large sharks, with pavement-like teeth, known as cochliodonts, adapted for crushing shell-fish, and possessing large fin spines, occur abundantly in rocks of the Mississippian period, in a great variety of species. A general progress in the development of fish-like forms toward the dominence of the bony fishes took place at this time. The huge arthrodires of the Devonian had disappeared, as had also the diversified ostracoderms.

The hosts of invertebrate animals which swarmed in the warm Mississippian seas show progress over their Devonian predecessors. The trilobites were becoming reduced in numbers, for they were approaching extinction. A most astonishing diversification occurred among the crinoids, or "sea-lillies," animals of the star-fish group usually growing on a stem attached to the sea bottom. Nearly four hundred species or kinds have been found in the limestone quarries of one locality. It is strange that the corals formed no reefs during the Mississippian, such as were seen during the Devonian. The cephalopods were being held in check by the shell-feeding sharks, and the nautaloids no longer ruled the seas.

The fossils found in the Mississippian of Kentucky indicate that the seas were warm and equable, a condition conducive to the expansion of many types of life. On the land the vegetation shows the effects of a mild climate, for the most part, although this was varied by semi-arid and cold conditions which had some notable effects on the expansion of life.

The Great Coal Period

The most conspicuous feature of the deposits formed in Kentucky and elsewhere is the many layers of coal. While coal

was formed in other places at later times yet by far the greatest amount of coal was formed during the Pennsylvanian period or the "Coal Measures" as the period is often called. About seven-tenths of the coal supply of the world is found in rocks of this age. It is an obvious and well known fact that ordinary coal is a compact, stratified mass of plants which have suffered some decay. The remains of animals, fishes, amphibians and invertebrates, mingled with the coal undoubtedly added to its volatile nature.

The significant advance in the life of the Pennsylvanian was the wide expanse of the land plants and their enormous development; the spread of the amphibians, now known for the first time from abundant fossilized skeletons; the beginnings of the true reptiles; the gradual development of bony fishes; the elimination of certain groups of invertebrates and the expansion of others. The insects were present in great numbers of cockroach-like forms. Spiders of an archaic type; millipeds, centipedes, scorpions, and other arachnid forms were present—their development being favored by the rapidly expanding forests of the warmer climates, and the abundance of food. Since the land plants, insects, amphibians, and reptiles constitute the new things in the geological succession of life in Kentucky accounts of these groups will be given in considerable detail. It is to be remembered however, that while all these changes were going on among the dwellers on the land, changes were also taking place among the inhabitants of the seas. The marine records are preserved in the thousands of feet of limestone which were deposited during the Pennsylvanian.

The climate of Pennsylvanian time was warm and genial the world over, and the lands bordering the seas were moist, with an abundant and well distributed rainfall. Conditions, such as these favored the rapid growth of plants and animals and brought about enormous developments, which under less favorable conditions, would have been of very slow accomplishment.

Since petroleum is of organic origin, being derived from the decomposition of animals and plants, the Coal Measures are rich in oil and gas. Pools of oil occur throughout the Mid-

Continental region in rocks of the sub-Carboniferous or Mississippian. In Kentucky the Devonian Sediments have been the largest producers of petroleum up to the present time.

Flowering plants are unknown in the Pennsylvanian, nor had the forage plants and grasses developed. They came on much later. It is estimated that more than three thousand kinds of plants lived in the swamps of the Pennsylvanian. Many of the kinds of plants which clothed the lands in late Devonian undoubtedly continued without much change into the Carboniferous, and the expansion of plant life to form the great coal beds doubtless consumed over a million years. It is reasonably certain that many plants existed during this time which are at present unknown. New forms are being described constantly.

This great Coal period has often been called the Age of Ferns, because plants of fern-like characteristics far outnumber all of their associates. They are the commonest fossils seen in the Kentucky coals, and some of the fern-like plants were of large size. The Paleozoic tree ferns (figure 11) are fairly well known. Some of them had trunks two feet in diameter and a height of 60 to 70 feet, with a splendid crown of large, spreading compound fronds at the summit. Some of these tree ferns of the Paleozoic are related to the elephant ferns now found growing in the tropics, much smaller than their ancient progenitors.

Seed-ferns we found existing in the Devonian, and we find them in great numbers in the Coal Period. One of these tree-like seed-ferns had a slender stem which growing in close association with thousands of other plants depended on its neighbors for support, and was probably unable to stand alone. It had adventitious roots exactly like the root-like growth Kentuckians see on their corn stalks. These were for support. The leaves were arranged spirally on the stem and formed a large graceful crown near the top. Some of the leaves were more than three feet in length. The seeds were barrel-shaped, about a quarter of an inch long, and enclosed in a cupule.

Tree-like plants of great importance during the Coal Measures were those known as the *Lepidodendrons*. These are

represented today by the little ground pine. Some of the Carboniferous scale trees (*Lepidodendrons*) were four feet in diameter, with a large trunk one hundred feet high. One trunk was found measuring 114 feet up to its first branches, and the crown above this must have attained a height of 135 feet. The trees had no true roots, but heavy underground parts, root-like in appearance, supported the enormous trunk. The trunk of the Lepidodendron was distinctly woody, though not like the solid wooded trees we know today.

Other tree-like plants are known as *Sigillaria*, looking oddly like the giant cactus travellers see in Arizona. One trunk six feet in diameter at the base and a foot at the top, was only eighteen feet high. Still other *Sigillaria* were tall and slender, attaining a height of a hundred feet, and without branches. The leaves were held for a long time and when finally dropped left six-sided scars. Both *Lepidodendron* and the *Sigillaria* bore cones, sometimes a foot in length, borne in a close whorl around the stems, from which spores, not seeds, were produced.

The *Cordaites* looked much like the Joshua trees or giant yuccas seen in the Mojave Desert of California. They were tall slender trees, often attaining great heights. The center of the trunk is pithy, and not very strong.

The scouring rushes, before the introduction of scouring powders, were used by housekeepers to scour their pots and pans, for which the rough, harsh coat of the horse-tail rushes fitted them. These plants were represented in the Coal Measures by large plants called *Calamites* and they are among the commonest fossils of the Carboniferous. The plants grew in wet, swampy places, had underground parts and upright stems, which bore branches at the nodes in whorls. Spores were borne by cones often a foot long.

It is thought that the evergreen trees, the conifers, began their development during the Pennslyvanian, but none of the fossils so far found permit a satisfactory study of the species.

Living in the pools and swamps, where the coal-forming plants grew so luxuriantly, there were a number of different kinds of amphibians, whose skeletons and rarely the soft parts,

are found in Pennsylvanian deposits in many places throughout the world—although none have yet been found in Kentucky. Some of their skeletons were found fossilized in *Calamite* trunks, along the coast of Nova Scotia. A single reptile has been found in cannel coal in Ohio.

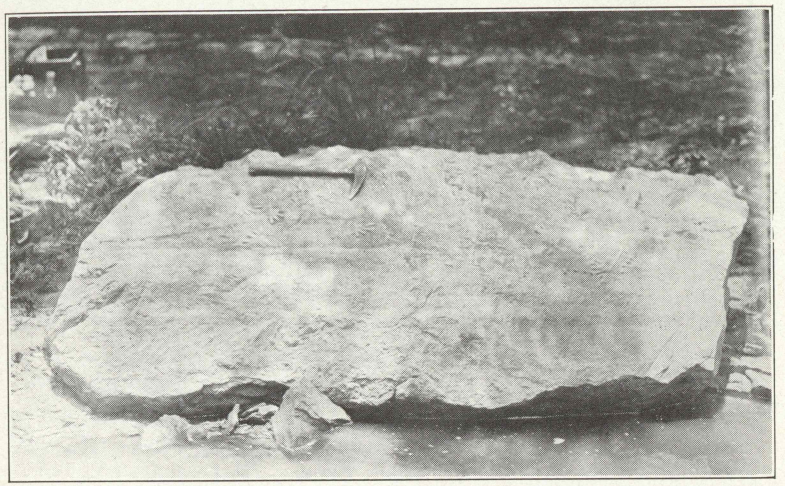


Fig. 15. A large slab of rock of Pennsylvanian age showing footprints of land vertebrates. Photo by *W. R. Jillson.*

The amphibians of the Pennsylvanian period are for the most part, small semi-aquatic vertebrates, comprising both naked and armored forms. In the cannel coal of eastern Ohio there occur a number of kinds of amphibians represented by hundreds of specimens. They are all crushed flat by the pressure of the rocks above the coal. Examples of these early land vertebrates may also be found in the extensive coal beds of Kentucky—a possible discovery of great interest. In rounding nodules in shales above the coal in Illinois occur other amphibians, and a large number are known from the Coal Measures of Canada.

Some of the amphibians appear to have been ancestral frogs, while others, known as *Branchiosauria*, gave rise to the salamanders known in Kentucky today as mud-puppies or water newts and efts living in the shaded streams and in many caves. The salamander-like creatures of the Carboniferous are very

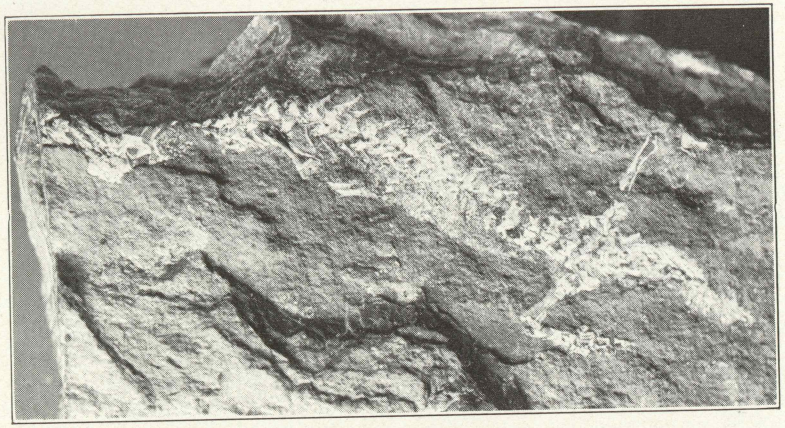


Fig. 16. Part of the skeleton of an amphibian, enlarged, as preserved in the rock. Part of the head is missing. The left fore limb is drawn close to the body. Part of the right hind limb is lost. Specimen in Walker Museum, Universty of Chicago.

small, ranging from two inches in length up to five inches. Their bodies are so well preserved that the muscles, skin, scales, eye pigment, lateral line canals and organs, the liver, the intestines and stomach are known. They seem to have been air-breathers without lungs, oxygenating the blood through the walls of the extensive buco-pharyngeal pouch.

Snake-like amphibians with skeletons consisting simply of a vertebral column and head are known to have lived with those species which were reptile-like. The animals are mostly known from fragments which were picked out of the dump at the mouth of the coal mines, while some were found in systematic splitting of hundreds of tons of coal.

The fresh-water and marine fishes of the Pennsylvanian are more nearly like the Mesozoic fishes than like the earlier Paleozoic fishes. The fishes of today were foreshadowed in the Coal Measures by forms showing a tendency toward the bony type. No new groups were developed and no great group was lost. The general tendency among piscine forms was upward toward the later types.

The insects of the Pennsylvanian were, many of them, the largest ever known, giants of their kind. The maximum size

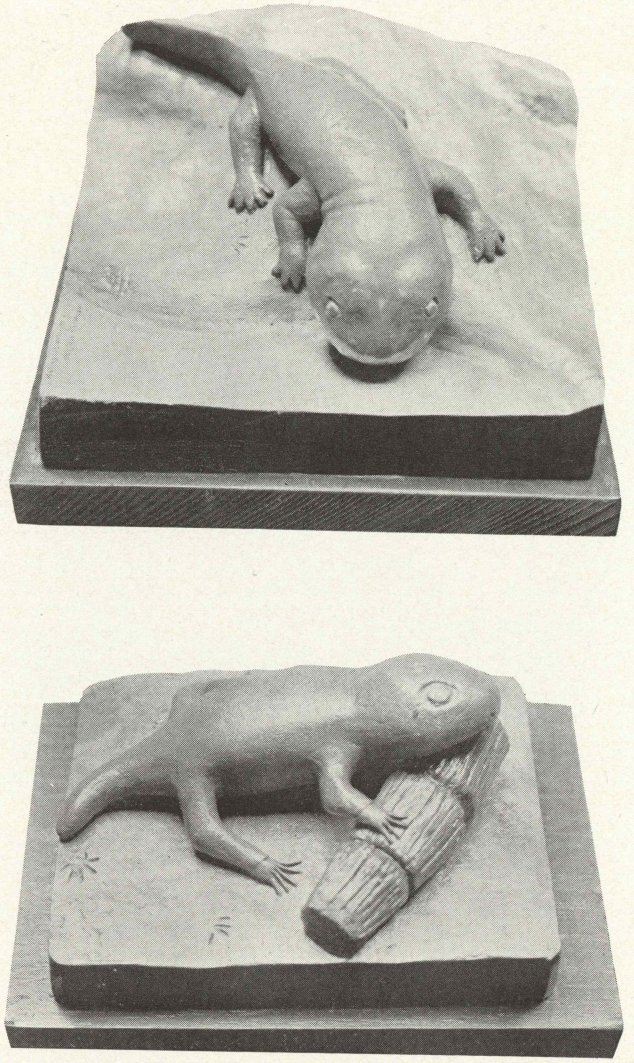


Fig. 17. Restorations of two Coal Measures (Pennsylvania) amphibians. Above is the salamander type, the originals of which measured less than two inches, and looked like small, modern, mud-puppies. Below is a reconsruction of a reptilian type, about three inches long, with short body, long legs and sharp claws. Both animals possessed small scales buried in the skin of the back.



Fig. 18. One of the slender elongate legged salamander-like stegocephalians, whose remains are known from the Mazon Creek Shales of Illinois. The animal, about five inches in length, is shown in the act of grasping a small crayfish-like animal. The picture is based on specimens in Yale University. On account of the fact that the crustacean is a salt water or brackish water creature the early Amphibia have been thought to inhabit the margins of the seas, a habitat now entirely unfamiliar to the group.

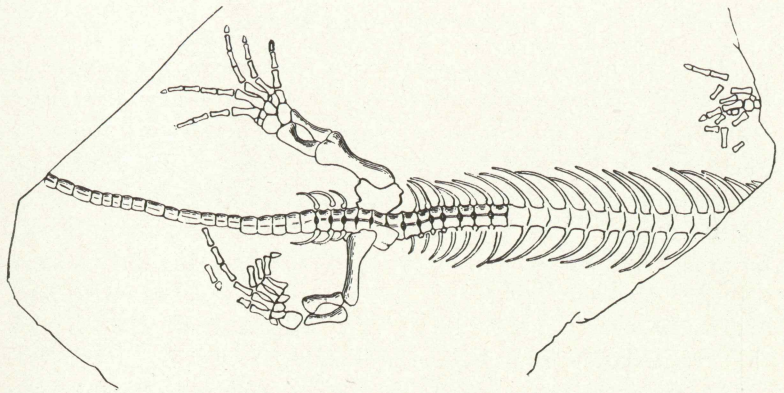


Fig. 19. The only known reptile found in the American Coal Measures. This specimen, preserved in the U. S. National Museum at Washington, was found in cannel coal in a nearby state.

was reached by those of the dragon-fly type, one of which, found in the Coal Measures of Belgium, measured 29 inches across the wings. They were the only flying creatures of their time. There are over 400 kinds of insects known from the Coal Period. At no subsequent time have insects grown so large. In addition to the large number just mentioned occuring in the lower and middle Pennsylvanian, there were some 800 different kinds of cockroaches, carnivorous and often measuring four inches in length.

The spiders of the Pennsylvanian in general resemble modern spiders. Closer examination, however, shows the body to have been segmented, unlike modern arachnids.

Scorpions of modern appearance, thousand legs or millipeds, land snails and fresh-water clams are some of the interesting developments of the great coal age. The small land snails were found in the hollow stumps of fossil trees (Sigillaria).

The invertebrate marine life of Pennsylvanian time was not only prolific but also varied, faunas everywhere being similar. Many of the Pennsylvanian limestones are composed exclusively of fossil shells of one-celled animals, the Protozoa.

Paleozoic Coral Reefs

It is rather surprising to learn that coral reefs exist in Kentucky. The oceans where corals live are now far away from the State but the fossil coral reefs assure us that the ocean has, in the past, covered the area now called Kentucky and has left coral reefs in the rocks formed at various times in the Paleozoic. The present climate of Kentucky, too, is not favorable for the growth of corals, even if marine waters were present. Present day corals live in tropical or warm waters, and we believe that the finding of fossil corals in what is now the Arctic indicates a change in climate.

Present day coral reefs are the combined product of the activity of many organisms, both plants and animals. The coral animals themselves are of primary importance because of their lime-secreting nature but in reef formation they are accompanied by the lime-forming bryozoans, with many at-

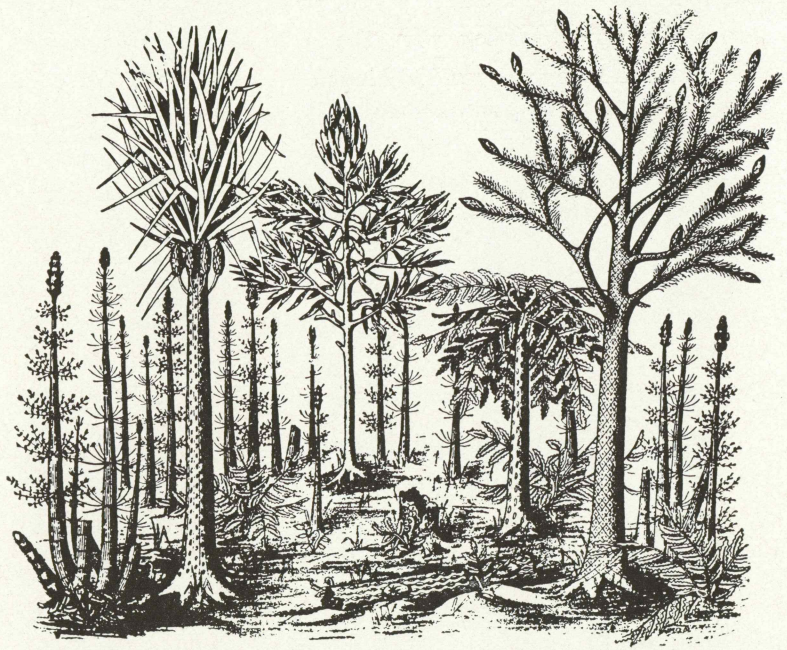


Fig. 20. Composite restorations of Coal Measures trees, as they may have appeared in the Kentucky swamps, millions of years ago. The *Lepidodendron* (the scale tree) is in the right foreground. *Sigillaria,* and huge scouring rushes, in the left foreground; *Cordaites* and a forty foot fern in the background; *Calamites* in outer circle. These tree-like plants had some woody parts. By permission of Henry Holt & Co.

tached shell fish. A great quantity of lime was also deposited by the action of bacteria and by lime-depositing sea-weeds. Reefs hundreds of feet thick, and many hundred miles long, both fossil and recent, are thus composite structures.

Geologically the history of fossil coral reefs begins in the pre-Cambrian and Cambrian, but of these we have no records in Kentucky. Reef masses of the bedded type occur in the State in rocks of Ordovician times, constituting the earliest Kentuckian representatives of this interesting rocky material. Coral reefs, of a complex nature are well developed in the Silurian and in the Devonian reach a very massive form, such as those near Louisville. The corals which occur in the Louisville reef extend northward into Alaska, so we are assured that Devonian climate was quite different from what it is at present.

Coral reefs during the Mississippian, whose rocks are so important in Western Kentucky, are not so well developed and wide-spread as in the Devonian, and none are known from the rocks of the State. Little is known of the nature of coral reefs during the Pennsylvanian. Life activities during the Coal period were more interesting on land than in the seas.

Coral reefs furnish protection for numerous animals but the nature of the sediment prohibits the preservation of many of these creatures. The action of the surf, in the past as now rends the coralline growths and by repeated poundings of the coral boulders produce a form of coral sand, and of course silicious sand was often washed into the growing reef. The irregular nature of reef formation, as well as the absence of regular bedding planes, renders fossil coral reefs unimportant for commercial quarrying.

Gaps in The Geological History of Kentucky

Between the closing of the Pennsylvanian—the great Coal Period—and the Pleistocene, millons of years later, the geological record in Kentucky is a blank, except for a short time during the Cretaceous and the Eocene. Great as this gap in the record is, and important as it has been in shaping the surface features and drainage pattern in Kentucky, we know that it was not the first but rather the last of a long series of sedimentary

breaks which are easily seen far back in our lower Paleozoic section particularly the Devonian and Silurian. During all of this time, however, in other parts of the world, significant events in the upward progress of life were taking place. In order to keep in mind some of the events which were transpiring elsewhere, it will be well to state briefly what these happenings were, naming the periods of the times.

Among the plants true woody plants came in; flowering plants and grasses became common and furnished food for many herbivorous animals. Great periods of dryness and intense cold left their impress upon animal and plant life.

The Permian period witnessed the closing of the great Paleozoic, and during this time all of North America was dry land. The period was one of great aridity, and desert conditions prevailed throughout much of the land areas of the world. The cold, glacial climate with numerous large sheets of ice made the period one of extreme hardship for plants and animals. Yet here and there groups survived and made progress. Insects developed into many groups, and land animals became common. This period witnessed the last of many of the Paleozoic invertebrates.

The Mesozoic era, lasting for millions of years after the end of the Permian, includes the Triassic, the Jurassic, the Comanchian and the Cretaceous periods, all properly constituting the Age of Reptiles. While the smaller denizens of the seas continued and expanded yet the new things on earth were the reptiles of land, sea and air. Accompanying these strange vertebrates and doubtless feeding on their eggs, were small mammals which were the ancestors of the creatures of the next era—the Cenozoic.

The age of mammals—the Cenozoic, is recorded by fossils in the rocks of the Eocene, Oligocene, Miocene, and Pliocene periods covering millions of years. The era witnesses the diversification, expansion, and advance of many groups of mammals. Some of them were strange and ill-adapted for a continuance of life under strange conditions, and so lost out. Many of them survived as present day warm-blooded animals. During this long period all of Kentucky, broadly speaking, was a

land area with the exception of some districts west of the Cumberland and the Tennessee Rivers. A wide and constantly changing variety of land animals traversed Kentucky during this time without doubt, but conditions in so humid and rapidly eroding an area were not good for the preservation of their remains in fossil form. Consequently this part of the geological record in Kentucky is essentially a blank.

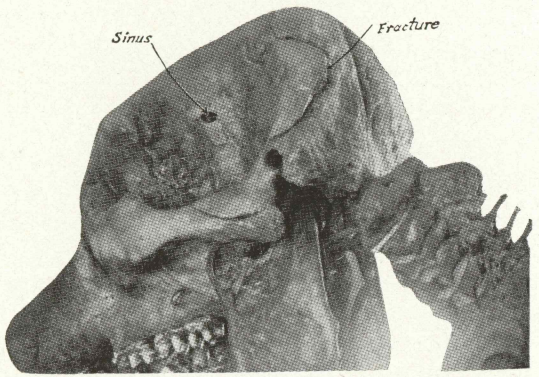
The Quaternary in Kentucky

A large number of terms are used by writers on geological subjects to designate that extent of time and events toward the close of the Cenozoic. The Great Ice Age, the Glacial Period or Epoch, the Quaternary, the Holozoic, the Psychozoic, the Pleistocene, and the Age of Man all designate, more or less closely the periods of time with which we are now concerned. The greatest events were the development of modern trees and plants, the occurrence of many groups of mammals, some of which became extinct during this time, and the appearance of man. The greatest physical event was the Great Ice Age, with its oft recurring advance and retreat of the great sheets of ice over the northeastern part of the continent, which extended southward to the Ohio River. The climatic changes were great and the intense cold affected life all over Kentucky but only the northern edge along the Ohio River suffered any physical changes.

The Pleistocene period may have endured for a hundred thousand years or more. It is regarded by some geologists as having closed 20,000 years ago. The action of the ice, at one time in places 6,000 feet thick, and the enormous amount of water liberated at its melting brought about vast changes in the northern lakes and rivers. The distribution of animals and plants advanced and retreated with the fluctuations of the ice sheets.

About 250 species of Pleistocene plants are known in all of North America, less than twenty of which are extinct. Leaves of trees in Pleistocene deposits near Toronto, Canada, show that the trees now living in Kentucky lived at that time far north. This indicates one of the striking changes in climate.

Another change is shown by the discovery of musk-ox bones, now an Arctic animal, in regions south of Kentucky. Blue Grass caves near Lexington have given up their significant treasures of Arctic bear and fox as well as other probably glacial animals.



Fif. 21. An injured skull of a Pleistocene mastodon. Pus had discharged from the opening marked "sinus" for a long time before the "fracture" was made.

Many strange mammals, long since extinct, lived in Kentucky during the Pleistocene. At Big Bone Lick in Boone County, animals have come for their salt for thousands and thousands of years. Scores of hundreds of them left their bones at many of these "licks." Among the most curious animals of these mammalian assemblages are the great ground sloths belonging to the same group as the modern anteaters and sloths. These huge Pleistocene edentates are thought to have been exclusively plant feeders, like the modern, upside-down-tree sloth of South America which feeds exclusively on the large leaves of the Cecropia tree. These large sloths are found in Pleistocene deposits all over the eastern states, and far away on the Pacific Coast, within ten miles of the ocean, they left their bones in the asphalt pits of the Rancho la Brea.

Remains of the Pleistocene mastodon have been found at eight localities along the northern boundary of Kentucky (figure 22). These have usually been uncovered by steam shovels in railroad or canal building or in excavations for wells. No complete skeletal materials of these proboscidians have been found within the State, but elsewhere complete skeletons are mounted, as in many of the great eastern museums. Enormous quantities of teeth have been found at Bigbone Lick. The famous Blue Licks area has also made its contribution, and in one instance, at least, described by Professor Jillson before the Kentucky Academy of Science, a well preserved tooth has been found well within the Eastern Kentucky coal field. The mammoths, of two species, are represented in Kentucky by fragmentary remains.

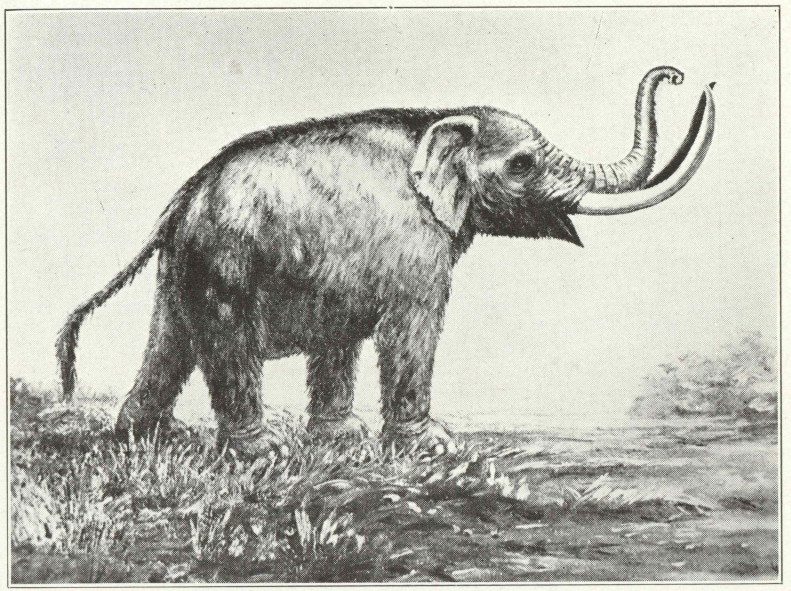


Fig. 22. The American Mastodon, whose teeth were so abundant at the Bigbone Lick that in 1804 Dr. Goforth took away a four-horse wagon load.

Fossil horses in America represent almost the entire history of that useful and intelligent mammal, beginning far back in the Cenozoic, from which time to near the close of the Pleistocene the group persisted, to become extinct shortly after the

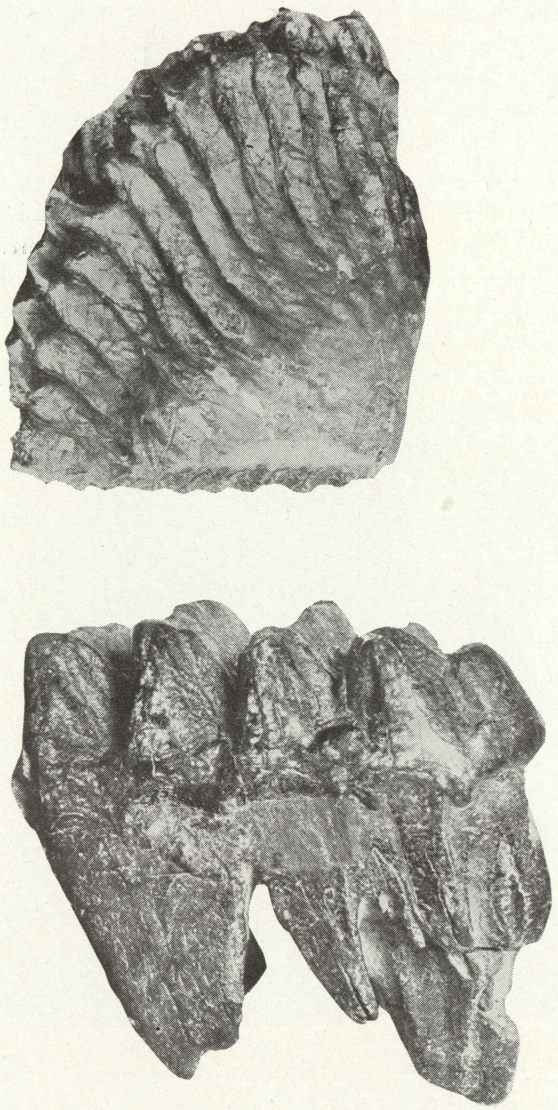


Fig. 23. The teeth of the mastodon and mammoth.

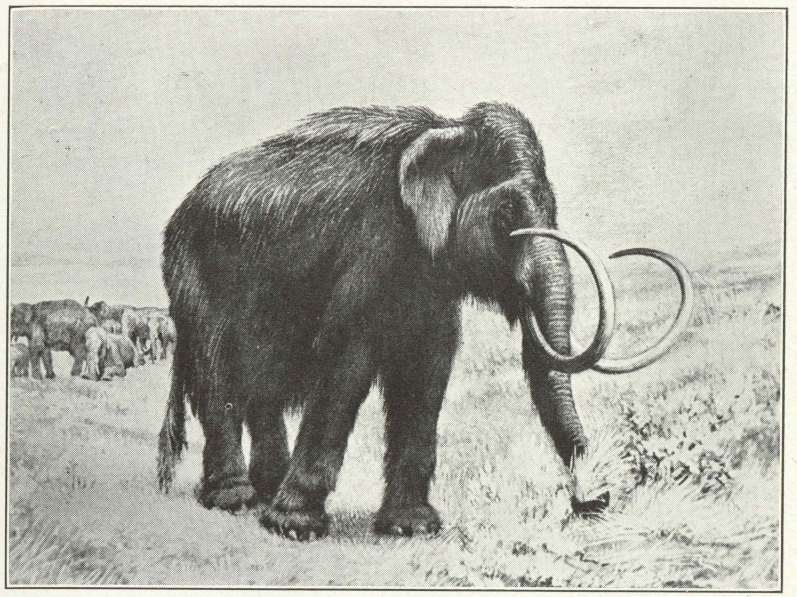


Fig. 24. The mammoth of the Kentucky Pleistocene.

Ice Age and when brought over by the Spanish explorers, thousands of years later, the horse family again found life kind in the continent of its ancestors At Big Bone Lick fragmentary horse remains show that the equines lived in Kentucky at the time of the mastodon and mammoth.

The tapir, a long-snouted animal now living in Brazil; the peccary; the Virginia deer; the elk; the reindeer; the musk-ox; the buffalo of two species are all represented in the Pleistocene of Kentucky by unsatisfactory and incomplete remains. Their geological position is often doubtful and even the place of origin is sometimes obscure. Further study of the exact paleontological history of these mammals in Kentucky is greatly needed to establish their status in the Pleistocene life of the State.

Of the nature of the fishes and the invertebrates living in Kentucky during the Pleistocene little is known. We have no reason to suppose they differed much from the animals now living within the State.

The Recent Period in Kentucky

The Recent is the geological period in which we are now living. It is usually regarded by geologists as having begun about 20,000 years ago. The most important event in the geological succession of life in Kentucky was the introduction of man.

We do not know when ancient man first reached Kentucky but it seems probable that the early human migrants, entering North America by way of Alaska, lived along the North American Pacific Coast, in the region of New Mexico, Yucatan, and Peru thousands of years before a group of forest dwellers found the Blue Grass State. Great civilizations undoubtedly grew and waned before Kentucky was inhabited by the human race. They reached this State, however, long before the coming of Columbus into Western waters.

One of the most interesting ways to study the manner of life of the ancient—the original Kentuckians, is by examinations of their mounds and forts. Excavations into the "trash-piles," garbage heaps, or Kitchen-middens as they are called, have also revealed much. These mounds of refuse were many generations in the making and at times burials were made in parts of the heaps. The bones of the animals which they have eaten, their pottery and stone implements, the hearths by which they cooked their food and warmed their bodies, the shells of mussels, the skeletons of fishes, not only give us an insight into the daily life of the early Kentucky Indian, but show us the kinds of animals and plants which lived at this time. We learn that the elk, deer, bear, and wild turkey furnished the largest amount of meat for the early inhabitants; while nuts, acorns, corn, and wild grains and fruits varied their diet. Fish, fresh water bivalves, and crawfish were not an inconsiderable item.

It is possible, by careful work, to study the chronological sequence of events by a study of these mounds, for the materials tend to be arranged in a stratigraphic order, much like the more ancient rocks whose evidences of life we have been considering. Many Indian graves have recently been opened, and from this single source a wealth of information and artifacts has been gleaned.

A most interesting, exact, and well-illustrated account of "*Ancient Life in Kentucky*" written by two Kentuckians, Professors Funkhouser and Webb, issued by the Kentucky Geological Survey, gives a very interesting account of early man in the State. Every Kentuckian should see and read this book. It is one of which they may feel proud.

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II

ORDOVICIAN FAUNA

By

ARTHUR C. MCFARLAN

THE ORDOVICIAN FAUNA OF KENTUCKY

By

ARTHUR C. MCFARLAN

INTRODUCTION

HIGH BRIDGE SERIES
(M. R. CAMPBELL, 1898)

Massive, cliff-forming limestone of Chazy and Stones River age. Three formations are recognized:

CAMP NELSON (A. M. Miller, 1905, p. 10). Limestone composed of irregular patches and ramifications of granular rock of the Oregon type distributed through a matrix of dense limestone of the Tyrone type, presumably algal in origin. On weathering the surface becomes honeycombed. Fossils are not common, the more characteristic being *Maclurites bigsbyi*, *Escharopora ramosa*, a species of *Rhinidictya*, and various cephalopods.

OREGON—Kentucky River Marble (A. M. Miller, 1905, p. 10). Grey to cream colored, granular, magnesian limestone.

TYRONE—Birdseye Limestone of Linney (A. M. Miller, 1905, p. 10). Dense gray, dove, or cream colored limestone, breaking with conchoidal fracture and with small facets of

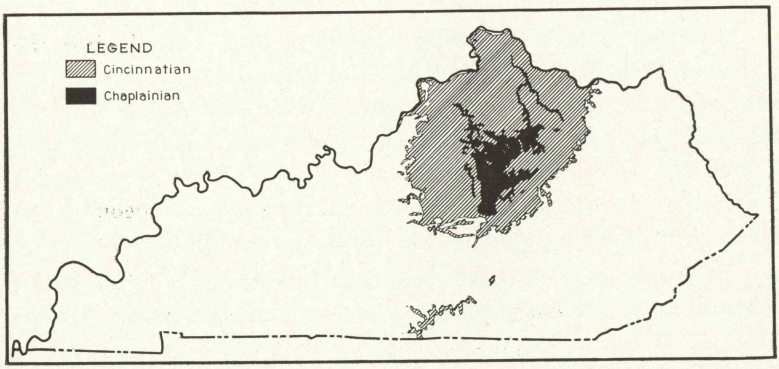


Fig. 25. Map of Kentucky showing outcrop of Ordovician rocks.

coarsely crystalline calcite. On weathering the surface becomes white, in which the darker facets are conspicuous, giving rise to the name Birdseye. A bed of bentonite, a greenish clay, occurs near the top. Fossils are few and include such forms as *Strophomena incurvata*, (see p. 80) *Orthis tricenaria*, *Leperditia fabulites*, and the cephalopods *Endoceras*, *Actinoceras*, and *Cameroceras*.

Lexington Limestone
(M. R. Campbell, 1898)

This is the Trenton of Kentucky. As originally defined it included the strata between the Tyrone and Flanagan Chert. As later applied by Miller (1905, p. 18) and Foerste everything up to the base of the Cynthiana is included. The series is richly fossiliferous and composed for the most part of thin limestone and shale. The following formations are recognized:

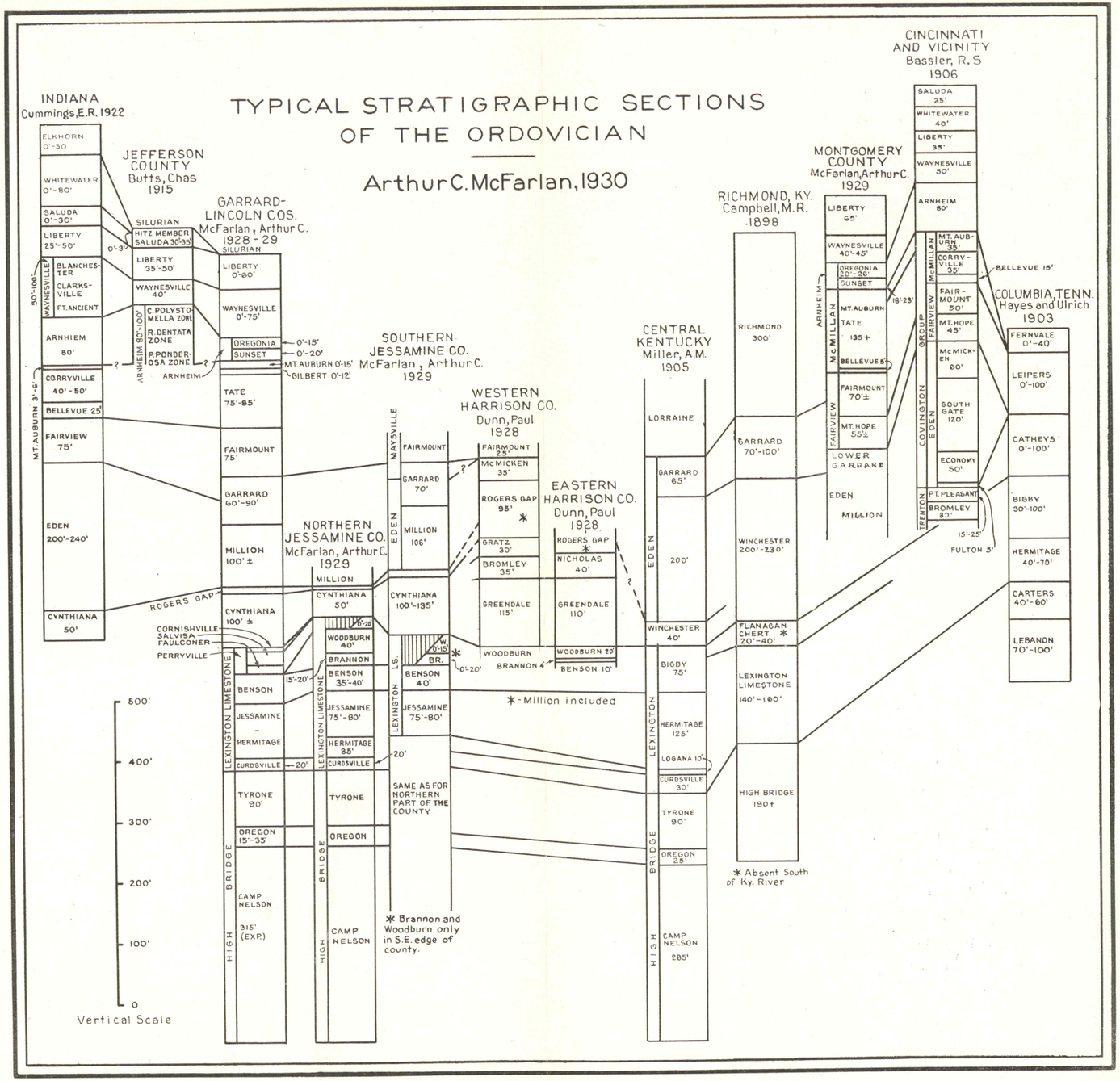
Curdsville (A. M. Miller, 1905, pp. 9, 18). Coarsely crystalline limestone with much chert. Characterictic fossils include *Orthis tricenaria*, *Dinorthis pectinella*, *Rhynchotrema trigonale*, *Streptelasma profundum*, and *Plectambonites curdsvillensis*.

Hermitage (E. O. Ulrich, 1903). A more or less siliceous limestone formerly known as the Logana (A. M. Miller, 1905, pp. 9, 18). Characteristic forms are *Dalmanella bassleri*, *Heterorthis clytie*, and *Prasopora falesi*. Near the top there is commonly a molluscan horizon where *Modiolodon oviformis*, *Protowarthia obesa*, *P. pervoluta*, and *Lophospira obliqua* stud the limestone.

Jessamine (A. M. Miller, 1919, p. 25). Replacing the name of Wilmore (Nickles, J. M., 1905, p. 15). This is the zone of *Prasopora simulatrix* together with *Dalmanella bassleri*, *Rhinidictya neglecta*, *Liospira americana* and *Hebertella frankfortensis*. Over much of Jessamine and Fayette counties, at least, the top of the formation is marked by a siliceous limestone containing a profusion of *Lophospira* and other mollusks.

Benson (A. F. Foerste, 1913, pp. 365, 389).[1] The association of *Rhynchotrema increbescens* and *Hebertella frank-*

[1] The Bigby formation of Ulrich (Columbia Folio) has been listed as equivalent to the Benson but is regarded as including the Benson, Brannon and Woodburn. The Paris bed (J. M. Nickles, 1905, p. 15) covers the same interval.



fortensis is more or less characteristic, though both occur lower in the column. The upper beds are characterized by the additional occurrence of *Stromatocerium pustulosum*, *Dinorthis ulrichi*, *Strophomena vicina*, and *Cyphotrypa frankfortensis*.

Brannon (A. M. Miller, 1913, p. 324). A fine-grained, siliceous, bouldery or concretionary limestone, with much shale in the lower part. On weathering it gives rise to a conspicuous zone of chert drift and forms the lower part of Campbell's (1898) Flanagan Chert. Fossils are not common except in the shale. The Brannon is the horizon where the remarkable sponges, *Brachiospongia digitata*, and *Pattersonia aurita* are usually found. Of interest is the early occurrence of *Eridotrypa briareus* with *Peronopora milleri*.

Woodburn (A. M. Miller, 1913, pp. 326, 327). A crystalline limestone, with unusually high phosphate content. The most useful index fossils are *Columnaria halli*, and *C. alveolata var.* associated with *Platystrophia colbiensis*, *Constellaria teres* (locally abundant) *Cyclora minuta*, and *Rhynchotrema increbescens*.

Perryville (J. M. Nickles, 1905, p. 15). This formation is best developed in the southern and western Bluegrass but outliers of both Salvisa and Faulconer occur in the vicinity of Lexington and Paris. Three members are recognized:

Faulconer (A. F. Foerste, 1912, p. 32). A porous, coarsely crystalline, light gray, massive limestone, in its typical development a crowded mass of gastropod shells, chiefly *Bellerophon troosti*, *Oxydiscus subacutus*, and *Lophospira medialis*. Silicification of this bed, in weathering, gives rise to the third chert horizon of the series, a fossiliferous chert.

Salvisa (A. M. Miller, 1913, p. 329). Upper Birdseye limestone of Linney. A compact limestone suggesting the Tyrone, including some of black color. Characteristic fossils include *Isochilina jonesi*, *Leperditia* (several species), and *Orthorhynchula linneyi*. Locally it is softer and more argillaceous.

Cornishville (Foerste, 1912, p. 32). Crystalline fossiliferous limestone characterized by the recurrence of the upper Benson fauna. It is restricted to the counties of the southern Bluegrass.

As indicated in the Garrard and Jessamine County section the development of the upper Lexington limestone is different in the southern area. In southern Jssamine County, except in the eastern part, the Cynthiana rests directly on the Benson. In central Garrard and northern Lincoln and Boyle counties, the interval between the Jessamine and Perryville beds is occupied by the lower Benson only.

Cynthiana

(A. F. Foerste, 1906, pp. 10, 13)

Fossiliferous limestone and shale. Basler, (1915), recognizes four divisions, the Greendale, Bromley, Gratz, and Rogers Gap members.

Greendale (A. F. Foerste, 1909c, p. 295). The characteristic faunal assemblage includes *Cyclonema varicosum*, *Eridotrypa briareus*, *Orthorhynchula linneyi*, *Herbertella maria parkensis*, *Homotrypa norwoodi*, *Constellaria emaciata*, *C. fischeri*, *Heterotrypa parvulipora*, *Allonychia flanaganensis*, *Rafinesquina winchesterensis*, *Platystrophia colbiensis*, and *Escharopora maculata*. A more richly fossiliferous and rubbly phase occurring in the eastern area of outcrop is known as the Millersburg. The faunal difference is quantitative rather than qualitative. It is in this bed that the precursors of the Fairmount forms are best developed.

Bromley (Bassler, 1906, p. 9). The name was given to the thirty feet of drab to blue shales outcropping in the lower part of the river bank at Cincinnati.

Gratz (undescribed in the literature). The name is taken from a village on the Kentucky River in western Owen County. It consists of a series of rather unfossiliferous shales. Its geographic extent is not known by the writer.

Overlying the Millersburg in Nicholas County is a coarse-grained limestone to which Foerste has given the name Nicholas limestone (A. F. Foerste, 1909, p. 210). At Carlisle a similar limestones overlying the Millersburg contains *Clitambonites*.

Rogers Gap (A. F. Foerste, 1914, pp. 109-156). The essentials of the type section are as follows:

(a) Lower coarse-grained crinoidal limestone up to eighteen feet thick. This may be the equivalent of the limestone with Clitambonites mentioned above.

(b) Argillaceous strata containing *Eridorthis nicklesi*, *E. rogersensis*, and *Clitambonites rogersensis* in the lower part.

(c) A gastropod horizon with *Belleophon rogersensis*, *Tetranota obsoleta*, *Liospira vitruvia*, and *Lophospira sp.*, a constant and well marked horizon.

(d) Argillaceous strata with *Eridorthis* at top.

(e) 20-25 above (a) an upper coarse grained crinoidal limestone with Eridorthis, which is most common just below it.

(f) Zone of abundant *Plectambonites rugosus* with associated *Strophomena halli* introduced about five feet above (e). This zone (*Plectambonites* does occur lower but not in the same abundance) has been regarded as marking the base of the Eden (Million) in Central Kentucky by Miller and others. It is one of the most conspicuous and consistent horizons throughout the area.

These beds are of wide extent in Central Kentucky. *Eridorthis* has been identified along the Ohio River at a level well below the Fulton layer (A. F. Foerste, 1914, pp. 119, 120), also in the lower Economy at several localities in that region (Foerste, 1909, p. 294). The stratigraphic relationships of this bed are not well known.

Eden

(E. ORTON, 1873, pp. 370, 371)

At Cincinnati four divisions are recognized:

Fulton (A. F. Foerste, 1905, p. 151). Shales characterized by *Triarthus becki*, *Leptobolis insignis*, *Plectambonites plicatellus*, and *Merocrinus curtus*.

Economy (R. S. Bassler, 1906, pp. 8-10). The *Aspidopora newberryi* zone of Nickles. It is characterized by *Coeloclema commune*, *Crepipora venusta*, and several species of *Aspidopora* (R. S. Bassler, 1903, p. 9).

Southgate (Bassler, ibid). The zone of *Ctenobolbina ciliata.*, *Aspidorpora eccentrica* and *Batostoma jamesi*. Cum-

mings and Galloway regard *Climacograptus typicalis* and *Bythocypris cylindrica* as characteristic in the Tanners Creek section.

McMicken (Bassler, ibid). The zone of *Dekayella ulrichi* of Nickles. Limestone is a more conspicuous element than in the lower members. The typical fauna includes *D. ulrichi*, *Coeloclema commune*, *C. alternatum*, *Batostoma Jamesi*, *B. implicatum*, and *Hallopora onealli*.

In Central Kentucky the Eden is divided into two members, the Million (J. M. Nickles, 1905, p. 25), and the overlying Paint Lick (A. F. Foerste, 1909c, 293) constituting the lower, massive part of the Garrard sandstone of Campbell (1898). The Paint Lick is quite barren of fossils. Among the more characteristic forms of Million are *Plectambonites rugosus*, *Dalmanella multisecta*, and *Ectenocrinus simplex*. The base is marked by the appearance in great numbers, commonly in a crinoidal limestone, of *Plectambonites rugosus* and *Hallopora onealli*. In some sections, at least, *D. multisecta* is introduced in equally large numbers ten or fifteen feet lower.

Maysville

(A. F. Foerste, 1905, pp. 149-52)

Fairview (R. S. Bassler, 1906, p. 10). This is the *Plectorthis plicatella* zone of Cumings and Galloway (1913, p. 2) and includes Nickles' Mt. Hope or *Amplexopora septosa* beds (1902, p. 76) and his Fairmout or *Dekayia aspera* beds (ibid. p. 78). The faunal change from the McMicken is not abrupt. Common forms are *Plectorthis plicatella*, *Platystrophia laticosta*, *Amplexopora septosa*, *Batostoma implicatum*, *Dekayia aspera*, *Eschapora falciformis*, *E. pavonia*, *Hallopora andrewsi*, *H. dalei*, *Heterotrypa subfondosa*, *Homotrypa curvata*, *Constellaria florida*, and *Peronopora vera*.

Mt. Hope. This formation overlies the *Dekayella ulrichi* zone and is characterized by the introduction of a rich bryozoan fauna and of *Platystrophia*. *Plectorthis neglecta* is regarded as characteristic. In Central Kentucky this horizon is represented in the upper Garrard. *Strophomena maysvillensis* occurs in moderate numbers.

Fairmount. At Cincinnati the Fairmount is marked at its base by the *Strophomena Planoconvexa* zone, a limited horizon where this species occurs in great numbers. The occurrence of several species of *Plectorthis*, *P. plicatella*, *P. fissicosta*, and *P. aequivalvis*, is characteristic. In the central and southern Bluegrass the fauna is that of the Maury phase (A. F. Foerste, 1912, p. 19). The base is marked by a profusion of *Strophomena maysvillensis* and *Constellaria florida*. Other characteristic forms are *Orthorynchula linneyi* (upper), *Escharopora hilli*, *Cyrtoceras valandinghami*, *Platystrophia ponderosa* (lowest occurrence), *Hallopora dalei*, *Monticulipora mammulata*, *and Homotrypa cincinnatiensis*.

McMillan

(R. S. Bassler, 1906, p. 10)

This series includes the Bellevue, Corryville and Mt. Auburn formations as exposed in the region around Cincinnati. In the southern Bluegrass it is represented by the Tate, Gilbert and Mt. Auburn, with the Bellevue appearing as the lower Tate farther north.

Bellevue, the *Monticulipora molesta* beds of Nickles (1902, p. 82) and the *Rafinesquina ponderosa* zone of Cumings and Galloway (1913, p. 2). This highly fossiliferous zone of thin bedded limestone extends south into Montgomery County on the east and Shelby County on the west.

Corryville, the *Chiloporella nicholsoni* (*C. flabellata*) zone of Nickles, (1902, p. 83). Other more or less characteristic fossils are *Bythorpora gracilis*, *Rafinesquina fracta*, *Amplexopora filiasa*, *Hallopora andrewsi*, *Dekayia appressa*, and *Heterotrypa paupera*.

Mt. Auburn, the *Platystrophia lynx* beds of Nickles (ibid., p. 85). *Platystrophia ponderosa auburnensis* is characteristic. Associated forms are *Coeloclema oweni* and *Homtrypa pulchra*. In the southern Bluegrass it is a similarly highly fossiliferous rubbly limestone with *Platystrophia ponderosa* and *Heterospongia subramosa* common. A third common species is *Amplexopora robusta*. Lithologically it is well marked, resting on the dense limestone of the Gilbert, and beneath the non-fossiliferous Sunset.

HARMON (Cumings and Galloway, 1913, pp. 2, 7), referred to as the *Rafinesquina fracta* zone, including the Corryville, Mt. Auburn, and Arnheim formations of Indiana. The most common fossils are *R. fracta* and *Hallopora ramosa*. Characteristic forms according to Cumings and Galloway are *Atactoporella ortoni*, *Coeloclema oweni*, *Homotrypa pulchra*, and *Dinorthis retrorsa* (*carleyi*).

TATE (A. F. Foerste, 1912, p. 18). A non-fossiliferous, gray shale and shaly limestone section of the southern Bluegrass. Northward on the eastward flank of the arch fossiliferous zones become more common and in northern Clark and Montgomery counties it is abundantly fossiliferous with *Platystrophia ponderosa*, *Amplexopora robusta*, and *Cyphotrypa clarksvillensis* (cc.). Here it overlies the Bellevue.

GILBERT (Foerste, ibid.). A zone of dove to gray, fine-grained to dense, hard limestone restricted to the southern Bluegrass. It grades into the Mt. Auburn. *Platystrophia ponderosa* and *Lophospira bowdeni* are common. The Tate and Gilbert of Lincoln, Garrard, etc., counties together fill the interval of the Bellevue and Corryville to the north.

RICHMOND

(Winchell and Ulrich, 1897, p. 53, formerly known as the Lebanon beds Orton, 1873, p. 371)

The Richmond has customarily been recognized as beginning with the Arnheim though the latter had originally been classified with the Maysville and was again referred to it in 1913 by Cumings and Galloway (1913, pp. 2, 8).

ARNHEIM (A. F. Foerste, 1905, p. 150), the Warren beds of Nickles (1902, p. 86). At the type locality in Brown County, Ohio, he placed the top at the lumpy limestone containing *Strophomena concordensis*. In the eastern and southern area of out-crop two divisions are recognized:

SUNSET (A. F. Foerste, 1910, p. 18). A relatively non-fossiliferous argillaceous series, comparable to the Tate and Waynesville, sometimes dolomitic. Throughout the region of

Garrard, Lincoln, Clark, and Montgomery counties it is capped by a few feet of hard limestone, mostly of the Gilbert type, in some layers of which ostracods are very common. Northward in Ohio the Sunset becomes quite fossiliferous.

OREGONIA (A. F. Foerste, ibid.). A highly fossiliferous, rubbly limestone, in which the characteristic Richmond brachiopods *Rynchotrema dentatum* (*var. arnheimensis*), *Leptaena richmondensis* (*var. precursor*), and *Dinorthis carleyi* (rare in Kentucky) are introduced. The association of any one of these species with Platystrophia ponderosa (upper limit of range) is regarded as diagnostic. *Heterospongia knotti* is rather characteristic in the area between Lincoln and Marion counties. Over much of this area the top is marked by about two feet of light colored shale, full of slender bryozoa, including a form resembling *Hallopora dalei* and a *Homotrypa* (see p. 93).

In Jefferson County which may be regarded as typical of the western area, Butts (1915, pp. 41-49) has divided the Arnheim into three members:

(a) *Platystrophia ponderosa* zone. According to Butts it rests disconformably on the Bellevue at Sulphur in Henry County and at Madison, Indiana. McEwan (1920) has shown the presence of the Corryville and Mount Auburn in the latter section.

(b) *Rhynchotrea dentatum* zone (assoc. *L. richmondensis*).

(c) *Constellaria polystomella* zone. Other common fossils are *Anomalodonta gigantea*, *Homotrypa bassleri*, *Hallopora subnodosa*, and *Platystrophia cypha*. *Platystrophia ponderosa* ranges through all these zones, *Dinorthis carleyi* is rare in both (a) and (c), and *Cyclonema bilix var. fluctuatum* occurs in all three.

WAYNESVILLE (Nickles, J. M., 1903, p. 205). In 1910 Cumings used the term *Damlmanella meeki zone*. Three members are recognized (Foerste, A. F., 1909, pp. 291-292) in Ohio.

Fort Ancient. Characterized by the abundance of Dalmanella meeki and absence of other characteristic Richmond brachiopods and corals. *Anomalodonta gigantea, Modiolopsis concentrica, M. pholadiformis, Opisthoptera fissicosta,* and *Pterinea demissa* are common. The top is marked by the *Orthoceras fosteri* (*duseri*) bed.

Clarksville. This member includes all strata up to the lower *Hebertella insculpta* horizon (Austin, G. M., 1927, includes the *Hebertella insculpta* zone in the Clarksville.). *Streptelasma vagans, Plectambonites rugosus, Strophomena planumbona, S. sulcata, Rhychotrema capax,* and *Leptaena richmondensis are common.* It may be traced southward into Fleming County, Kentucky, (Foerste) but is not recognized in the western area of out-crop.

Blanchester. Terminated by the upper *Hebertella insculpta* horizon which has commonly been recognized as marking the basal Liberty but has more recently been included in the Waynesville (A. F. Foerste, 1909, p. 290). It has the richest fauna of the Waynesville and may be traced south into Bath County. *Strophomena nutans, S. neglecta,* and *S. vetusta* form a well-marked horizon in the middle. *Leptaena richmondensis, Rhynchotrema capax, Platystrophia clarksvillensis,* and *P. cumingsi* are common.

In Jefferson and adjoining counties the Waynesville is a series of shales and shaly limestones, the base marked by the occurrence of *Columnaria alveolata* and *Tetradium minus* (Fisherville coral reef of Foerste, 1909, p. 29). Above is a zone of shale with *Cyphotrypa clarkvillensis* (cc.). The rest of the formation is sparingly fossiliferous with *C. clarksvillensis* and *Zygospira kentuckiensis* characteristic.

Across the southern Bluegrass the Waynesville is almost void of fossils but becomes fossiliferous again to the north in Montgomery County.

Because of the close faunal relationship between the Waynesville and Liberty Foerste (1912, p. 22) proposed the name Laughery formation for the combined sequence.

Liberty (Nickles, 1903, p. 207)—The *Strophomena-Rhynchotrema* bed of Cumings (1900), and *Strophomena planumbona* zone of Cumings and Galloway (1913, p. 2). Over most

of its area of outcrop in Kentucky the base is marked by a coral reef, the Bardstown reef of Foerste (1909, p. 290) composed of *Columnaria alveolata, C. vacua, Tetradium minus, Calapoecia cribriformis,* and the associated *Beatricia undulata,* and *B. nodulifera.* It may be traced southward into Lincoln County on the one side, and Marion County on the other. The Liberty is missing along the axis of the arch. The more characteristic species include *Dinorthis subquadrata, Plectambonites rugosus, Phynchotrema capax, Strophomena planumbona, Streptelasma rusticum, Rhombotrypa quadrata, R. subquadrata, Protarea richmondensis,* and *Homotrypa austini.* In the region between Lincoln and Montgomery counties, at least, the basal reef is often missing and the bottom of the formation is marked by a massive dolomitic limestone. The presence of *Herbertella insculpta* would place this bed at the top of the Waynesville. The rest of the limestone over this same region is more or less dolomitic and fossils not well preserved. *Strophomena sulcata, Bythopora meeki, B. delicatula,* and occasionally *R. capax* are present. The upper part of these beds may include the Whitewater.

Saluda—Whitewater

The Saluda (A. F. Foerste, 1902, p. 369) is a dolomitic limestone, scantily fossiliferous except for an upper member, the Hitz limestone (A. F. Foerste, 1903b, p. 347), earlier designated as the *Murchisonia hammeli bed* (A. F. Foerste, 1896, pp. 218-222) which contains a Whitewater fauna. In the lower part of the formation, a few feet above the base, a reef of *Columnaria* and *Tetradium,* similar to the lower reefs is a characteristic horizon marker. This is the Madison coral reef of Foerste, (1909, p. 290).

The Whitewater (J. M. Nickles, 1903, p. 208) and Saluda are contemporaneous phases of sedimentation, the former wedging out and overlapping the Saluda to the south where it is represented by the Hitz member, the latter (Saluda) thinning northward. The Whitewater may be represented in the upper part of the "Liberty" on the eastern flank. The fauna is much like that of the Liberty, the bryozoa, *Batostoma variable, Homotrypa nicklesi* and *H. nitida* being restricted to it. Other common forms include *Bythopora delicatula, Homotrypa constel-*



Photo W. R. Fillson

HIGH BRIDGE AND LEXINGTON LIMESTONES AT BOONESBORO

These massive divisions of the Ordovician are markedly faulted at this point on the Kentucky River. To gain a sense of the really magnificent proportions of this clifted exposure note the figure of a man in the lower right hand corner. His hand is resting on the plane of fault displacement.

DESCRIPTION OF SPECIES

Family DYSTACTOSPONGIDAE

Genus HETEROSPONGIA Ulrich

Sponge sublobate or of compressed branches, surface showing mouths of branching, more or less tortuous canals which curve outward from the center. A few oscula present, distinguished by their larger size and surrounded by radiating channels. Sponge skeleton between the canals of variable thickness, sometimes appearing nearly solid, at others of loosely interwoven spicules.

HETEROSPONGIA SUBRAMOSA Ulrich

Pl. XII, figs. 5-6; Pl. XIV, fig. 13

Sponge subramose, of cylindrical or compressed branches up to 30 mm. or more in width. Its general features are shown in the accompanying figures.

This species has its best developent in the Mount Auburn of the southern Bluegrass, is common in the Oregonia and is locally common in the Fairmount and Waynesville.

HETEROSPONGIA KNOTTI. Ulrich

Pl. XIV, fig. 8

Distinguished from H. subramosa by the relatively small apertures, (6-8 in 5 mm. instead of about 5) and the presence of oscula scattered over the surface at intervals of 8-20 mm.

Common in the Arnheim of the southern Bluegrass, also in the Mount Auburn at Burdett Knob (Garrard County). Foerste mentions its occurrence in the Liberty near Lebanon. The specimen figured is exceptionally large.

Family BRACHIOSPONGIDAE

Genus BRACHIOSPONGIA Marsh

Sponge consisting of a hollow central body, circular or elliptical, with an opening on the summit, continuous radially with a number of downward curving, hollow, distally closed arms.

BRACHIOSPONGIA DIGITATA. Owen
Pl. III, fig. 9; Pl. LV, figs. 1-2

This species has from eight to twelve arms. In the figured specimen the diameter is about 23 cm., that of the central body 14½ cm., osculum 4½ cm., height of collar about osculum 2-2½ cm. Length of arms 5½ cm.

This remarkable form is found in the Brannon of Franklin County where it is common at two localities, unknown elsewhere. The writer has a specimen from the Curdsville, possibly basal Hermitage, from a few miles east of Nicholasville along the West Hickman Fault zone. It is rather small, with seven arms, and noteworthy because of the unsilicified condition. This has made possible the preparation of sections showing the characteristic hexactinellid spicules which are represented by calcareous casts (see Pl. IV, fig. 2). A silicified specimen from the chert waste near Dix River Dam may come from the Curdsville also. Other species have been described from the Mt. Hope and Liberty.

Family PATTERSONIIDAE

Genus PATTERSONIA (Miller)

PATTERSONIA AURITA. (Beecher)
Pl. III, fig. 10

This species was originally described under the generic designation of Strobilospongia. Its general features are shown in the accompanying figure. According to Beecher (1889 p. 15) the spicular structure "so far as observed" agrees with that of Brachiospongia.

The type is from the *Brachiospongia* bed (Brannon) on Benson Creek in Franklin County. Fragments of the basalia are quite common in the Brannon chert drift in the central Bluegrass, some coming from above in the Woodburn. The only locality where good specimens may be obtained so far as the writer knows, is on the farm of Dr. A. M. Peter in northern Fayette County.

Family PROTOSPONGIDAE

Genus HINDIA Duncan

Free, spheroidal characterized by a series of minute bifurcating canals radiating from the center and opening on the surface.

HINDIA PARVA. Ulrich
Pl. IV, fig. 7

A very common species of the Trenton varying from 5-10 mm., in diameter. They are most common at the Brannon horizon.

Phylum COELENTERATA

Class HYDROZOA

Family BEATRICEIDAE

Genus BEATRICEA

Cylindrical or angulated stems, often fluted, and ranging in size to over ten feet in length and a foot in diameter. A central tube with cystose tabulae and a peripheral vescicular structure characterize the fossil. (Grabau and Shimer 1909 pp. 46, 47.)

BEATRICEA UNDULATA. Billings

Up to 6cm. in diameter, characterized by longitudinal, rounded ridges separated by broad shallow grooves. These are not always continuous and often show a spiral twist.

Characteristic of the basal Liberty. In southern Indiana it has also been identified from just above the *Columnaria* reef of the basal Saluda.

BEATRICEA NODULIFERA. Foerste

Distinguished by a nodulose surface, the nodes more or less irregularly distributed but tending toward an arrangement in somewhat spiral vertical rows. *B. nodulifera intermedia* (Pl. XVI, fig. 1) is intermed'ate in character.

An associate of *B. undulata* in the basal Liberty. It may be a synonym of *B. nodulosa* Billings.

Family LABECHIIDAE

Genus STROMATOCERIUM

"Coenosteum massive, of dense, thick horizontal and concentric discontinuous laminae, separated by very narrow interspaces. No radial pillars. Small vertical tubes penetrate the several laminae, connecting interlaminar spaces. No astrorhizae." (Grabau and Shimer 1909, p. 46).

STROMATOCERIUM PUSTULOSM. (STAFFORD)

This very common Ordovician species forms masses from a few inches in diameter up to three or four feet, the surface characteristically pustulose. The base is usually concave with irregular, concentrically wrinkled epitheca. In all specimens observed by the writer, other than those which had been silified, the material was recrystallized.

This form, possibly including some which are specifically distinct, occurs at a number of horizons in the local Ordovician, including the uppermost Bensons (cc). Woodburn (r), Cynthiana (cc), Mount Auburn (c), Oregonia member of the Arnheim (c), and Liberty.

CLASS GRAPTOLITOIDEA

FAMILY DIPLOGRAPTIDAE

GENUS CLIMACOGRAPTUS. HALL

The principal character of Climacograptus is the peculiar geniculation of the thecae which, in their proximal part, are attached parallel to the axis thereby placing the aperture into a more or less deep transverse excavation between two successive thecae. (Ruedemann 1908, p. 400)

CLIMACOGRAPTUS TYPICALIS. HALL

Rhabdosome long and narrow, characterized by the slender, whip-like sicular end, the very small overlap of the early thecae, and the aspect of the thecae in the mature part of the rhabdosome, their distal free parts standing out as a series of squares from the broad median part of the lateral face.

A characteristic Eden species.

CLASS ANTHOZOA

FAMILY ZAPHRENTIDAE

GENUS STREPTELASMA. HALL

Corallum turbinate, often curved. Septa alternately long and short, the edges of the longer twisted together at the center. Tabulae few or absent. Tetrameral arrangement well shown externally with removal of epitheca.

STREPTELASMA PROFUNDUM. (OWEN)

Corallum several cm. in length characterized by the great depth of the calyx, extending nearly to the base of the coral.

Septa relatively few, (60-74 in mature specimens) not twisted at the center, and with crennulated margins. Primary septa strong, with three pseudo-fosulae, and double cardinal fossula, divided by the cardinal septum.

Tyrone and Curdsville.

STREPTELASMA RUSTICUM BILLINGS

Corallum straight or slightly curved with strong annulated epitheca. Length up to 10 cm., or more, diameter 2-4 cm., depth of calyx 1-1½ cm. Septa one hundred or more alternating in size, the larger strongly twisted at the center.

Common in the Liberty, also in the Blanchester member of the Waynesville of Ohio, Indiana and Northern Kentucky, and the Whitewater of Ohio and Indiana.

STREPTELASMA DIVARICANS. NICHOLSON

A small commonly attached species, usually occurring in clusters. Length 15-20 mm., septa 58-62, alternately large and small, strongly twisted at the center. Calyx deep. No fossula.

Range and distribution essentially the same as S rusticum. Common also in the Saluda.

FAMILY CYATHOPHYLLIDAE

GENUS COLUMNARIA. GOLDFUSS

Corallum massive of prismatic contiguous corallites with more or less developed septa. Walls thin, imperforate. Tabulae numerous.

COLUMNARIA HALLI. NICHOLSON
Pl. IV, fig. 5

Distinguished from *C. vacua* by the smaller corallites (Foerste 1909 p. 313). Specimens from this lower horizon have coralites varying from 2-3 mm. to 3-4 mm. in diameter, a conspicuous feature being the great irregularity in size within the same corallum. This last feature may be diagnostic, tho a feature of the smaller coralla with the rapidly diverging corallites.

Very common in the Woodburn, less so in the Cynthiana.

COLUMNARIA ALVEOLATA. Goldfuss
Pl. IV, fig. --, Pl. XVI, fig. 13

Massive coralla attaining a diameter of several feet. Corallites hexagonal or pentagons, of unequal size, the larger averaging 4 mm. in diameter. Septa alternately large and small, the latter rudimentary, the former extending almost if not quite to the center, this feature characterizing the species. Twelve to 15 or more septa in each series. Tabulae spaced about 1 mm. apart.

Foerste's variety *interventa* from the Woodburn is distinguished by the great inequality in size of the corollites within the same corallum. (see above). It occurs also in the Cynthiana.

This species forms a conspicuous reef (Bardstown reef) in the basal Liberty. In Southern Indiana a similar reef occurs in the basal Saluda (Madison reef), another occurs in the basal Waynesville (Fisherville reef). It is occasionally found elsewhere in the Richmond.

COLUMNARIA VACUA. Foerste

An assocate of *C. alveolata*, distinguished by the meagre development of septa, which occur as sharp striae. Corallites usually about 4mm. in diameter.

Family HELIOLITIDAE

Genus PROTAREA. E. and H.

Thin incrusting coralla. Corallites polygonal with shallow calices. Septa 12.

PROTAREA RICHMONDENSIS. Foerste
Pl. XVI, fig. 12

Corallum an incrusting layer about 2 mm. thick. Corallites polygonal, of about equal size, 4 in 5 mm. Septa 12, scarcely reaching half the distance to the center. In some associated specimens the septa are replaced by papillae giving the appearance of a Protares incrusted by Labechia papillata.

P. richmondiesis makes its appearance in the Clarksville member of the Waynesville in Ohio and is common in both Liberty and Whitewater. In Kentucky it is characteristic of the Liberty on both sides of the arch.

Family FAVOSITIDAE

Genus CALAPOECIA. Billings

Septa well developed tho short. Mural pores large, arranged in vertical rows between the septa.

CALAPOECIA CRIBRIFORMIS. Nicholson
Pl. XVI, fig. 2

Corallum massive. Distributed between the normal corallites with diameter of 2-3 mm., a variable number of smaller corallites, their number determining the shape of the larger ones. Septa as strong vertical ridges extending only a short distance into the cavity, 20-24 in number. Mural pores oval, large, in rows between the septa, 5-6 in 5 mm., longitudinal interspaces less than half the greater diameter of the pore. Tabule thin, a tube diameter or less apart.

Common in and rather characteristic of the Liberty, also present occasionally at other Richmond horizons.

Family CHAETETIDAE

Genus TETRADIUM. Dana

Massive coralla of long slender prismatic corallites, quadrangular or petaloid in section. Four primary septa and numerous tabulae.

TETRADIUM FIBRATUM. Safford
Pl. V, fig. 13

Septa nearly reaching the center. Diameter of corallites about .04″. (See below.)

According to Bassler (1915) this is the Trenton-Maysville form.

TETRADIUM APPROXIMATUM. Ulrich

This is the species commonly referred to as T. minus. It is distinguished from *T. fibratum* in the smaller size of the corallites which are described as 1/3-1/4 line in diameter, i. e. 0.02″-0.03″.

It is listed by Bassler as from the Richmond. Foerste notes it also in the Maysville. Measurements on specimens from the Waynesville and Liberty show them to have 3-4 corallites in 2 mm. There is considerable variation within the corallum and some of the larger measure 2½ in 2 mm. Specimens from the

Cynthiana, Lexington, and Tyrone commonly measure 1½-2 in 2 mm., rarely the smaller individuals in a corallum as high as 3 in the same distance. No specimens from the Maysville were available. The finer tubed forms of the Richmond constitute the *T. approximatum*, the earlier coarser ones *T. fibratum*. Those of the Maysville are perhaps intermediate. A number of specimens labeled as coming from the upper Cincinnatian from Belk Island are of the coarse type, *T. fibratum*, measuring 1½-plus in 2 mm.

Phylum ECHINODERMATA

Class CRINOIDEA

Family HETEROCRINIDAE

Genus HETEROCRINUS. Hall

Crown subcylindrical, calyx small. Three radials transversely and more or less equally bisected, or compound, these being, in addition to the right posterior the right and left anterior or sometimes the anterior in place of the latter. Anal tube delicate and straight, first tube plate resting on the shoulders of both posterior radial, but not further entering the cup. Arms irregularly dichotomous, somewhat divergent. Stem pentagonal, quinquepartite, with interradial sutures.

HETEROCRINUS HETERODACTYLUS. Hall

Calyx small, about 4 mm. in length and almost as wide. Arms about 15 mm. long. Basals pentagonal forming nearly one-third the height of the body. The species is characterized by the small size of the calyx compared with the column, which has a diameter almost half that of the calyx, and the irregularity in the arrangement of the plates of the arms.

EDEN

Genus ECTENOCRINUS. S. A. Miller

Calyx about as in Heterocrinus. Arms heteronomous, with ten main branches, straight, rather closely abutting, composed of a continuous series of syzygies of two plates each, the epizygals giving off ramules. Stem round tripartite (Zittel 1913, p. 212).

ECTENOCRINUS SIMPLEX. (Hall)

Pl. IX, fig. 21

Calyx small, a little longer than wide, tapering regularly from above to the column. Arms above their origin on the second or third costal simple and composed of a single series of plates. Calyx and arms together give a subcylindrical form often overlooked because of their resemblance to a group of small stems. Length about 5 mm.

Eden and lower Maysville.

ECTENOCRINUS GRANDIS. (Meek)

Pl. IX, fig. 22

A more robust species with the armplates proportionately shorter and more wedge shaped. Length of calyx about 8 mm. and the whole crown about 50 mm.

An associate of *E. simplex*. It is also listed from the Rogers Gap.

Family MELOCRINIDAE

Genus GLYPTOCRINUS. Hall

Calyx often highly ornamented, brachials passing imperceptibly into the arm plates and the IBr into the disk. Radials and costals subequal, distichals 2-8 or more. Arms rarely branching above the second bifurcation. IBr. numerous enclosing suplementary anals which sometimes form a series, also numerous interdistichals and interpalmers. Anus excentric at the top of a small protubrance. Disk depressed hemispheric extending very slightly above the level of the arm bases, composed of minute plates irregularly arranged, decreasing in size toward the arms. Arms 10-20. Pinnules slender, closely arranged. Column usually round.

GLYPTOCRINUS DECADACTYLUS. Hall

Calyx obconical, interradial and interdistichal spaces more or less flattened giving pentagonal or decagonal section. Surface ornamented by angular ridges, radiating from the center of each plate, those following the rays more prominent. Arms 20, simple. Costals and distichals two.

Fairmount, Cincinnati region.

GLYPTOCRINUS DYERI. Meek

Distinguished from *G. decadacylus* by the more globose calyx, and second bifurcation of the rays in the free arms. Eight distichals in the calyx, and one to seven additional ones before bifurcation. Ridges less angular. Arms thinner.

Corryville, Cincinnati region.

PHYLUM MOLLUSCOIDEA
CLASS BRACHIOPODA
FAMILY ORTHIDAE
GENUS DALMANELLA. HALL

Plano-convex or subequally biconvex Orthids, with pedicle valve the more convex, surface radially striated, and hinge line commonly shorter than greatest width of shell. Brachial valve with median groove. Teeth prominent, supporting lamellae produced forward circumscribing a rather short, suboval or subquadrate muscular area. Cardinal process prominent, continued as a median ridge separating the muscular impressions.

DALMANELLA EMACERATA. HALL
Pl. IX, figs. 15-18

D. emacerata is a semi-elliptical or subquadrate, finely striated, thin shelled species. Typically width about 20 mm., length about 0.75 width. Anteriorly 16-17 striae in 5 mm. Pedicle valve depressed convex, brachial flat, with faintly developed sinus.

Eden.

DALMANELLA BASSLERI. FOERSTE
Pl. II, figs. 1-3

A species of the *D. emacerata* type, distinguished (Foerste 1909, p. 215) by the somewhat more robust growth, the pedicle valve distinctly though not strongly convex, the brachial valve though nearly flat, sufficiently convex toward the beak to make the shallow sinus fairly distinct. Radiating striae coarser and their fasciculate arrangement more evident. In average specimens from the Jessamine there are 14-16 striae in 5 mm., width 15-20 mm., length, 0.75-0.80 width. In some of the more robust individuals the dorsal sinus is quite distinct.

Very common in the Hermitage and Jessamine formations of the Lexington limestone.

DALMANELIA MULTISECTA. (MEEK)

A relatively small, rounded, and more coarsely striated species than the above. Pedicle valve quite convex, rounded or centrally ridged, brachial valve flattened, and in the more robust forms with a well developed median sinus. Hinge line distinctly shorter than greatest width of shell. Commonly 10-12 striae in 5 mm. along the anterior margin. Width 12-15 mm., length 0.8-0.85 width.

This is the characteristic Eden *Dalmanella*, ranging up into the Mt. Hope and basal Fairmount.

DALMANELLA MEEKI. (MILLER)
Pl. XV, figs. 2, 3

This species is a larger and more robust form than *D. multisecta*. Muscular impressions deep set. Dorsal sinus well marked. Striae variable in coarseness, measuring as low as 6 or 7 in 5 mm. along the anterior margin to twice that many. Width typically about 18mm., length about 0.8 width.

Cumings lists this species (1908, faunal chart) from as low as the upper part of the McMillan. It is common in the Arnheim and Waynesville.

GENUS HEBERTELLA. HALL

Shell resupinate, the pedicle valve with well developed cardinal area. Surface radially striated. Fold and sinus well developed in most species. Teeth large, supported by thick lamellae which continue as strong ridges around a short, obcordate muscular area, which is divided by a median ridge. Diductors flabellate. Cardinal process elongate, simple. Shell impunctate except in the later species.

HEBERTELLA FRANKFORTENSIS. JAMES
Pl. III, figs. 1-3

A species characterized by the relatively short hinge line, with greatest width at, or a little anterior to the middle. Fold and sinus inconspicuous, visible only when viewed anteriorly. Plications usually simple, strong, 4-6 in 5 mm.. anteriorly, about 40 in all, and more closely spaced laterally. Width commonly 15-20 mm., length 0.75-0.80 width, convexity about 0.5 width.

H. frankfortensis is first introduced low in the Jessamine, recurring again near the top and has its best development in the Benson. Where the typical Woodburn is developed it is not common. It recurs again in the Cornishville member of the Perryville.

HEBERTELLA OCCIDENTALIS. HALL
Pl. V, figs. 1, 2

Hinge line approximating the greatest width of the shell. Area common to both valves, extending much higher on the

pedicle. Brachial strongly and evenly convex with incurving beak. Sinus broad. Width 30-40 mm., length about 0.7 width.

Common from the Fairmount through the Richmond.

HEBERTELLA SINUATA. Hall
Pl. XII, fig. 8

The characters distinguishing this species from *H. occidentalis* as listed by Hall (1847, p. 128) are:

1. The stronger and more prominent striae which are more regularly bifurcating; 2. beak of the pedicle valve more elevated and acute giving a greater height to the cardinal area; 3. brachial valve without the central depression (a faint sinus developed in the umbonal region); and 4. sinus more abrupt and deeper, often accompanied by a corresponding elevation in the brachial valve.

Different combinations of these characters are common. Characters 2 and 3 are not of great practical value, and of the remaining two, coarsely striated, shallowly sinuate forms are as common as deeply sinuated ones. If the two are to be separated it would seem to be desirable to limit the species to the medium to coarsely striated forms with deep sinus, the latter character being suggested in the name.

It has essentially the same range as *H. occidentalis*.

HEBERTELLA SUBJUGATA. Hall
Pl. V, figs. 3, 4

A finely striated *H. occidentalis*. In the original description it occupies an end position in the series with the coarsely striated *H. sinuata* at the other end and H. *occidentalis* between. Mention was also made of the absence of the dorsal groove.

About the same range as the preceding species, but more common in the Maysville.

HEBERTELLA ALVEATA. Foerste

A *H. occidentalis* with a distinct and broad median depression extending from the beak to the anterior margin of the brachial valve. In the types the hinge line is prolonged giving acute cardinal angles. For the associated form with rounded cardinal angles and hinge line less than greatest width of shell

Foerste (1909, p. 224) has proposed the varietal designation *richmondensis*.

Liberty and Whitewater of Ohio and Indiana.

HEBERTELLA INSCULPTA. Hall
Pl. XV, figs. 4, 5

Shell small, subequally biconvex with greatest width at or a little anterior to the middle. Pedicle valve evenly convex, brachial marked by a prominent depression extending from the beak to the anterior margin. Surface marked by coarse bifurcating and trifurcating striae crossed by prominent lamellose lines of growth which are particularly conspicuous in the grooves between the striae and give the surface a sculptured appearance. Interior of pedicle valve with strong vascular markings. Width commonly 17-22 mm., length of hinge 0.75-0.80 width, length 0.80-0.85 width.

To this type of *Hebertella* Foerste (1914, p. 258) has applied the generic name of *Glyptorthis*.

H. insculpta occurs at several rather restricted horizons: a. base of the Blanchester division of the Waynesville; b. base of the Liberty (or top of the Waynesville); and, c. a zone 15′-20′ above the base of the Liberty.

In Kentucky it is known from the base of the Liberty along the eastern area of out-crop as far south as Montgomery County.

Representatives of this genus corresponding in character to *H. occidentalis*, *H. sinuata*, and *H. subjugata* are common in the Cynthiana and basal Million. Two species have commonly been recognized. *H. maria parkensis* is a finely striated form with moderately developed sinus, essentially *H. subjugata*. *H. latasulcata*, (types from the Rogers Gap) has moderately coarse striae, and a broad shallow sinus, corresponding in character to *H. occidentalis*. The narrow muscle scar referred to by Foerste (1914, p. 131) in comparing *H. latasulcata* with *H. occidentalis* the writer does not believe to be characteristic of the Cynthiana species, and while the obcordate scar is better developed in the later forms, it is a feature of the larger in-

dividuals which are more common at the higher horizons. *H. maria parkensis* is also known from the Salvisa member of the Perryville.

GENUS PLATYSTROPHIA. KING

A spiriferoid Orthid with long straight hingeline and strongly plicated biconvex shell. Brachial valve with strong median fold, pedicle valve with corresponding sinus. Cardinal area about equally developed on each valve. Hinge teeth thick and prominent.

On the basis of the development of the plications of the fold and sinus Cumings (1903, p. 40) has grouped the species into the uniplicable, biplicate, and triplicate groups. All species described below are included in the *Triplicata* which has been further subdivided by McEwan (1919, p. 390) into—

A. Low fold subgroup
   - P. colbiensis
   - P. precursor
   - P. clarksvillensis
   - P. acutilirata

B. Ponderosa subgroup
   - P. ponderosa
   - P. ponderosa auburnensis
   - P. preponderosa

C. High fold subgroup
   - P. laticosta
   - P. unicostata
   - P. cypha

PLATYSTROPHIA COLBIENSIS. FOERSTE

Pl. IV, figs. 3, 4; Pl. VII, figs. 4-6

A small *Platystrophia* with only moderately elevated and not strongly compressed fold and shallow sinus. Plications 4 on the fold, 3 in the sinus, subequal in size. Lateral plications 8-10. Hinge line usually a little less than greatest width of shell. Width 21-22 mm., length about 0.8 width. The Woodburn specimens average somewhat smaller.

Common in the Woodburn and Cynthiana (Greendale) of Central Kentucky, also in the Rogers Gap.

PLATYSTROPHIA LATICOSTA (MEEK)

Pl. XI, figs. 1, 2

Shell transverse, with high, moderately compressed fold and deep sinus; cardinal angles seldom less than seventy degrees.

Lateral slopes flatly-convex with 5-7 broad, angular plications. Fold with four, sinus three plications, the lateral ones much reduced. Width commonly around 30 mm., length, 0.6-0.7 width.

Common throughout the Maysville, typically developed in the Fairmount. Similar specimens are found in the Waynesville.

PLATYSTROPHIA CYPHA. JAMES

Pl. XV, fig. 14

The characteristic features of *P. cypha* are the high compressed fold and deep sinus with a tendency toward the disappearance of the lateral plications leaving two prominent plications on the fold and one in the sinus. Jame's type is a form with extended hinge. Such forms have from 10-12 plications on the lateral slopes. On the other extreme are forms with more or less rectangular cardinal angles and 6-8 plications laterally. A contrast with *P. laticosta* is one of the degree of compression of the fold and reduction of the lateral plications. An extreme is a form with the general contour of *P. laticosta*, i. e. more or less rectangular cardinal angles and 5-6 plications on the lateral slopes, but with the lateral plications almost or entirely obsolete. For this "uniplicate *P. laticosta*" from the Bellevue, Cumings has given the name *P. unicostata*.

Foerste has recognized the variety *P. cypha conradi*, (Arnheim), a shell with the prolonged hinge, numerous plications on the lateral slopes, and stronger lateral plications on the fold and sinus.

McMillan—Richmond.

PLATYSTROPHIA CLARKSVILLENSIS. FOERSTE

Pl. XIV, figs. 4, 7

A species of the *P. laticosta* type but with narrower and more numerous plications on the lateral slopes (7-9), the plications of the fold and sinus of more nearly equal size with the resulting relatively broader and less angular fold and sinus. The lateral slopes are somewhat fuller, giving less prominence to the fold.

Arnheim, Waynesville, and Liberty formations.

PLATYSTROPHIA ACULTILIRATA. Conrad

Typical *P. acutilirata* is a strongly ventricose shell, characterized by a low, broad, rounded fold with four approximately equal plications, and numerous plications along the convex lateral slopes. There is every variation in hinge line from long, with spine-like cardinal extremities, to shorter than greatest width. The following varieties have been recognized:

var. *prolongata*—forms with spine-like cardinal extremities. The typical form of P. acutilirata has the very extended hinge and acute cardinal angles, but not spinelike; and var. *senex*—a gerontic form with greatly thickened shell, thickness often in excess of length and a tendency toward the more rectangular cardinal angle.

Liberty and Whitewater of Ohio and Indiana. The var. *prolongata* and var. *senex* are from the Whitewater.

PLATYSTROPHIA PONDEROSA. Foerste
Pl. XIV, fig. 15; Pl. XII, fig. 3

Characterized by the large size, greatly thickened valves, and quadrangular outline. Fold prominent, though rounded, with usually four plications. Plications on the lateral slopes 7-9.

Common from the Fairmount through the Arnheim, rare at higher levels.

PLATYSTROPHIA PONDEROSA Var. AUBURNENSIS. Foerste
Pl. XIII, fig. 4

A variety with hinge line much shorter than greatest width of shell resulting in fewer plications on the lateral slopes (5 or 6) and a more globose form.

Very common in and characteristic of the Mount Auburn in the region around Cincinnati.

PLATYSTROPHIA PREPONDEROSA. McEwan

This species is based on specimens from the Catheys near Nashville, Tennessee. It is smaller than *P. ponderosa* and has a more compressed and elevated fold, these constituting the only differences. Greatest width 26-27 mm., width along hinge 24 mm., length 20 mm., thickness 20 mm.

Specimens of what may be this species were found at the top of a railroad cut about five miles southeast of Winchester on the Ruckersville road, just above the crinoidal limestone marking the introduction of abundant *Plectambonites rugosus*.

Genus PLECTORTHIS. Hall

Resembles *Orthis* in the strong ribbing but differs in the comparatively low area of the pedicle valve and subequal biconvexity. Compared with *Hebertella* it lacks the fold and sinus and the shell is not resupinate.

PLECTORTHIS SORDIDA. Hall
Pl. XI, figs. 16, 17

A small rounded, subequally biconvex *Plectorthis* with hinge area inconspicuous and not exceeding one third the width of the shell. Width 8-9 mm. Length about the same. Surface marked with about twenty simple plications.

Fairmount, Cincinnati and vicinity.

PLECTORTHIS NEGLECTA. James
Pl. XI, figs. 11, 12

A species in which the intercallation of the secondary plications begins within a few millimeters of the beak, others added anteriorly. These soon attain the strength of the primary plications giving a uniformly plicated shell. Width about 15 mm., length 0.65-0.80 width.

Characteristic of the Mt. Hope.

PLECTORTHIS PLICATELLA. Hall
Pl. XI, figs. 3, 4

A species with typically simple primary plications though in the larger individuals there is usually a trace of secondary plications anteriorly. Width of average individual around 20 mm., length about 0.7 width.

Fairmount of the Cincinnati region.

PLECTORTHIS FISSICOSTA. Hall
Pl. XI, fig. 5

Distinguished from *P. plicatella* by the addition of secondary plications at a distance of about 10 mm. from the beak. The primary plications remain more conspicious to the anterior margin, where with the two or sometimes three secondaries a

fasciculate arrangement is distinct. The postero-lateral plications tend to remain simple.

Upper Fairmount around Cincinnati.

PLECTORTHIS AEQUIVALVIS. Hall

A shell distinguished from the preceding in that the secondary plications more nearly attain the strength of the primaries anteriorly.

These last three species characterize the Fairmount of southern Ohio and Indiana and adjoining parts of Kentucky.

Family RHIPIDOMELLIDAE

Genus DINORTHIS

A resupinate, impunctate shell with brachial valve convex, pedicle elevated at the umbo and becoming flat or gently concave anteriorly and laterally. Dental lamellae prominent, extended around the subquadrate muscular area. Cardinal process erect.

DINORTHIS PECTINELLA
Pl. I, figs. 7, 8

Shell subcircular to semi-elliptical, characterized by from twenty to thirty coarse, broadly rounded and widely spaced plications, suggestive of the Pelecypod genus *Pecten*. Width normally about 25-30 mm., length 0.8-0.9 width.

Characteristic of the Curdsville.

DINORTHIS ULRICHI. Foerste
Pl. III, figs. 4, 5

Of the *D. subquadrata* type differing in the following minor points (Foerste, A. F., 1909c, p. 320); 1. more conspicuous flattening of the pedicle valve; 2. a shallow sinus anterior on the pedicle valve of some specimens; 3. shell frequently wider posteriorly than across middle; 4. plications usually somewhat coarser; and, 5. muscular area of pedicle valve relatively smaller, occasionally less than half the length of the valve.

Characteristic of the upper Benson, recurring again in the Cornishville member of the Perryville.

DINORTHIS CARLEYI. (Hall)
Pl. XV, figs. 16, 17

Shell suboval to subquadrate, width 30-40 mm., length about 0.8 width. Characterized by the relatively large cardinal area

of the pedicle valve which is strongly recurved anteriorly bringing the beak some distance anterior to the hinge line. Radiating striations rather coarse and rounded. Beak of the brachial valve strongly incurved.

Characteristic of the Oregonia member of the Arnheim as far south as Nelson County on the west, and Mason and Lewis counties on the east.

DINORTHIS SUBQUADRATA. Hall
Pl. XV, fig. 15

A subquadrate form with hingeline a little less than greatest width of shell and sharply rounded cardinal angles. Brachial valve evenly convex with a shallow sinus which sometimes extends up on the umbo. Pedicle valve a little convex at the umbo, becoming flat or slightly concave anteriorly and laterally, with beak smaller and less incurved. Lateral striae curving strongly outward, some terminating on the cardinal margin.

Common in Liberty and Whitewater faunas. It is ordinarily introduced just above the upper Hebertella *insculpta* horizon.

Genus HETERORTHIS

HETERORTHIS CLYTIE. Hall
Pl. II, figs. 7, 8

A depressed plano-convex, transversely elliptical shell, with the general appearance of a *Strophomenid* but with open delthyrium. Surface striae fine. Pedicle valve convex, with large muscular impression extending anterior to the middle consisting of small adductors centrally situated and two greatly enlongate, flabellate diductors which do not unite in front. Cardinal process simple, prominent extended anteriorly as a median ridge through the muscular area. Shell substance punctate.

This genus is represented by a single species *H. clytie* Hall, from the lower Hermitage. Width about 30 mm., length 0.7-0.75 width.

Family STROPHOMENIDAE

Genus STROPHOMENA. Blainville

Resupinate concavo-convex shells, essentially biconvex in the sinuate species. The species described below may be conveniently grouped as follows:

A. Sinuate biconvex forms. Sinus on pedicle valve, fold on brachial. *S. millioninsis*, *S. sinuata*, *S. sulcata;* B. muscular area of pedicle valve bordered by a distinct ridge, which is deflected anteriorly leaving a median gap. *S. planumbona*, *S. vicina*, *S. nutans*, *S. planoconvexa*, *S. maysvillensis*, and *S. vetusta;* C. flabellate muscular area. *S. incurvata*, and *S. neglecta;* and, D. muscle scar weakly delimited. *S. hallie.*

STROPHOMENA INCURVATA. Shepard
Pl. I, fig. 9

A rather large, semicircular, finely striated species. Cardinal angles 75-85 degrees. Muscular area of pedicle valve flabellate, with sharply raised border, deflected anteriorly leaving a gap. Radial markings extended beyond border. Interior of pedicle valve distinctly thickened along anterior and lateral margins. Length commonly 40-45 mm., width: length 4:3. Convexity of brachial valve 7-10 mm., in specimens 40 mm. wide.

Fenton (1928 Midland Naturalist Vol. XI, p. 147) abandons this species on the basis of Shepard's inadequate description and figures, and absence of the types.

Tyrone and Camp Nelson. Ulrich (1888, p. 108) also lists it from the Curdsville.

STROPHOMENA VICINA. Foerste
Pl. II, figs. 9, 10

A semi-elliptical, finely striated shell of the *S. planumbona* type. Width 30-35 mm., length 0.6-0.7 width. Convexity of the brachial valve 4 or 5 mm. in the semi-elliptical and 6-7 mm. in the more quadrate forms.

Characteristic of two horizons in the Lexington limestone, the upper Benson and Cornishville. This type of shell is next known in the upper Arnheim where it re-appears as *S. concordensis.* (Foerste 1912, pp. 36, 37).

STROPHOMENA MILLIONENSIS. Foerste

A small sinuate form distinguished from *S. sulcata* by the wider spaces between the radiating striae and relatively narrower shell. The striae are rather coarse, 4-6 in 2 mm. The largest specimen seen (Foerste) is 19 x 13.5 mm. Cardinal angles 80-90 degrees.

Base of the Eden from the vicinity of Million, Madison County Kentucky.

STROPHOMENA HALLIE. Miller
Pl. VIII, figs. 11, 12

Small, subtriangular or subpentagonal, cardinal angles more or less rectangular. Brachial valve flattened posteriorly for 5-7 mm. then curving rapidly antero-laterally. Pedicle valve with a reversal of curvature near the middle resulting in a plano-, rather than concavo-convex shell. Striae moderately coarse, 4-5 in 2 mm. anteriorly. Width of larger individuals 27 mm., length, 0.85 width. Muscle scar of pedicle valve weakly delimited especially anteriorly.

In the Cincinnati area it is most common in the Southgate, though also present in the Economy. In Central Kentucky it ranges from just above the Rogers Gap beds to the base of the Garrard.

STROPHOMENA MAYSVILLENSIS. Foerste
Pl. XI, figs. 8, 9

Closely related to *S. planoconvexa.* It is larger and proportionately longer, triangular or pentagonal in outline due to the downward deflection of the antero-lateral parts of the brachial valve. Convexity of the brachial valve distinctly greater in the longer forms. Width, 25-35 or 40 mm., length, 0.9 width. Convexity frequently 0.4 length. Cardinal angles more or less rectangular rounded in the older individuals.

S. maysvillensis is introduced in the Mt. Hope in Central Kentucky, has its best development, associated with *Constellaria florida*, in the basal Fairmount, and occasionally ranges as high as the Orthorhynchula horizon of the upper Fairmount. In north central Kntucky and adjoining parts of Indiana and Ohio there are two *Strophomena* horizons in the Maysville, a lower one in the basal Mt. Hope where *S. maysvillensis* is common, and a higher one characterized by *S. planoconvexa* in the basal Fairmount. *S. hallie* is regarded as a precursor.

STROPHOMENA PLANOCONVEXA. Hall
Pl. XI, figs. 6, 7

Shell semi-elliptical, brachial valve moderately convex, pedicle valve but slightly concave giving a plano-convex

shell. Striae coarse, 3-4 in 2 mm. near the anterior margin. Width 25-40 mm., length, 0.7 width. Convexity of brachial valve commonly not more than 6 mm., concavity of pedicle valve 1-2 mm. Foerste has suggested that the difference in form between *S. maysvillensis* and *S. planoconvexa* is one of environment, *S. maysvillensis* being merely the more healthy form.

Throughout Northern Kentucky and adjoining parts of Ohio and Indiana *S. planoconvexa* characterizes a zone in the basal Fairmount. Farther south it occurs higher and ranges to the top of the Fairmount.

STROPHOMENA SINUATA. Meek
Pl. XI, fig. 10

A sinuate *Strophomena* distinguished from *S. sulcata* by its somewhat larger size and coarser striae. The deeper, narrower sinuses are more common in *S. sulcata* than in *S. sinuata.* Width often 25mm., length, 0.6-0.65 width. Striae about 2.5 in 2 mm.

Fairmount of southern Ohio and Indiana, and northern Kentucky.

STROPHOMENA PLANUMBONA. Hall
Pl. XV, figs. 11-13

Shell finely striated, quadrate. Brachial valve flattened 2/3 of the way anteriorly from the hinge. Muscular area of pedicle valve circular, deeply impressed, bordered by curved, sharply elevated ridges which are deflected forward producing an anterior gap. Shell distinctly thickened along the anterior and lateral margins, crossed by vascular grooves. Striae normally subequal or alternating in size, less frequently an alternation of one coarse with 2 or 3 fine ones. Width, 30 mm., length, 0.75 width, striae 5 in 2 mm.

In the Richmond areas of southern Ohio *S. planumbona* is introduced near the base of the Clarksville, more commonly as the variety elongata, the typical forms common in the upper Blanchester and Liberty. Southward in Kentucky on both east and west flank it is limited to the uppermost Waynesville and Liberty.

STROPHOMENA SULCATA. Verneuil
Pl. XV, figs. 9, 10

Shell biconvex with fold on the brachial and sinus on the pedicle valve, semi-circular, with hinge line about equal to greatest width of shell. Muscular area of the pedicle valve about three-tenths the width of the valve, bounded posteriorly and laterally by a sharply elevated border which disappears anteriorly. Width, 18-23 mm., length 0.8 width. Striae about three in 2 mm.

S. sulcata has a vertical range from the Clarksville to the top of the Whitewater. In the Liberty-Whitewater it is represented in Kentucky as far south as Madison and Marion counties. In the Waynesville it is known from the Clarksville in Lewis County.

STROPHOMENA NUTANS. Meek
Pl. XV, figs. 7, 8

A strongly concavo-convex, finely striated species of the *S. planumbona* type with pentagonal outline. Margins of posterior half of shell only moderately divergent. Hinge occasionally a little extended. On the pedicle valve and anterior part of the brachial valve several fine striae alternate with a coarse one, posteriorly on the brachial valve the striae are coarser and subequal or alternating in size. Anterior and lateral margins of pedicle valve abruptly and strongly thickened on the interior, the thickened border crossed by strong vascular markings. Width, 20-30 mm., length 0.7-0.8 width. Foerste (1912, p. 70) regards the typical form as the retarded gerontic form of *S. concordensis.*

Associated with *S. neglecta* and *S. vetusta precursor* forming a conspicuous *Strophomena* zone with a vertical range of only a few feet in the middle Blanchester from Lewis County, Kentucky to southern Indiana.

STROPHOMENA NEGLECTA. James

A large, subquadrate, finely striated species with flabellate muscle area in the pedicle valve. Width, 40-45 mm., length, 0.75 width. Hinge often extended. Shell thin, rather evenly concavo-convex. Muscle area of the pedicle valve large, circular to elliptical, diameter about 2/5 the width of the shell. Lateral border sharply elevated but impressed area rises gradually anteriorly.

Restricted to the middle Blanchester. Along the eastern area of out-crop it is known as far south as Bath County. It is known in southern Indiana but has not been listed from the western area in Kentucky.

STROPHOMENA VETUSTA. James
Pl. XV, fig. 20

A large species often attaining a width of 40 mm., length, 0.7 width, with rectangular or slightly extended cardinal angles, and high cardinal area. Radiating striae very fine on the pedicle valve (18-21 in 5 mm.), much coarser (8-10 in 5 mm.) on the brachial valve. The presence on the pedicle valve of concentric wrinkles, growth lines, and the tendency of the striae to change their direction anteriorly and laterally gives a characteristic irregularity to the surface markings. Shell vertically wrinkled along the hinge line.

Middle Liberty to the top of the Whitewater (also Saluda). It is known in Kentucky as far south as Madison County in the east, and Nelson County in the west.

Genus RAFINESQUINA. Hall and Clarke

Concavo-convex striated shell with straight hinge line and well developed cardinal area. Pedicle valve convex with faintly delimited flabellate diductors enclosing elongate adductors. Cardinal process bilobed.

RAFINESQUINA ALTERNATA. (Emmons)
Pl. V, fig. 7

A common and variable species commonly around 40 mm. in width, length, 0.8 width. Cardinal angles rectangular to acute. Convexity variable. Striae alternating in size commonly one coarse to several fine ones.

Common throughout the Trenton-Richmond formations.

RAFINESQUINA ALTERNATA VAR. FRACTA
Pl. XIII, figs. 5, 6

A thin, fragile, flattened variety with length equalling or slightly exceeding width. Cardinal angles rectangular to slightly obtuse, lateral margins parallel or slightly convergent posteriorly. Width, 30-40 mm.

Common in the McMillan.

RAFINESQUINA WINCHESTERENSIS. Foerste
Pl. VIII, fig. 14, Pl. V, figs. 8, 9

Similar to *R. fracta* in general contour but thicker and more convex and the shell averages a little smaller.

A characteristic Cynthiana species.

RAFINESQUINA ALTERNATA VAR. PONDEROSA. Ulrich
Pl. XIII, fig. 4

A large, massive variety with more deeply excavated muscle scars, and vascular markings and unusually large cardinal process. Width commonly 50-60 mm.

Common in the Bellevue at Cincinnati also in the upper Fairmount of the southern Bluegrass.

RAFINESQUINA NASUTA. (Conrad)

Distinguished from *R. alternata* by the nasute anterior outline. Width commonly around 40-50 mm. Length somewhat greater.

McMillan beds of the Cincinnati region.

Genus LEPTAENA. Dalman

Concavo-convex, finely striated Strophomenids characterized by a conspicuous concentric wrinkling of the shell which is abruptly deflected anteriorly. Outline transversely subquadrate or semi-elliptical, hinge line forming greatest width. Muscle area of pedicle valve subcircular, with flabellate diductors. Cardinal process bifid. Interior of brachial valve prominently elevated at line of geniculation.

LEPTAENA RICHMONDENSIS. Foerste
Pl. XIV, figs. 1-3

Shell transversely subquadrate with more or less extended cardinal extremities. Width, 25-40 mm. Length, 0.5 width. This species differs from the well known *L. rhomboidalis* with which it was formerly identified by the shallower and less numerous wrinkles and broader striations with narrower intervening grooves. The shell is relatively wider and in most specimens the top of the pedicle valve is relatively flat.

A common and charactristic Richmond species appearing in the Oregonia member of the Arnheim as the variety precursor which is distinguished by the less conspicuous wrinkling, smaller

geniculation anteriorly and more convex pedicle valve. In Jefferson County Butts finds it in the *Rhynchotrema dentata* and *Constellaria polystomella* zones of the Arnheim.

PLECTAMBONITES. Pander

Small, concavo-convex, very finely striated, transversely semi-elliptical Strophomenids. Hingeline forming greatest width of shell, cardinal extremities often acuminate. Cardinal process large, simple, occupying the partly closed delthyrium. Crural plates short giving rise to two septa.

PLECTAMBONIESS PLICATELLUS. Ulrich
Pl. VIII, figs. 15, 16

A very small semi-circular, remarkably coarsely striated (plicated) species. Width about 5 mm., length, 0.5 width. Five striae occur in a space of 5 mm. The plicated appearance is characteristic.

A characteristic species of the Fulton in the Cincinnati region.

PLECTAMBONITES RUGOSUS. Meek
Pl. VIII, fig. 1; Pl. XVI, figs. 3, 4

A transversely, semi-circular, very finely striated shell. Width commonly 15-20 mm., length 0.5 width. Cardinal angles usually a little acuminate. A silky luster is a characteristic feature of the shell.

A very common species of the Eden. In Central Kentucky the introduction of this species in great numbers is regarded as marking the base of the Million. It is quite common at a horizon near the top of the Jessamine and again lower in the same formation. A somewhat larger form is characteristic of the Curdsville. It recurs again in the Richmond in the lower parts of the Clarksville and Blanchester divisions of the Waynesville, lower Liberty where it is very common, and again in the lower Whitewater.

Family RHYNCHONELLIDAE Schuchert

Genus RHYNCHOTREMA. Hall

Rostrate, thick shelled, strongly plicate shells, with well marked fold on the brachial, and sinus on the pedicle valve. Deltidial plates concave, thick. Teeth strong. Median septum of brachial valve extending more than one half the length

of the shell, with the small cardinal process on its posterior extremity. Muscular impressions usually well defined. Beak of pedicle valve closely incurved over that of the brachial valve.

RHYNCHOTREMA INCREBESCENS. (Hall)
Pl. III, figs. 6-8

A small species with three plications in the sinus, four on the fold and 4-5 on either side. Length usually 10-15 mm., length:width = 1:1. It differs from *R. capax* chiefly in the small size, and more angular plications, fold, and sinus.

A characteristic species of the Lexington limestone with its best development in the Benson and higher formations, quite common also at various levels in the Jessamine. A small, more triangular form, *H. trigonale* is found in the Curdsville.

RHYNCHOTREMA CAPAX. (Conrad)
Pl. XVI, figs. 5-7

A species varying from rather thin, flattened forms in the younger individuals to highly ventricose forms with thickness often exceeding length. Beaks closely incurved. Plications 4 on the fold and 3 in the sinus. Growth lines prominent. In the younger individuals where the size is comparable to that of the average *R. increbescens* the thickness is proportionately much less and fold and sinus are shallow.

A characteristic Richmond species ranging from the base of the Liberty to the Whitewater.

RHYNCHOTREMA DENTATUM. (Hall)
Pl. XIV, figs. 9-10

A subtriangular species characterized by the development of two plications on the fold and one in the sinus. Width 12-15 mm., length, 0.9 width. Lateral plications 3-4.

A characteristic species of the Whitewater of Ohio and Indiana, occasionally found also in the Liberty. A variety *R. dentatum arnheimensis* Foerste is a characteristic member of the Oregonia fauna throughout its extent, also of the middle Arnheim (*R. dentatum* zone) as defined by Butts (1915, p. 42) in Jefferson County, Kentucky. According to Foerste (1909a, p. 228) it is distinguished by its usually larger size, more triangular and less globose outline, especially posteriorly, and

the more angular plications. The majority of specimens seen by the writer from this horizon are relatively small.

GENUS ORTHORHYNCHULA. HALL AND CLARKE

A plicate *Rhynchonelloid* with the cardinal area extending about one third the width of the shell, shared by both halves, that of the pedicle valve being the higher.

ORTHORHYNCHULA LINNEYI. (JAMES)
Pl. IV, fig. 11; Pl. XI, fig. 13

The only described species is a subelliptical shell with the greatest width anterior to the middle. Pedicle valve with sinus, brachial with prominent fold. Four plications usually on the fold, three in the sinus, and about eight on either side. Width, 22 mm., length 0.9 width.

O. linneyi is found at three horizons in the local Ordovician, the Salvisa member of the Perryville, the Greendale member of the Cynthiana, and the upper Fairmount. Comparing specimens from these levels Foerste (1912, p. 133) states that the beaks of the Perryville forms are less incurved, that there is a tendency for the Fairmount forms to be more globose than those from the Cynthiana, and that there is a tendency among the Cynthiana individuals to increase the usual four plications on the fold to five or six.

FAMILY ATRYPIDAE

GENUS ZYGOSPIRA. HALL

A small, rostrate, sub-circular, biconvex, plicated, genus. Pedicle valve with median fold, brachial with sinus. Spirals with few coils, apex directed inward. Primary lamellae united by transverse jugum.

ZYGOSPIRA RECURVIROSTRIS. (HALL)

Distinguished from Z. *modesta* (Foerste 1914, p. 132) by the broader and shallower sinus within which the plications are subequal while in that species the central plication is distinctly larger than those on either side. A corresponding difference in the pedicle valve is the slightly more evident fold in Z. *modesta* and the median groove along it a little more evident.

Very common throughout the High Bridge, Lexington and Cynthiana formations.

ZYGOSPIRA MODESTA. HALL
Pl. V, figs. 14-16

A small species. Width, 9 mm., length, 8 mm., thickness 4 mm., with low median fold on the pedicle valve and sinus on the brachial. The sinus is occupied by about four plications and 7-9 occur on each lateral slope. The median groove on the fold of the pedicle valve is distinctly wider than the adjoining grooves and in the sinus the corresponding plication is comparatively stronger.

Common from the Cynthiana to the Richmond.

ZYGOSPIRA CINCINNATIENSIS. MEEK

A comparatively large species with length, 8 or 9 to 14 mm., width, 1.2 length. It is distinguished from Z. *modesta* in addition to the larger size by the smaller number, hence coarser primary lateral plications (5-6 on each side), more common bifurcation of the lateral plications of fold and sinus and more prominent fold and sinus.

Fairview formation of southern Ohio, Indiana, etc.

ZYGOSPIRA KENTUCKIENSIS. JAMES
Pl. XIV, figs. 11, 12

A large species attaining a length of 14-15 mm., distinguished from Z. *cincinnatiensis* by the greater number and smaller size of the plications.

Characteristic of the Waynesville of Oldham, Jefferson, etc., counties, also Clark and adjoining counties in the eastern area of outcrop.

CLASS BRYOZOA

FAMILY CERAMOPORIDAE

GENUS CHILOPORELLA. ULRICH

Zoarium forming parasitic sheets giving rise to flabellate fronds. Apertures ovate with prominent lunaria. Mesopores numerous.

CHILOPORELLA FLABELLATA. ULRICH
Pl. XII, figs. 1, 2

This is the only described species. It forms flabellate expansions from a few to 15 mm or more thick. Rounded nonticules sometimes developed. Mesopores more or less isolating

the zooecia. Apertures round to oval, constricted posteriorly where a conspicuous hood shaped lunarium is developed.

A characteristic and common form in the Corryville.

GENUS COELOCLEMA. ULRICH

Ramose hollow zoaria with oblique zooecial apertures. Lunaria hood-like. Mesopores bundant.

COELOCLEMA COMMUNE. (ULRICH)

Distinguished from C. alternatum by the more robust growth, well marked maculae with subsolid centers (closed mesopores) surrounded by apertures somewhat larger than normal.

Abundant in the Eden, most common in the Economy.

COELOCLEMA ALTERNATUM (JAMES)

Zoarium of somewhat irregular, hollow or compressed branches, 2-5 mm. in diameter. Maculae absent. Zooecial aperatures in more or less regular diagonal series, about six in two millemeters.

A common species of the middle and upper Eden.

COELOCLEMA OWENI. (JAMES)

Zoarium of small hollow contorted stems with prominent lunaria, giving the surface a rough appearance. In tangential section the lunarium is semicircular with its ends indenting the zooecial apertures.

A characteristic species of the Mt. Auburn of the Cincinnati region.

FAMILY *MONTICULIPORIDAE*

GENUS MONTICULIPORA. D'ORBIGNY

Cystiphragms are developed in both (m) [1] and (im). Particularly characteristic are the grannulose wall structure and the small, usually numerous acanthopores, which lack the central lumen and concentric structure. Mesopores variable.

MONTICULIPORA MAMMULATA. D'ORBIGNY
Pl. X, fig. 7

Zoarium massive to lobate, surface with conical or somewhat elongate monticules composed of zooecia slightly larger than normal. Mesopores few. Acanthopores small, numerous. Longitudinal section shows a succession of (m) and (im), the

[1]Thruout the paper the mature and immature regions are indicated by (m) and (im).

former characterized by the thickening of the walls and closer spacing of diaphragms.

Fairly common in the Fairmount of the southern Bluegrass.

MONTICULIPORA MOLESTAA. ULRICH
Pl. XIII, fig. 9

A species distinguished from the preceding by its frondescent growth. It shows the same succession of (m) and (im).

Characteristic of the Bellevue.

MONTICULIPORA EPIDERMATA. ULRICH AND BASSLER

Distinguished from *M. mammulata* by its mode of growth which is more discoidal with diameter up to 30 cm. and height about ½ diameter. Base concave with concentrically wrinkled epitheca. Mesopores more numerous. Acanthopores small, inconspicuous, appearing as small grannules, 2-3 to the zooecium.

Characteristic of the Whitewater. The writer has collected a similar *Monticulipora* from the Oregonia of Clark County which differs in the larger and more numerous acanthopores.

GENUS HOMOTRYPA. ULRICH

Cystiphragms are restricted to the (m) and mesopores are few or wanting. Bassler (1903 pp. 566-568) has grouped the described species as follows:

A. diaphragms present in the (m)
B. diaphragms absent in the (m)
   1—cystiphragms in all zooecia
   2—cystiphragms present only in the maculae.

HOMOTRYPA CURVATA. ULRICH

Zoarium of smooth, compressed branches about one half cm. thick. Acanthopores small, 3-4 surrounding a zooecium. Mesopores absent except in the maculae. Diaphragms in both (m) and (im). Ten zooecia in two mm.

Common in, and characteristic of the Fairmount in the Cincinnati region.

HOMOTRYPA OBLIQUA. ULRICH

A tuberculated dendroid species with cylindrical or slightly compressed branches 5-15 mm. in diameter. It is distinguished from *H. curvata* by the absence of diaphragms and the slight crinkling of the zooecial walls in the (im).

Common in the Fairmount, Bellevue, and Corryville.

HOMOTRYPA CINCINNATIENSIS. Bassler
Pl. X, figs. 2-4

Zoarium small, composed of cylindrical to subfrondescent branching stems 2-4 mm. in diameter. Surface smooth, zooecia direct, about nine in 2 mm. Mesopores moderately developed in maculae and elsewhere. Acanthopores small, variable in number, sometimes 8-10 around a zooecium.

Common in the Fairmount of the southern Bluegrass.

HOMOTRYPA PULCHRA. Bassler

Zoarium of smooth surfaced, branching fronds 3-5 mm. in thickness. Maculae not elevated but conspicuous because of great size of the zooecia. Mesopores few and restricted to the maculae. Zooecia thin-walled, direct. Acanthopores absent. Diaphragms 1-1½ tube diameters apart in the (im), 4-5 times as numerous in the (m), associated with an increasingly crowded series of cystiphragms.

Characteristic of the Mount Auburn in the Cincinnati region.

HOMOTRYPA BASSLERI. Nickles
Pl. XIV, fig. 19

Zoarium of small cylindrical or flattened branches 4-5 mm. thick, with strongly tuberculed surface. Zooecia small, 10 in 2 mm. Acanthopores small, moderate in number. Diaphragms absent.

Common in the upper Arnheim (*Constellaria polystomella* zone) along the western side of the arch.

HOMOTRYPA WORTHENI. (James)
Pl. XIV, fig. 18

A strongly and sharply monticuled ramose species distinguished from *H. bassleri* by the more numerous acanthopores, presence of a moderate number of diaphragms in the (m) and in tangential section by the thick walled zooecial tubes with characteristic dotted or granular structure.

Characteristic of the Whitewater. The figured specimen is from the Oregonia from west of Lebanon in Marion County where it occurs in abundance. The writer cannot separate it from *H. wortheni.*

HOMOTRYPA Sp.

A species of *Homotrypa* is common in the light colored clay at the top of the Oregonia in Lincoln County, a ramose, slightly tuberculated form having the general appearance of *H. richmondensis* or *H. cylindrica*, and agreeing with the latter in many points of internal structure. The walls are much thickened in the (m) and the acanthopores are large and numerous occupying about one-third of the junction angles. In longitudinal section it differs in that the cystiphragms are limited to the early part of the (m), only occasionally occurring higher. In the (im) occasional diaphragms are developed and are present also associated with the cystiphragms in the (m) and continuing above them.

HOMOTRYPA NORWOODI. (Nickles)
Pl. V, fig. 12

As originally described this species, referred to *Homotrypella*, forms rounded or compressed branches, 3-6 mm. thick and 2-12 mm. wide. Surface covered with small, conical monticules. Apertures polygonal, walls of only moderate thickness, and averaging 12 in 2 mm. Mesopores absent except in the monticules which are composed of zooecia slightly larger than the average. Acanthopores small, very numerous, three to five surrounding, and commonly indenting the apertures. Diaphragms widely spaced in the (im). Cystiphragms small, numerous in the (m), accompanied by an equal number of diaphragms. The types are from Pleasant Valley, Carlisle County.

Numerous specimens of a very similar form have been collected by the writer from exposures of the upper Cynthiana east of Winchester and other localities which differ from the species as described above in the more robust growth, attaining a thickness of 8 mm., and in the absence of acanthopores. The zooecia are a little smaller averaging about 10 in 2 mm. In spite of the difference in development of acanthopores the writer regards the two as specifically the same. In both the original specimens and in those just mentioned the meagre development of mesopores does not suggest the genus Homotrypella.

A common and characteristic fossil of the upper Cynthiana.

Genus HOMOTRYPELLA. Ulrich

Distinguished from *Homotrypa* by the development of numerous mesopores.

HOMOTRYPELLA HOSPITALIS. (Nicholson)

This species is exceptional for the genus in its massive, hemispherical form, commonly attached to brachipod or other shells, and 2-4 cm. in diameter. Surface smooth or with maculae of larger apertures slightly elevated. Mesopores numerous, closely tabulated. Acanthopores numerous and strong. Cystiphragms line the zooecial tubes. In assigning this species to *Homotrypella* instead of *Prasopora*, only a very short region in the proximal end which is free of cystiphragms may be recognized as the (im). The difference in development of acanthopores is distinct.

Blanchester, Liberty and Whitewater.

Genus ASPIDOPORA. Ulrich

Zoarium discoidal, composed of two or more superimposed layers, lower size concave, with wrinkled epitheca. Acanthopores small. Diaphragms usually wanting in the zooecia, close set in the mesopores.

ASPIDOPORA NEWBERRYI. (Nicholson)

Pl. IX, fig. 8

A thin discoidal expansion about 2 cm. in diameter. Surface smooth with maculae of larger apertures. Diaphragms closely spaced in the mesopores. Cystiphragms lining the walls of the zooecia.

A common and characteristic species of the Economy member of the Eden.

ASPIDOPORA ECCENTRICA, (James)

Pl. IX, figs. 3-7

A small species about 5 mm. in diameter characterized by the eccentricity of the concentrically wrinkled epitheca.

Southgate member of the Eden.

Genus PRASOPORA. Nicholson and Etheridge

Zoarium more or less hemispherical with concentrically wrinkled epitheca. Zooecia thin-walled and generally surrounded by angular mesopores. Acanthopores when present, never numerous or strong. The massive Monticuliporas differ in the grannular acanthopores and wall structure.

PRASOPORA SIMULATRIX. Ulrich

Pl. II, figs. 16, 17

Zoarium flattened discoidal to subconical, diameter normally 2-10 cm., base more or less concave. Zoarium occasionally lobate. Apertures subcircular, 7-8 in 2 mm., more or less in contact except at the junction angles. Maculae conspicuous, of larger apertures and more numerous mesopores. Acanthopores absent. Diaphragms closely spaced, about one-half tube diameter apart, accompanied by a series of cystiphragms lining the zooecial walls.

A common and characteristic form of the Hermitage and Jessamine, in the latter attaining the subconical form ("chocolate drop bryozoan"). Occasionally also in the Benson.

PRASOPORA Sp.

Pl. VI, fig. 5

In the lower Cynthiana, particularly in the southern Bluegrass, occasionally also in the Brannon, there occurs a form differing from *P. simulatrix* in the discoidal form and presence of small acanthopores at many of the junction angles. In these respects it suggests the following species. Zoarium 4-8 cm. in diameter.

PRASOPORA FALESI. (James)

Pl. II, figs. 11, 12

James based his species on specimens resembling small individuals of *P. simulatrix*, characterized by the presence of a conical, sharp pointed groove impressed on the wrinkled under surface. According to Bassler (1906, p. 48) this groove, representing the excavation left by the object (Hyolithes or tapering end of a cephalopod) upon which the colony grew, lacks systemmatic value. The species is distinguished by its smaller size (about 2 cm. in diameter), flatter form, weaker epitheca, and presence of small acanthopores.

Hermitage and Jessamine. In spite of the lack of systemmatic value of the basal groove the form it represents does have stratigraphic value.

GENUS PERONOPORA. NICHOLSON

A bifoliate Monticuliporid.

PERONOPORA VERA. NICKLES

Frond 2-6 mm. thick and 10 or more cm. high, more or less undulating and branching. Apertures circular, 7-8 in 2 mm. Mesopores numerous, occupying the relatively wide interspaces. Acanthopores small, numerous. Maculae conspicuous, of larger apertures, often with a central cluster of mesopores. Cystiphragms lining the zooecial tubes, accompanied by a smaller number of diaphragms.

Common in the Eden and Fairview.

PERONOPORA DECIPIENS. (ROMINGER)

Distinguished from *P. vera* by the fewer mesopores, correspondingly narrower interspaces, and smaller apertures. The zoarium in some specimens is almost massive.

Common through the Maysville and Richmond.

PERONOPORA MILLERI. NICKLES

A form closely related to *P. vera* and *P. decipiens*. According to Nickles the zooecia are smaller than in *P. vera*. Zoarium commonly 1-3 mm. thick. Eight zooecia occur in 2 mm. Acanthopores numerous, often inflecting the zooecial walls, from 2-5 surrounding each aperture. The writer is not certain that he can separate it from these later forms.

A very common fossil of the Cynthiana, occuring in great numbers in the lower part (Greendale), common also in the Brannon.

FAMILY HETEROTRYPIDAE

GENUS HETEROTRYPA[1]. NICKOLSON

Zoarium frondescent; acanthopores small. Mesopores generally abundant; diaphragms numerous.

HETEROTRYPA PARVULIPORA. ULRICH AND BASSLER

Pl. VII, fig. 2

A large frondescent species distinguished from *H. frondosa* by the smaller zooecia (10 in 2 mm.), smaller and generally fewer acanthopores, and fewer mesopores. Surface smooth, or with slightly raised maculae.

[1]Cumings (E. R. 1902, pp. 197-217) has questioned the distinctness of the three genera Heterotrypa, Dekayella and Dekayia.

Common in the Greendale and Millersburg phases of the Cynthiana.

HETEROTRYPA FRONDOSA. O'ORBIGNY

Zoarium large, frondescent, surface with small, sharp monticules at 3 mm. intervals. Zooecia moderately thick-walled, polygonal to circular. Mesopores abundant, rather uniformly distributed. Zooecial walls much thickened in the deep (m). Diaphragms absent in the (im.), moderately to very abundant in the (m). Acanthopores fairly numerous, of small size with occasionally a larger one.

McMillan formation of Cincinnati and vicinity.

GENUS DEKAYELLA

Ramose or frondescent bryozoa distinguished from *Heterotrypa* by the development of two sets of acanthopores, large and small.

DEKAYELLA ULRICHI

Pl. IX, fig. 23

Zoarium ramose to subfrondescent, 5-10 mm. in diameter. Surface smooth to sharply monticulated, maculae of larger zooecia and mesopores. Zooecia rounded, 7-8 in 2 mm. Mesopores abundant. Acanthopores fairly numerous, of two sizes. Diaphragms few to absent in the axial region, ½-2 diameters, apart in the periphery, closely set in the mesopores.

A characteristic fossil of the McMicken member of the Eden, ranging from the Southgate to the Fairmount.

DEKAYELLA TRENTONENSIS. (ULRICH)

Zoarium dendroid, branches compressed, dividing frequently and rather irregularly, from 4-10 mm. in width. Surface smooth, or with low, rounded monticules 2.5 mm. apart; occupied by clusters of cells a little larger than the average, with occasionally a few mesopores at their summits. Apertures subangular, about 9 in 2 mm. Interspaces rather thick. Acanthopores large and prominent, when preserved, about 6 or 7 in 3 mm. Zooecia with thin slightly flexuous walls in the axial region and with diaphragms 2-4 times their diameter apart. As they curve gently into the (m), the walls thicken, and diaphragms become much more numerous. (Nickles 1905, p. 42)

According to Nickles, from the Lexington series associated with *M. multitabulata* and *P. simulatrix*. This indicates the Jessamine.

DEKAYELLA FOLIACEA. Ulrich and Bassler

A flabellate *Dekayella* from 5-10 mm. thick. Zooecia angular, about 8 in 2 mm. Mesopores few, somewhat variable. Diaphragms remote in the axial region, 1½-3 to the tube diameter in the periphery. Large acanthopores about 2/5 as numerous as the zooecia, small set several times as numerous, sometimes obsolete in the older specimens.

Described as from the Lexington limestone, later referred to the Cynthiana (Bassler 1915), Lexington, Kentucky.

DEKAYELLA MILLERI. Sp. Nov.
Pl. VI, figs. 6, 9

The type consists of the basal part of a ramose or subfrondescent zoarium 2 cm. thick, branching, and with a rounded celluliferous base. Surface with low monticules consisting of zooecia larger than normal. Zooecia thin-walled, sometimes crinkled, in the (im), turning fairly abruptly into the (m) which is 2-3 mm. thick. Diaphragms few to absent in the (im) but occasionally a cluster of diaphragms 1-3 diameter apart occurs, in the (m) 1/3-1/2 diameter apart. The inverted V structure and hollow central tube of the acanthopores distinct. In tangential section the zooecia are relatively thin-walled, polygonal, 10 in 2 mm. Mesopores practically restricted to the maculae. Acanthopores of two sizes, the larger about 2/3 as numerous as the zooecia, frequently 2/5 the size of the zooecial tubes. The smaller ones are much more numerous, but in the greater part of the sections could not be detected.

The species is characterized by the rounded base of the zoarium and its large size. Other features are much like those of *D. foliacea*. The acanthopores are more numerous and the zooecia smaller. Surface features are essentially as in *Heterotrypa parvulipora*.

Greendale member of the Cynthiana from the vicinity of Lexington.

Genus DEKAYIA. M. E. and H.

Distinguished from *Heterotrypa* in the single set of large acanthopores, and more meagre development of diaphragms in the periphery.

DEKAYIA ASPERA. M. E. and H.
Pl. XI, fig. 15

Zoarium ramose 6-10 mm. in diameter, characterized by the very large acanthopores, conspicuous externally as small spines. Surface more or less smooth, with maculae of larger cells and mesopores. Mesopores lacking except in the maculae. Zooecia polygonal, 10 in 2 mm. Diaphragms absent in the (im), and few to absent in the (m).

The species ranges from the McMicken to the Fairmount, and is especially characteristic of the latter horizon.

Genus CYPHOTRYPA. Ulrich and Bassler

Massive Heterotrypids with thin-walled, prismatic zooecia. Diaphragms and acanthopores well developed. Mesopores wanting.

CYPHOTRYPA FRANKFORTENSIS. Ulrich and Bassler
Pl. IV, fig. 13

Zoarium of thick undulating to subspherical masses. Zooecia thin-walled 9-10 in 2 mm., with comparatively large acanthopores averaging about one to the zooecium. Surface usually with small sharp monticules. Diaphragms wanting in the (im), one to two diameters apart in the (m). It is characterized by the monticuled surface, small zooecia, few acanthopores and absence of diaphragms in the (im).

Common in the upper Benson, also in the Cornishville and Cynthiana formations of Central Kentucky.

CYPHOTRYPA CLARKSVILLENSIS. Ulrich
Pl. XIV, fig. 14; Pl. XV, fig. 6

Subspherical to massive zoaria. Surface smooth or with maculae of larger zooecia slightly elevated. Zooecia 9-10 in 2 mm. Acanthopores large, occupying almost all junction angles. Diaphragms widely spaced in the (im), one to two diameters apart in the (m). The (m) recurs at successive levels in the zooecial tubes.

Common in the Waynesville, especially the lower part along the western side of the arch, also along the eastern from Montgomery County north. Common also in the Oregonia member of the Arnheim of the southern Bluegrass.

GENUS STIGMATELLA. ULRICH AND BASSLER

Zoarium variable. Characterized by the periodic thickening of the walls of the zooecial tubes, the development of acanthopores in these zones, and the meagre development of diaphragms.

STIGMATELLA DYCHEI. (JAMES)
Pl. XV, fig. 1

Zoarium an expansion loosely incrusting crinoid stems, in size up to 60 mm. in diameter. It is characterized by its zoarial habit, the practical absence of mesopores, thin-walled primatic zooecia, acanthopores of fair size in the periodic zones but small or absent elsewhere, and the almost complete absence of diaphragms.

Characteristic of the Mount Auburn in the Cincinnati region. It is not common.

FAMILY CONSTELLARIDAE

GENUS CONSTELLARIA. DANA

Dendroid or frondescent zoaria with depressed stellate maculae, the interray spaces occupied by raised clusters of zooecia. Mesopores chiefly in the maculae, with gradually crowding diaphragms.

CONSTELLARIA TERES. ULRICH AND BASSLER
Pl. IV, fig. 12

Characterized by its mode of growth, consisting of rigid cylindrical to subcylindrical stems 5-10 mm. in diameter bifurcating at regular intervals, seldom less than 50 mm. Diaphragms are more abundant in the (m) than in *C. florida*, and in the (im) are 2-3 tube diameters apart.

Abundant in the Woodburn, also the Greendale member of the Cynthiana.

CONSTELLARIA FLORIDA. ULRICH
Pl. VI, fig. 1-2; Pl. X, fig. 1

Zoarium ramose or subfrondescent, 3-5 mm. thick, with conspicuous stellate maculae spaced at intervals of about 2½ mm., consisting chiefly of angular mesopores, commonly closed at the surface, and largest near the center of the cluster. In between the rays are groups of 5-15 zooecia compactly wedged together and forming conspicuously elevated radial ridges. These often coallesce to form more or less continuous transverse ridges. In shallow sections innumerable minute acanthopore-like structures are present in the zooecial walls and secondary material closing the mesopores. Diaphragms few in the zooecia, practically wanting in the (im). Mesopores closely tabulated, increasingly so as the surface is approached, the diaphragms occurring at the same level in adjoining tubes.

Common in and characteristic of the Fairview formation, also present in the Greendale division of the Cynthiana. A variety *C. florida prominens* Ulrich with monticules about twice the normal size occurs in the McMicken member of the Eden and the Fairview.

CONSTELLARIA EMACIATA. ULRICH AND BASSLER
Pl. VII, fig. 3

This species agrees with *C. florida* in all internal characters but differs in the dwarfed growth and the more sharply and more narrowly rayed maculae. "The usual growth obtaining in *C. florida is* of rather broad, flat branches, seldom less than 10 mm. in breadth and 3 or 4 mm. in thickness dividing rather regularly at intervals of several centimeters. *C. florida emaciata*, however, is dwarfed in growth, the branches being usually rounded and from 3 to 5 mm. in diameter but sometimes reaching a breadth of 6 or 7 mm. Division occurred at short, irregular intervals, and an entire zoarium consisted of a small clump of closely interwoven narrow branches instead of a rather broad expansion as in *C. florida*" (Ulrich and Bassler, 1904a, p. 38).

Common in the Cynthiana of Central Kentucky. A single specimen was found in the upper Benson. Many individuals of *C. florida* from the Fairview are similar.

CONSTELLARIA FISCHERI. ULRICH
Pl. VI, figs. 3, 4

Zoarium frondescent, sometimes of small flattened branches. Surface usually smooth but sometimes slightly monticulated.

It is distinguished from *C. florida* by the much smaller and more closely spaced maculae which are two or three times as numerous within a given area, commonly not elevated, and by the nature of the maculae. The zooecia in the interray spaces are not wedged together but are more or less separated by mesopores. When the zoarium is monticuled it is the maculae (mesopores) that are elevated.

Common in the Greendale division of the Cynthiana.

CONSTELLARIA LIMITARIS. Ulrich

A smooth surfaced, ramose or subramose species usually 5-10 or more mm. in diameter with stellate maculae essentially as in *C. florida* but without the elevated clusters of zooecia in the interrays. Maculae on the same level with or slightly depressed below the general surface.

Common at various horizons in the Richmond from the Waynesville to the Whitewater. A similar form occurs in the Cynthiana.

CONSTELLARIA POLYSTOMELLA. Nicholson
Pl. XIV, fig. 17

A species resembling *C. florida*, distinguished by the more frondescent growth, the numerous diaphragms in the (im) (1-1½ tube diameters apart) and the nature of the "stars." According to Nicholson (1875, p. 215) "the different stars are definitely bounded . . . . .and appear to occupy definite polygonal areas, whilst in the former no line of demarcation can be detected between the different stars other than that afforded by the outer terminations of the elevated ridges. Each star is (in the best preserved portions of the coral) circumscribed and separated from adjacent stars by a distinct hexagonal border which has no great width and is occupied solely by the coenenchymal tubuli and not by the ordinary corallites." The writer has been unable to use this latter feature with the numerous specimens from the Arnheim and some from the Waynesville.

Common throughout the Richmond appearing first in the upper Arnheim.

Family BATOSTOMELLIDAE

Genus ERIDOTRYPA. Ulrich

Zoarium ramose, with more or less oblique, thick-walled zooecia. Diaphragms most numerous in the early portion of the short (m). Acanthopores small, few or wanting. Mesopores variable.

ERIDOTRYPA AEDILIS. (Eichwald)
Pl. II, figs. 13, 15; Pl. VIII, fig. 13

This species, commonly known as *E. mutabilis* Ulrich consists of smooth, cylindrical, infrequently dividing branches. Zooecia more or less oblique with thick interspaces. In the younger specimens the apertures are drawn out anteriorly, in the older, the zooecia are more direct and the apertures subcircular. Maculae present. Mesopores variable. Acanthopores represented by dark spots at the junction angles. The zooecial tubes curve gradually toward the surface. Diaphragms about 2 diameters apart in the (im) and about 1 D. apart in the (m).

Lexington limestone and Cynthiana.

ERIDOTRYPA BRIAREUS. (Nicholson)
Pl. V, fig. 5

The chief feature is in the nature of the zoarium which forms smooth cylindrical branching stems 3-10 mm. in diameter with a rounded or pointed base. Zooecia rather thick-walled, oblique, with oval apertures in the more slender zoaria, about 7 in 2 mm. Acanthopores absent. Mesopores few. Diaphragms particularly common in the early part of the (m).

Common in and characteristic of the Cynthiana. An earlier though not common occurrence, is in the Brannon.

Genus BYTHOPORA. Miller and Dyer

Zoarium of smooth slender branches, with small oblique zooecia, the apertures narrowing above and with channeled interspaces. Mesopores and diaphragms few or wanting. Acanthopores never numerous.

Cumings and Galloway (1913, p. 61) recognize two groups within the genus; *B. arctipora* group—characterized by delicate zoaria, rather large zooecia and scarcity of diaphragms and acanthopores; and, *B. gracilis* group— characterized by larger zoaria and conspicuous acanthopores.

BYTHOPORA ARCTIPORA. (Nicholson)
Pl. IX, fig. 1, 2

A slender ramose species, 1-2 mm. in diameter, with oblique apertures which are attenuated above. These are arranged in obscurely longitudinal alternating series. The borders are distinctly marked off by impressed lines.

Common in and characteristic of the Eden shale of Cincinnati and vicinity.

BYTHOPORA GRACILIS. (Nicholson)
Pl. XIII, fig. 1

Zoarium dendroid, of smooth cylindrical branches 2-3 mm. in diameter. Zooecia small, about ten in 2 mm., opening obliquely on the surface with circular or elliptical apertures between which occur a moderate number of minute more or less circular mesopores. Small acanthopores present. Walls very thick and completely amalgamated in the (m). A few diaphragms occur in the (m).

Common in the upper Fairview and McMillan.

BYTHOPORA MEEKI. (James)
Pl. XV, fig. 19

Distinguished from *B. gracilis* in the more robust zoarium (6-10 mm.) and consequently less oblique apertures.

Common in the Richmond from the Waynesville up.

BYTHOPORA DELICATULA. (Nicholson)

A very slender form with characters essentially as in *B. gracilis* but of smaller size and lacking diaphragms and mesopores. Zooecia emerge very obliquely with oval apertures measuring about 8 in 2 mm. longitudinally.

Common in the Waynesville and higher formations of the Richmond.

Family AMPLEXOPRIDAE

Genus AMPLEXOPORA. Ulrich

Zoarium ramose, discoidal, or massive. Zooecia prismatic. Acanthopores variable. Diaphragms often quite irregular, oblique or curved.

AMPLEXOPORA SEPTOSA. Ulrich
Pl. XI, fig. 14

Zoarium ramose, 5-10 mm. in diameter. Maculae composed of larger zooecial apertures and some mesopores, sometimes a little elevated. Diaphragms few in the (im), about a half-tube diameter apart in the (m). Zooecia polygonal with numerous small acanthopores inflecting the zooecial walls.

Common in the McMicken and Fairview. Nickles recognized the Mt. Hope as the *A. septosa* zone.

AMPLEXOPORA FILIASA
(Not D'Orbigny according to Cumings, 1907, p. 765)

A massive species 25-100 mm. in diameter and 2/3-3/4 as high. Surface monticulated. Zooecia thin walled, polygonal, 9 in 2 mm. Acanthopores small, numerous. Longitudinal sections show alternating zones of (m) and (im), with diaphragms one to two diameters apart in the (im), and one half to one third diameters apart in the (m).

Fairmount, Bellevue, and Corryville around Cincinnati.

AMPLEXOPORO ROBUSTA. ULRICH
Pl. XIII, figs. 7-10

Zoarium dendroid, of smooth cylindrical stems 10-12 mm. in diameter. Maculae conspicuous at intervals of 3-4 mm. composed of larger apertures. Zooecia thin-walled, polygonal, 7-8 in 2 mm. Mesopores absent. Zooecia curving uniformly toward the surface, with diaphragms never numerous in the (im), and closely spaced in the (m). Here they frequently simulate cystiphragms. The nature of the tangential section varies with the age of the specimen and depth of the cut. In a shallow section of a robust individual the wall is typically amalgamate and about 2/5 the diameter of the aperture in thickness, has a well marked cingulum, and acanthopores are but feebly shown. A little deeper, or in younger individuals, the cingulum disappears, small acanthopores become conspicuous at the junction angles with a row of very small ill-defined ones in between, 2-4 to each side of the aperture, giving a grannular appearance to the wall. With greater depth these minute acanthopores disappear and the sharp black line of the integrate wall becomes distinct. Diameter of the normal zooecium about 0.25 mm.

This species is listed from the Bellevue around Cincinnati. It is very common in the Mount Auburn, again in the Sunset of the southern Bluegrass.

GENUS RHOMBOTRYPA. ULRICH AND BASSLER

Ramose forms with the zooecial tubes rhombic or quadrate in cross-section in the (im). Acanthopores usually wanting.

RHOMBOTRYPA QUADRATA. (ROMINGER)
Pl. XVI, fig. 11

Zoarium ramose to lobate, diameter of branches 4-10 mm. Surface smooth or with maculae of larger apertures slightly elevated. Acanthopores commonly described as absent but distinct rounded clear spots occur at the junction angles. Diaphragms few in the (im), closely spaced in the (m). Mesopores absent. Seven-eight zooecia occur in 2 mm. The characteristic rhombic zooecia may be seen in deep tangential sections or the weathered tips of the branches.

A common and characteristic species of the Liberty and Whitewater.

RHOMBOTRYPA SUBQUADRATA. (ULRICH)
Pl. XVI, figs. 9, 10

A smaller ramose form than the preceding species with diameter 2-3 mm., characterized by the development of mesopores. Ulrich and Bassler (1904, p. 45) have pointed out that the "mesopores" are inter-zooecial spaces instead of tubes with walls of their own.

Waynesville and basal Liberty of the Cincinnati region.

FAMILY HALLOPORIDAE

GENUS HALLOPORA. BASSLER

Zoarium ramose. Diaphragms closely spaced in the tapering proximal end of the zooecia, few or wanting in the rest of the (im), crowded again in the (m). Closely tabulated mesopores more or less abundant.

HALLOPORA MULTITABULATA. ULRICH
Pl I, figs. 5, 6

Zoarium of dendroid branches 7-8 mm. in diameter, with strongly elevated more or less conical monticules occupied by zooecia of about normal size. Zooecia thin-walled, direct. Mesopores few. Diaphragms abundant throughout the zooecial tubes, about 1 diameter apart in the (im) and several times as abundant in the (m).

Particularly common in the Jessamine but ranging up through the Woodburn.

HALLOPORA ONEALLI. (JAMES)
Pl. IX, figs. 10, 12

Zoarium dendroid, branches 1.5-2 mm. in diameter, frequently anastomosing. Surface smooth or with inconspicuous monticules. Zooecia thin-walled, apertures oval, 5-6 in 2 mm. Mesopores small, angular, abundant. Diaphragms moderately numerous in the proximal end, and closely spaced in the (m).

Common in the Economy member of the Eden, less common at higher levels

Several varieties are recognized:

var. *communis* (Pl. VIII, fig. 18;) ranging throughout the Eden but best developed in the McMickens, is of larger size, diameter about 7mm. The mesopores tend to pinch out toward the surface resulting in fewer showing on the surface and the zooecial apertures correspondingly more angular. It occurs also in the lower Million east of Winchester.

var. *sigillaroides*, (Pl. IX, figs. 13, 14) from the Eden, (all members) is distinguished on zoarial character. The branches are 4-5 mm. in diameter, do not anatomose, and bifurcate infrequently.

A recurrence of this species or closely related form in large numbers is found in the light colored clay at the top of the Oregonia. Cumings and Galloway (1913 faunal chart) show such an occurrence in the Tanner's Creek section in the Corryville-Arnheim and Waynesville.

HALLOPORA DALEI. (M. E. AND H.)
Pl. X, fig. 10

Distinguished from *H. ramosa* by its more slender zoarium and smaller monticules.

Common throughout the Fairview.

HALLOPORA RAMOSA. D'ORBIGNY
Pl. XIII, fig. 3

Zoarium dendroid, 3-8 mm. in diameter, with prominent conical monticules several mm. apart which are characterized by the more numerous mesopores. Mesopores small, angular, abundant, in some cases completely isolating the zooecia.

Particularly characteristic of the McMillan but ranging down in the upper Fairview.

HALLOPORA RUGOSA. (M. E. AND H.)
Pl. XIII, fig. 2

Distinguished from *H. ramosa* by the transversely elongate monticules often forming discontinuous ridges.

Characteristic of the McMillan, its best development above that of *H. ramosa.*

HALLOPORA ANDREWSI. (NICHOLSON)
Pl. XIII, fig. 11

Zoarium ramose 6-12 mm. in diameter. Surface typically with low rounded monticules composed of larger apertures and more numerous mesopores. Zooecia about 7 in 2 mm. surrounden by a variable number of angular or subcircular mesopores. Tabulation of zooecia variable.

Bellevue and Corryville.

HALLOPORA SUBNODOSA (ULRICH)
Pl. XV, fig. 18

Zoarium dendroid, 6-12 mm. in diameter. Surface with low rounded monticules composed of apertures larger than normal and more numerous mesopores. Zooecial apertures circular, surrounded by a variable number of mesopores. Diaphragms numerous only in the proximal end of tubes, rare or absent above. Cumings (1908 p. 797) notes considerable variation in the tabulation.

A common Richmond fossil from the upper Waynesville up.

FAMILY TREMATOPORIDAE

GENUS BATOSTOMA. ULRICH

Zoarium irregularly ramose. Acanthopores usually large and numerous. Mesopores variable. Zooecia much thickened in the (m), in section appearing ring-like.

BATOSTOMA JAMESI. (NICHOLSON)
Pl. IX, fig. 20

Zoarium dendroid, the branches irregularly thickened and nodulose, 5-10 mm. in diameter. Apertures circular or oval, about 6 in 2 mm., separated by a series of mesopores. Acanthopores small, rather numerous. Diaphragms in the zooecia widely spaced.

From the associated *B. implicatum* it is distinguished by the greater development of mesopores, consequently more rounded

apertures, thinner walls, and smaller acanthopores. The latter forms flattened branches.

Both are characteristic Eden species, the latter ranging up into the Fairmount.

BATOSTOMA VARIANS. (JAMES)

Distinguished from *B. jamesi* (Bassler 1906, p. 18) by the thin-walled, angular zooecia, few mesopores, fewer diaphragms, and lobate to subfrondescent growth.

Common throughout the Richmond.

BATOSTOMA VARIABLE. ULRICH

Zoarium of smooth, cylindrical or subcompressed infrequently dividing branches with conspicuous maculae of larger zooecia. Zooecia thin-walled, polygonal, mesopores practically wanting. Acanthopores variable. Zooecia 6-7 in 2 mm.

Characteristic of the Whitewater.

FAMILY PTILODICTYONIDAE

GENUS ESCHAROPORA. HALL

Zoarium a simple or branching frond articulating with a basal expansion. Zooecial apertures in diagonally intersecting series, surrounded by sloping hexagonal areas.

ESCHAROPORA RAMOSA. ULRICH

Zoarium ramose, branches acutely elliptical in cross-section, 3-6 mm. in width, with tapering articulating base. Apertures circular or elliptical 9 in 2 mm. along the diagonal rows. Margin nonporiferous.

Tyrone and Camp Nelson limestones.

ESCHAROPORA ACUMINATA. (JAMES)

Distinguished from *E falciformis* by the more slender and comparatively thicker zoarium being compressed cylindrical rather than acutely elliptical in cross-section. Length, 1½-3 cm., width, 2-3 mm. Thickness 1-2 mm.

Eden from Cincinnati and vicinity. Bassler (1906, p. 36) notes that within the Eden there are all transitions to the broader forms of the typical *E. falciformis.* Similar forms occur also in the Greendale member of the Cynthiana at Lexington.

ESCHAROPORA FALCIFORMIS. (Nicholson)
Pl. XI, fig. 19

A thin, sharp edged, falciform frond. Length seldom over 50 mm., width usually less than 5 mm., thickness about 1 mm. Diagonal rows make an angle of about 60 degrees with each other and 30 with the edge of the frond. Occasionally a frond branches.

Fairview formation of Cincinnati and vicinity, occasionally also in the upper Eden. The Greendale member of the Cynthiana in Central Kentucky contains what is probably the same species.

ESCHAROPORA MACULATA. (Ulrich)
Pl. V fig. 10, 11; Pl. XI, fig. 18

A more robust form. Width up to 4 cm., length, 13 or more cm., thickness not exceeding 2-3 mm. It is characterized by the conspicuous, usually slightly elevated maculae several mm. apart, composed of larger apertures. Its growth may be falciform but more commonly it expands symmetrically from an articulating base.

Fairmount from Cincinnati and vicinity, and Greendale member of the Cynthiana in Central Kentucky.

ESCHAROPORA PAVONIA. (D'Orbigny)
Pl. X, figs. 5, 6

A thin undulating expansion attaining much greater width and irregularity than *E. maculata*. Maculae relatively inconspicuous.

Fairview of Cincinnati and vicinity. It is also common in the basal Cynthiana of southwestern Fayette and adjoining parts of Jessamine County.

ESCHAROPORA HILLI. (James)
Pl. X, figs. 8, 9

An unbranched, flattened frond, gradually expanding from an articulating base commonly 1-2 cm. in width and up to 10 cm. in length. It is characterized by the development of more or less discontinuous transverse ridges (monticules) which do not interrupt the diagonal series of apertures.

Characteristic of the Fairmount of the southern Bluegrass. A closely related form occurs in the Cynthiana.

Family RHINIDICTYONIDAE

Genus RHINIDICTYA. Ulrich

Zoarium dendroid, of narrow, compressed, parallel edged branches continuous with an expanded base. Apertures in longitudinal rows.

RHINIDICTYA NEGLECTA. Ulrich
Pl. II, figs. 5, 6

Narrow branches 1.5-2 mm. wide, dividing at intervals of 4-7 mm. Zooecia in 9 (8-11) longitudinal rows, oblique with elliptical apertures, 16-18 in 2 mm. Six rows occur in the same distance. Interspaces comparatively thick, with a series of small grannules. Apertures of marginal rows directed outward in some specimens.

Common in the Lexington limestone, particularly the Jessamine, also rather common in the Cynthiana.

RHINIDICTYA. Sp.

Associated with *Escharopora ramosa* in the upper beds of the Camp Nelson is a Rhinidictya, in growth essentially as in *R. neglecta*, but with conspicuous superior hemiseptum. There are 10-13 ranges of zooecia, 5-6 rows in 2 mm., and longitudinally 17 apertures in 2 mm. The marginal rows show the apertures directed slightly outward. Compared with *R. fidelis* the branches bifurcate more frequently, are a little wider with one or two more rows of apertures, and the zooecial tubes make a more acute angle with the median lamina.

Phylum MOLLUSCA

Class PELECYPODA

Family CTENODONTIDAE

Genus CTENODONTA. Salter

Shell equivalve, smooth or with concentric growth lines. Hinge arcuate, with series of curved, transverse teeth. Cardinal area not striated. Ligament small, immediately behind the beaks. Adductor impressions subequal. This genus is abundantly represented in the local Ordovician.

Family PTERINEIDAE Dall

Genus PTERINEA. Goldf

Left valve convex, right flat, inequilateral, auriculate anteriorly and posteriorly. Area amphidetic, grooved longitudinally. Anterior teeth obscure, transverse, posterior elongate, nearly parallel to the cardinal margin. Posterior adductor scar large, anterior small, strong, located below the anterior wing.

PTERINEA DEMISSA. (Conrad)

Distinguished by the strong concentric growth lines and large anterior ear (Grabau and Shiner 1909, p. 419). Measurements of a typical specimen—hinge line 42 mm., beak to center of base along oblique umbonal ridge 37 mm., beak about one-third distance from the anterior end.

Common in the Maysville and Richmond.

Family AMBONYCHIIDAE

Genus BYSSONYCHIA. Ulrich

Equivalve, inequilateral, more or less winged posteriorly with beaks nearly or quite terminal. Valves ventricose, with byssal opening in the upper half of the anterior side, and marked by moderately strong radiating ribs. Two or three slender lateral teeth and several cardinals are present. Ligament external. Area striated.

BYSSONYCHIA RADIATA. Hall

Shell obliquely ovate, extending into acute curving beaks. Surface with about 45 radiating plications. Length of average specimen about 40 mm., greatest width about 3/4 length, convexity about 1/6 length. Anterior slope nearly straight making an angle of a little less than 90 degrees with the cardinal margin. Posterior angle quite obtuse rounding more or less gradually into the cardinal outline. Cardinal margin about one-half the greatest length of shell.

Maysville and Richmond.

Genus ALLONYCHIA. Ulrich

Distinguished from *Byssonychia* in the absence of cardinal and lateral teeth. It is more erect than other *Ambonychia*-like forms, (Grabau and Shimer 1909, p. 432) and with no posterior alation.

ALLONYCHIA FLANAGANENSIS. Foerste

Pl. VII, fig. 1

This species is characterized by the long hinge line and the very oblique anterior and posterior margins, producing an elongate rather than erect form. The shell is strongly convex, the anterior slope of the more gibbous specimens practically vertical except for the protrusion of the bysal opening. Shell thick, radiating plications very flat and separated by very narrow and shallow grooves, readily overlooked. Measurements given by Foerste are: length 11 cm. from beak along the umbonal ridge, hinge area 6½ cm. in length extending 5-8 mm. anterior to the beak. Hinge area 4-6 mm. high.

Very common in and characteristic of the Cynthiana, particularly the Millersburg phase.

Genus ANOMALODONTA. Miller

Distinguished from Byssonychia in the absence of cardinal and lateral teeth. Distinguished from *Allonychia* in the more oblique form and strong posterior alation.

ANOMALODONTA GIGANTEA. Miller

An unusually large pelecypod 8-10 cm. in length and almost as wide, alate posteriorly and marked by 30-40 strong radiating ribs. Anterior edge about at right angles to hinge line. Beaks sharp, slightly incurved, and situated at the anterior end of the cardinal margin. Byssal opening immediately below the beak, 6-7 mm. in diameter. In a specimen 8 cm. long the hinge has a length of about 5 cm. From 4-14 cartilage grooves extend from the end of the wing to the byssal opening.

A characteristic Richmond species known from the Arnheim to the Whitewater. In the region around Louisville it seems to be restricted to the Arnheim.

Family MODIOLOPSIDAE

Genus MODIOLOPSIS. Hall

Shell thin, obliquely elongate very inequilateral, with small anterior and large posterior end. Beaks not prominent, near anterior end. Valves crossed by oblique depression extending backward from anterior portion of umbo, and marked by con-

centric lines of growth. Teeth absent. Anterior adductor scar large and deep, posterior one large but faint. Ligament chiefly external.

MODIOLOPSIS MODIOLARIS.' (CONRAD)

The principal features are the comparatively straight hinge line posterior to the beak, a moderately convex or nearly straight basal margin, absence of median sulcus, and conspicuous extension of the anterior margin of the shell in front of the beaks. The umbonal ridge disappears ventrally in the general convexity of the shell. Measurements after figures by Foerste (1914b, p. 282) are: length about 60 mm., height at beak about 1/3 length, height posteriorly about ½ length, beaks 10-11 mm. behind anterior margin; convexity of valve about 4 mm., angle between cardinal and ventral margin 11-12 degrees.

Maysville and Richmond.

MODIOLOPSIS CONCENTRICA. HALL AND WHITFIELD

About 2/3 the size of *M. modiolaris* with concentric lines which become obsolete on the umbonal ridge. The basal margin is a little concave and the anterior end extends but little beyond the beaks.

Waynesville of the Cincinnati region.

GENUS MODIOLODON. ULRICH

Modioliform shells distinguished from *Modiolopis* by the presence of 2-3 cardinal teeth in each valve.

A common genus from the Black River to the Richmond.

CLASS GASTROPODA

FAMILY CYRTOLITIDAE

GENUS CYRTOLITES. CONRAD

Volutions 2 or 3, gradually enlarging, scarcely contiguous. Carinated on the back, often on the sides, giving subquadrate cross section. Aperture with or without median notch in outer lip, no slit band. Shell without callosities. Surface reticulated or cancellated.

CYRTOLITES ORNATUS. CONRAD

Average shell 20-25 mm. in diameter, of 2 or 3 strongly carinated volutions, rhombic-subquadrate in cross-section, and rapidly expanding. Side subangular or narrowly rounded, the

dorsal slope gently convex with strong transverse furrows and subangular ridges, the umbilical slope almost flat, without undulations. Ventral side with sharp impressed zone. Umbilicus wide and deep. Surface marked by raised transverse lines with short connecting lines in alternating series. In the outer part of the last whorl there are commonly 7-8 of the transverse, and 8-9 of the short lines in 2 mm. There is no preceptible recurving of the transverse lines in crossing the dorsal carina.

Maysville and Richmond. A small variety, *C. ornatus* minor with a diameter not in excess of 11 mm. occurs in the Trenton of Minnesota and elsewhere.

FAMILY BUCANIIDAE

GENUS SINUITES. HALL

This genus includes those forms which have commonly gone under the name of *Protowarthia*, a synonym. It is distinguished from Bellerophon in the absence of the slit band, in the lack of abruptly expanded aperture, and presence of revolving striae as well as growth lines.

SINUITES CANCELLATA. (HALL)

The most common of the Ordovician Bellerophontids characterized by the evenly rounded dorsum, rounded apertural lobes, and moderately deep sinus which is *U* rather than *V*-shaped. Surface marked by fine lines of growth crossed by fine revolving striae. The surface features are seldom preserved. Diameter up to about 25 mm., height about 4/5 diameter.

Trenton to Richmond.

GENUS OXYDISCUS. KOKEN

A Bellerophontid characterized by the lenticular form, compressed, sharply keeled volutions which expand gradually to the aperture. Outer lip with *V*-shaped excission continuing as a long and very narrow slit. Inner lip without callosity. Surface with growth lines only, in which feature it is not typical of the *Bucaniidae*.

OXYDISCUS SUBACUTUS. (ULRICH)

Shell from 15-30 mm. in diameter. Thickness about ½ diameter. Volutions 3½-4½, each embracing 1/3-1/2 of the preceding. Umbilicus 1/3 or less the diameter of the shell,

with abrupt, subangular edge exposing all volutions. Aperture obcordate, indented below by the sharp dorsum of the preceding whorl. Surface concave bordering the sharp periphery and marked by fine rather indistinct lines of growth.

Lexington limestone, particularly common in the Faulconer.

Family BELLEROPHONTIDAE

Genus BELLEROPHON. Montfort

Shell subglobose. Umbilicus never large. Aperture generally expanded, with callosity on inner lip. Outer lip with central notch and with well developed slit band or elevated blunt keel. Surface with growth striae only.

BELLEROPHON TROOSTI. D'Orbigny

Pl. IV, fig. 8

Shell rarely exceeding 17 mm. in diameter, aperture flaring laterally, diameter somewhat in excess of height. Adult forms with rounded carina, surface flat or slightly excavated, in younger forms, with distinct slit band. Notch deep, rather narrow subrectangular. Fine growth lines approach the slit band nearly at right angles and are then abruptly deflected backward.

A common Trenton species, particularly abundant in the Faulconer.

Genus LOPHOSPIRA. Whitfield

Spire more or less elevated. Whorls closely coiled, angular on the periphery, generally with several carinae, the peripheral one strongest. Umbilicus small. Outer lip more or less deeply notched, but no slit. Surface markings of growth lines.

LOPHOSPIRA BOWDENI. Safford

Height 45-50 mm., volutions 8-10, moderately angular with thick subcentral peripheral band. Upper slope more or less concave in the lower half, upper half convex, sometimes obscurely carinate. Lower carina obscure, space above a little concave. Apical angle 25-35 degrees. Umbilicus minute covered by reflected inner lip in the narrow specimens. Surface with unequal growth lines, strongly recurved toward the peripheral band indicating a deep *V*-shaped notch.

Common through the Trenton-Richmond.

LOPHOSPIRA MEDIALIS. Ulrich

Pl. IV, fig. 9

Height 12-22 mm., apical angle 60-65 degrees with 6-7 volutions. Upper slope nearly flat. Lower carina never strong, the slope between it and the strong peripheral carina more or less concave. Band rounded, with growth lines strongly recurved toward it. Umbilicus small.

Common in the Lexington series.

LOPHOSPIRA PERANGULATA. Hall

Distinguished from *L. medialis* by the smaller apical angle (usually about 52 degrees), lower carina more distinct, and the last volution tending to become free. Peripheral band prominent, sharp, trilineate. Surface markings of stronger growth lines with finer in between.

High Bridge and Lexington series.

Genus LIOSPIRA. Ulrich

Shell sublenticular, subconical, sharply rounded at the periphery, almost smooth. Suture close, scarcely distinguishable. Umbilicus often filled by reflected inner lip. Aperture deeply notched, band obscure. Surface markings of growth lines and spirals.

LIOSPIRA MICULA. Hall

Small, diameter 11-12 mm., height about ½ diameter, of usually four volutions, with shallow suture, the upper surface forming an almost even slope. Umbilicus filled by reflection of inner lip. Surface markings of fine growth lines and exceedingly fin spirals. The former are strongly deflected backward along the slit band which is located on the upper edge of the periphery. Inner lip essentially vertical in the Trenton forms, always more so than in the later forms.

Trenton-Richmond.

LIOSPIRA VITRUVIA. Billings

Diameter about 25 mm., height about ½ diameter. Characteristic features are the open umbilicus with angular margin and flattened sides, and the unusually prominent, and sharply curved outline of the lower lip. Upper side of last whorl a little concave because of the slight elevation of the peripheral band.

Black River-Richmond.

LIOSPIRA MUNDULA. Ulrich

A small species about 12 mm. in diameter and 7 mm. high, of 4-5 volutions, distinguished by the thick ridge above, adjoining the suture, the elevated band on the upper edge of the periphery, and concave surface between. Umbilicus open. Base uniformly rounded.

Trenton.

LIOSPIRA AMERICANA. Billings
Pl. II, fig. 4

Diameter 30-40 mm. distinguished from *L. vitruvia* by the broader curvature of the lower lip which is like that of *L. progne*, *L. micula*, etc., and the broader and less abrupt umbilicus without the angulation as in that species. With specimens commonly preserved in the Lexington limestone as molds, these criteria are difficult to apply. According to Ulrich, *L. vitruvia* has commonly been identified as this species.

Specimens of this type are very common in the Jessamine but seldom preserving the diagnostic features.

Stones River-Richmond.

LIOSPIRA PROGNE. *Billings*

Distinguished from *L. micula* only in size, with diameter 25-35 mm. and from *L. americana* in the closing of the umbilicus which is more or less filled with shell material. In internal molds where the umbilicus is occupied by the same material filling the whorls the umbilicus was open. For this reason *L. americana* and *L. vitruvia* seldom have the umbilical cavity entirely free of the matrix material.

Stones River and Trenton.

Family EUOMPHALIDAE

Genus MACLURITES. Lesueur

Shell sinistral discoidal, upper surface flat showing all of the few, rapidly enlarging whorls. Base convex, and strongly umbilicated. Surface marked by growth lines, revolving lines sometimes shown in the peripheral region. Ulrich and Schofield (1897, p. 1038) regard the shell as dextral with the flat surface the base.

MACHLURITES BIGSBI. Hall
Pl. I, fig. 10

Shell 50-60 mm in diameter, height ½ diameter. Umbilicus deep, rather abrupt, from one-third to one-half the diameter of the shell in width, exposing half or more of the inner whorls. Operculum with nucleus at the inner angle.

Camp Nelson.

Family TROCHONEMATIDAE

Genus CYCLONEMA. Hall

Shell turbinate, non-umbilicated, with short spire, composed of few more or less ventricose whorls. Aperture oblique with reflected inner lip, always excavated. Surface with spiral lines and small ridges crossed obliquely by sharp lines of growth.

CYCLONEMA VARICOSUM. Hall
Pl. V, fig. 6

Distinguished from the *C. bilix* type by the more ventricose whorls and stronger surface markings. The curvature is uniformly convex with no sign of a shoulder at the suture. The revolving ridges are strong and between each pair there are usually several finer ones. Nine or ten of the principal carinae occur on the body whorl, five or six exposed on the higher whorls. Volutions never exceeding five. Suture deep.

Characteristic of the Cynthiana, particularly the Greendale and Millersburg phases. A small variety occurs in the Rogers Gap.

CYCLONEMA MEDIALE. (Ulrich)

Distinguished from *C. varicosum* by the less convex whorls, shallower suture, and more slender spire with six to seven whorls. The surface markings are weaker and the columnar lip not as straight. Revolving lines either subequal or stronger ones with several weaker ones in between.

The common species of the Maysville.

CYCLONEMA BILIX. Conrad

A turbinate shell, with height equal to or a little greater than width. Apical angle 55-75 degrees. Whorls 2 to 4, depressed convex, flattened or even a little concave centrally on the exposed outer part, with a shoulder-like convexity at both

top and bottom giving a deeply impressed suture. Base of last whorl more or less flattened, narrowly rounded at the periphery. Surface with subequal revolving striae on the upper whorls, generally alternating on the body whorl, crossed diagonally by finer growth lines. These are exceptionally fine for the genus, about 12 in 2 mm. on the last whorl, 9-12 ridges occur on the exposed part of the upper whorls. On the body whorl about 4 in 2 mm.

This is the common *Cyclonema* of the Richmond.

CYCLONEMA BILIX var C. FLUCTUATUM. (James)
Pl. XIV, fig. 16

A variety distinguished by the much finer surface markings and almost constant concavity of the outer part of each whorl. The lower whorl commonly shows a series of transverse undulations but this feature is not constant nor restricted to it.

Rather characteristic of the Arnheim in the western area of out-crop in Kentucky, from the Arnheim and Waynesville in Ohio and Indiana, possibly also the Whitewater.

Genus CYCLORA. Hall

Minute spiral shells of rounded whorls loosely embracing so as to leave a deep suture and umbilicus. Surface smooth. Aperture circular, lip thin.

CYCLORA MINUTA. Hall

"Subglobose, wider than high, with much depressed spire of three rapidly increasing volutions; suture almost channeled; umbilicus small. Possibly pelagic protoconchs of other gastropods." (Grabau and Shimer, 1909, p. 673.)

Very common throughout the Trenton-Richmond. In Central Kentucky it is particularly common in the Woodburn where its occurrence is genetically related to the phosphate deposits.

Family PYRAMIDELLIDAE

Genus FUSISPIRA. Hall

Shell fusiform, whorls convex or flat. Aperture elongate oval, acuminate above, canaliculate below. Columella nearly vertical, slightly twisted, thin. Surface smooth or with revolving or longitudinal rows of small punctures.

FUSISPIRA SULCATA. Ulrich
Pl. VIII, fig. 17

Shell thick, of about 6 gradually expanding very depressed convex whorls the last forming about 2/5 the entire height of the shell. Apical angle about 32 degrees. Suture faint externally, deep in molds. Aperture elongate, obliquely subelliptical, somewhat acuminate at both ends. Surface smooth except for revolving rows of very fine punctae. Surface of molds with several more or less obscure revolving furrows. Height of average specimen 6-7 cm.

Specimens referred to this species are rather common in the Rogers Gap, the types coming from the type locality at Rogers Gap, Grant County.

Class CEPHALOPODA

Family ENDOCERATIDAE

Genus ENDOCERAS. Conrad

Othocones with large, more or less eccentric siphuncle, the funnels extending only to the next preceding septum.

ENDOCERAS PROTEIFORME. Hall
Pl. I, fig. 11

E. proteiforme is characterized by its enormous size, sometimes attaining a length of 10-15 feet, circular section, comparatively shallow chambers, and large submarginal siphon. The spacing of the septa increases toward the body chamber. Relative diameters of the shell and siphuncle in available specimens about 2:1.

A wide-spread and common species throughout the Mohawkian and Cincinnatian.

Family ACTINOCERATIDAE Saemann

Genus ACTINOCERAS. Bronn.

Orthoceracones and *cyrtoceracones*, depressed elliptical in section, characterized by the large, nummuloidal siphuncle, short compressed funnels, and nearly globular sheaths. Septa often double.

ACTINOCERAS BIGSBYI. Stokes
Pl. I, fig. I

A large species with deeply concave septa. Siphuncle excentric, large, the siphonal beads occupying fully two thirds the diameter of the shell. Endosiphonal walls thick.

Tyrone.

Family ORTHOCERATIDAE

Genus ORTHOCERAS. Breyn

Long slender, usually tapering orthoceracones with small central or subcentral siphuncle. Shell smooth or with transverse striae.

ORTHOCERAS DUSERI. Hall and Whitfield

A rather rapidly expanding shell, circular in section, typically about 20 cm. in length, expanding from 5 to 35 mm. Septa moderately concave, closely spaced, less so toward the living chamber where 10 chambers in the above specimen occur in 40 mm. Siphuncle eccentric somewhat nearer center than margin, very small where passing through the septa, expanding to about 4 times that diameter within each chamber. Surface smooth except for the raised edges of the septa which form narrow rings and the presence opposite the siphuncle of a narrow raised longitudinal line extending the length of the shell, slightly interrupted just above each of the annular rings.

An important horizon marker at the top of the Fort Ancient member of the Waynesville, known as the *O. "fosteri"* horizon. It is listed by Cumings from the McMillan and lower Arnheim of Indiana.

Class TRILOBITA

Family TRINUCLEIDAE Emmrich

Genus CRYPTOLITHUS. Green

Cephalon very broad proportionately with long genal spines, and broad, regularly pitted border. Glabella inflated, pear-shaped, smooth or with indistinct furrows. Eyes generally absent. Thorax of 6 segments which are nearly straight at their extremities; axis narrow. Pygidium with margin entire. (Grabau and Shimer 1909, p. 258))

CRYPTOLITHUS TESSALATUS. Green
Pl. IX, fig. 19

Head semicircular or subcrescentic, typically about 10 mm. long, 15 mm. wide, convexity of about 6 mm. Genal angles with or without spines. Glabella smooth, very prominent, produced posteriorly into a short, blunt spine. Anterior and lateral margins surrounded by a broad flattened border, marked by 3-5 concentric rows of deep rounded pits in front and one or two additional rows laterally, becoming irregular toward the genal angles. More familiarly known as "Trinucleus concentricus."

Particularly common in the Eden, also in the Cynthiana. It is listed by Nickles from the Point Pleasant beds (1902, p. 64). It occurs in large numbers thirty feet above the Cornishville and about 75 feet below the *Plectambonites* layers of the Million in Lincoln and Boyle counties.

Family OLENIDAE

Genus TRIARTHRUS. Green

Elliptical. Cephalon semicircular. Glabella large and well defined with straight sides and rounded front, marked by three deep furrows extending toward the center from each side. Eyes small. Central axis of thorax wider than lateral lobes; furrows of axis not continuous with those of pleura. Thoracic segments 14-16. Pleural segments grooved. Pygidium with 6 segments in the axis and with entire margin. (Grabau and Shimer, 1910, p. 286)

TRIARTHRUS BECKI. (Eaton)
Pl. IX, fig. 9

Length about 20 mm., width, 0.5 length. Center of each axial segment marked by a tubercule.

A characteristic Fulton species, recurring in the Southgate.

Family ASAPHIDAE Burmeister

Genus ISOTELUS. DeKay

Isotelus belongs to the subfamily Asaphinae with bifurcated hypostome. Carapace oval with broad axial lobe, and obsolete segmentation of pygidium and glabella. Eyes large and prominent. Thorax of eight segments, pleura grooved, with rounded extremities. Free cheeks large, the suture emerging well within the genal angles.

ISOTELUS GIGAS. DeKay

A large species commonly attaining a length of 200-250 mm., at times practically double the figure. Width somewhat over half the length. Axis forming about one-half the width. The most distinctive feature is the subtriangular form of the pygidium with length about 3/4 width. Cephalon similarly subtriangular. Genal spines short, present only on the smaller specimens.

Mohawkian and Cincinnatian.

ISOTELUS MAXIMUS. Locke

This species has commonly been distinguished from the preceding by the development of genal spines extending back as far as the fifth or sixth thoracic segment. According to Raymond and Narraway (1910, p. 55) the pygidium is short and rounded, contrasting with the subtriangular form of *I. gigas*. In this it agrees with the young individuals of that species. It does not attain the large size of *I. gigas*.

Trenton-Richmond.

Class OSTRACODA

Family LEPERDITIIDAE Jones

Genus LEPERDITIA. Rouault

Shell large, suboblong with oblique backward swing. Ventral outline rounded, greatest thickness ventrally, lower edge usually blunt. Right valve overlapping the left ventrally. Hinge simple. Surface frequently horny, smooth and glossy, in some specimens grannulose or punctate. Eye spot usually present on antero-dorsal fourth. Large, rounded, subcentral muscle scar well marked on the interior, sometimes discernible externally.

LEPERDITIA CAECIGENA. S. A. Miller

Shell obliquely subovate, length about 3 mm., width 2/3, and thickness 1/3 length. Anterior end but little produced beyond hinge, posterior end protruding about one-third the length of the shell. Anterobasal margin sloping abruptly. Otherwise much like *L. fabulites*. Eye tubercule obsolete.

Whitewater-Saluda.

LEPERDITIA CAECIGENA var. FRANKFORTENSIS. Ulrich
Pl. IV, fig. 14

A variety distinguished in that it "has the dorsal angles sharper, an appreciably flattened border or flange at the ends of both valves and the ventral edge is a trifle more convex. The eye tubercule, and the reticulated spot as well, is, though always very small, generally distinguishable." (E. O. Ulrich, 1890, p. 177.)

Common in the Salvisa member of the Perryville.

LEPERDITIA FABULITES. Conrad

Shell obliquely subovate, length 10-11 mm., height, and length of hinge about 2/3 length, thickness about 4 mm. Height of ends about as three is to four, both obliquely and about equally truncate above, the anterior end narrowly and posterior end more broadly curved. Ventral edge gently rounded, overlap strongest ventrally. Eye tubercule faint.

Tyrone and Curdsville.

Genus ISOCHILINA. Jones

Distinguished from *Leperditia* in the equal non-overlapping valves.

ISOCHILINA JONESI. Wetherby
Pl. IV, fig. 10

An average large specimen shows the following measurements: Length 20 mm., width 13 mm. Length of hinge 14mm. In available specimens the length varies from 8-25 mm. Posterior end more produced than anterior, hinge extremities slightly mucronate. Eye spot sharp, near dorsal margin.

Developed in great numbers in the Salvisa, particularly where the rock is more grannular and somewhat argillaceous, associated with several species of *Leperditia*.

Family BEYRICHIIDAE

Genus CTENOBOLBINA. Ulrich

Shell oblong or subovate, posterior two-fifths bulbous or sub-globular, bordered anteriorly by a deep, obliquely curved sulcus which extends from the dorsal margin more than half way across the valves postero-ventrally. Anteriorly another oblique, but shallower sulcus. Dorsal margin long and straight,

hingement simple. Ventral edge thick, contact margin generally with a row of small spines on each side, and concealed on lateral view by an extended, flattened border.

CTENOBOLBINA CILIATA. (EMMONS)
Pl. VIII, fig. 19

Shell subovate, length 1½-2 mm., width 2/3 length, length of hinge 3/4. Anterior and posterior widths subequal, curvature of the two ends much alike, the posterior end curves in farther dorsally making a more acute angle with the hingeline. Posterior sulcus crescent shaped, narrow and deep. Anterior sulcus not so well defined. No eye tubercule. Surface minutely grannulose.

A common Eden form, particularly characteristic of the Southgate member.

ILLUSTRATIONS OF ORDOVICIAN FOSSILS

Explanation of Plate I

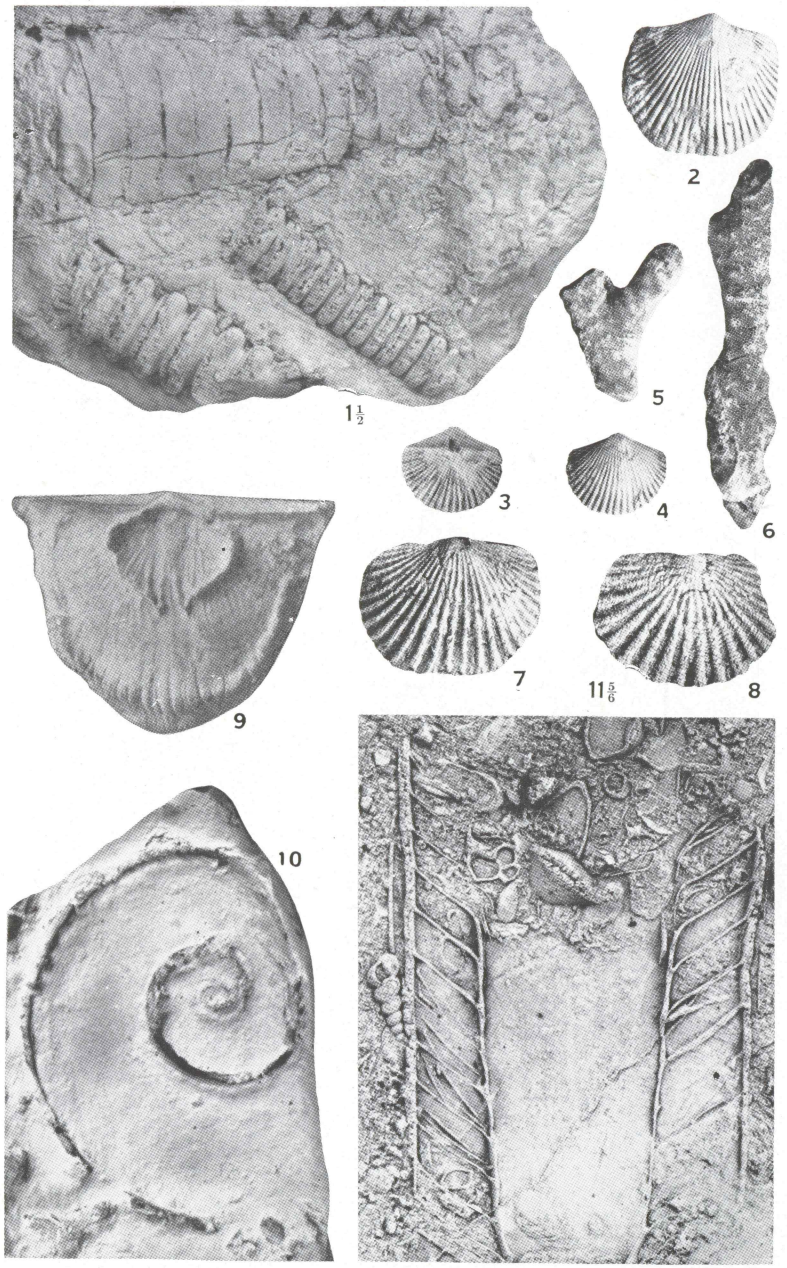
(High Bridge and Lower Lexington)

Figure

1. *Actinoceras bigsbyi* Bronn. (1681a) X ½, Tyrone, Jessamine County, Kentucky.
2- 4. *Orthis tricenaria* Conrad. (527c) Upper Black River, near Little Current, Ontario, Canada.
5- 6. *Hallopora multitabulata* (Ulrich). (2090) Lower Jessamine or Hermitage, Elk Licks Falls, about twelve miles southeast of Lexington, Kentucky.
7- 8. *Dinorthis pectinella* (Emmons). (2056) Curdsville formation, Mercer County, Kentucky.
9. *Strophomena incurvata* (Shepard). Tyrone limestone, High Bridge, Kentucky. After Foerste, Bul. Sci. Lab. Dennison Univ. Vol. 17, Pl. XI, fig. 7, 1912.
10. *Maclurites bigsbyi* Leseur. (850) Camp Nelson limestone, Jessamine Creek, Jessamine County, Kentucky.
11. *Endoceras proteiforme* Hall. (2081) x ⅚ Top of Jessamine formation, about a mile southwest of Spears, southeastern Jessamine County, Kentucky.

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Fossils of the High Bridge and Lower Lexington—Ordovician

Explanation of Plate II

(Lexington)

Figure

1- 3. *Dalmanella bassleri* Foerste. Fig. 1 (2070) lower Hermitage, near Union Mills, Jessamine Co.; Figs. 2-3 (2072) Jessamine, three-fourths mile south of Downing Lane, Hickman Creek fault zone, Jessamine County, Kentucky.

4. *Liospira americana?* Billings. (2083) Jessamine, from quarry about 12 miles southeast of Lexington on Richmond road.

5- 6. *Rhinidictya neglecta* Ulrich. (2086) Jessamine, from quarry eight miles south of Lexington, Stop 17 on Nicholasville Interurban.

7- 8. *Heterorthis clytie* Hall. (563) Hermitage, Frankfort, Ky.

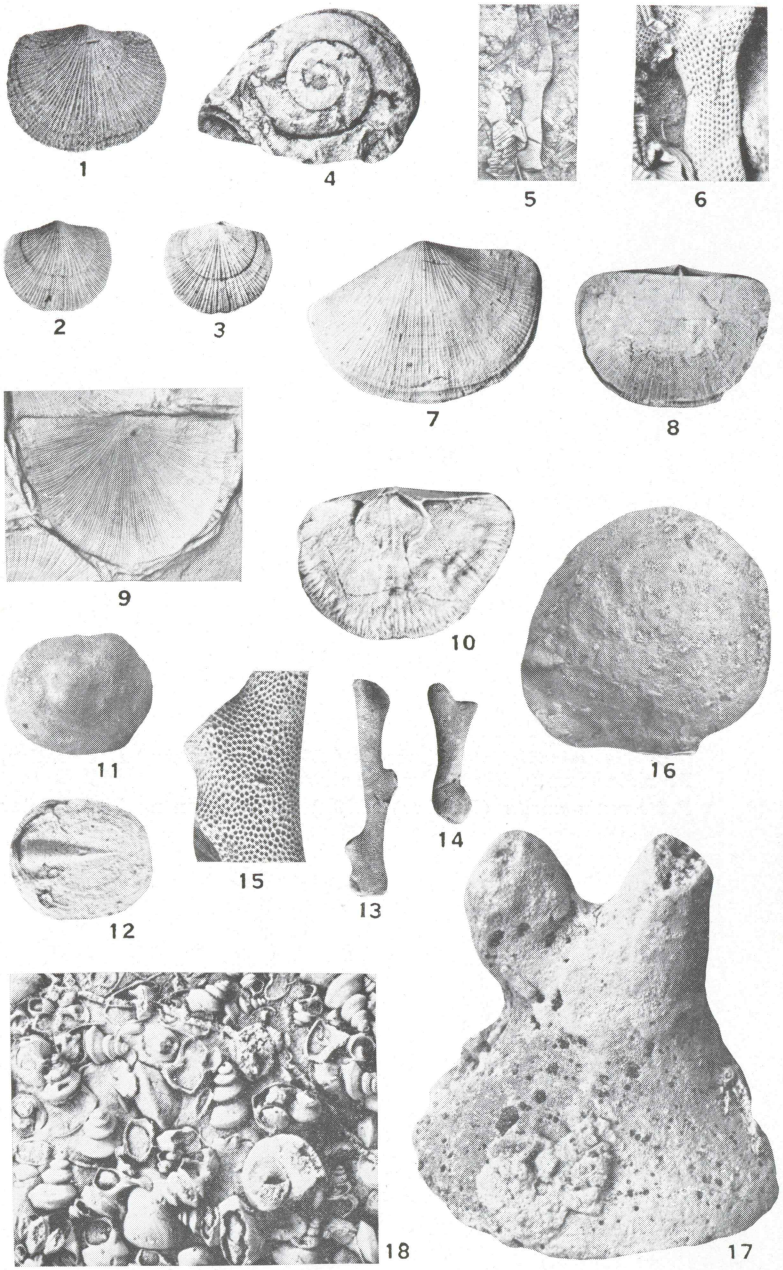
9-10. *Strophomena vicina* Foerste. Fig. 9, (2069) Brannon, Armstrong Mill Pike and DeLong road, Fayette Co.; fig. 10, (2057) top of Benson, near Lexington.

11-12. *Prasopora falesi* (James). (2068) Jessamine, 70-80 feet above Tyrone, Chenault bridge section at Dix River crossing on Lexington-Danville road.

13-15. *Eridotrypa aedilis* (Eichwald) (2075) Jessamine, four miles north of Wilmore on Lexington-Harrodsburg road. Fig. 15, lower part of 13, x 3. (See VIII, 13).

16-17. *Prasopora simulatrix* Ulrich. Fig. 16, (2071) Jessamine, along road from Duncan Station to Glen Creek southwest of Frankfort, Ky. Fig. 17, (2077) Jessamine, four miles north of Wilmore on Lexington-Harrodsburg road.

18. *Gastropod bed* at top of Jessamine, a mass of Lophospira, Ctenodonta etc., (2085) from quarry 2½ miles south of Lexington along Tates Creek Pike.



Fossils of the Lexington Limestone—Ordovician

Explanation of Plate III

(Lexington)

Figure

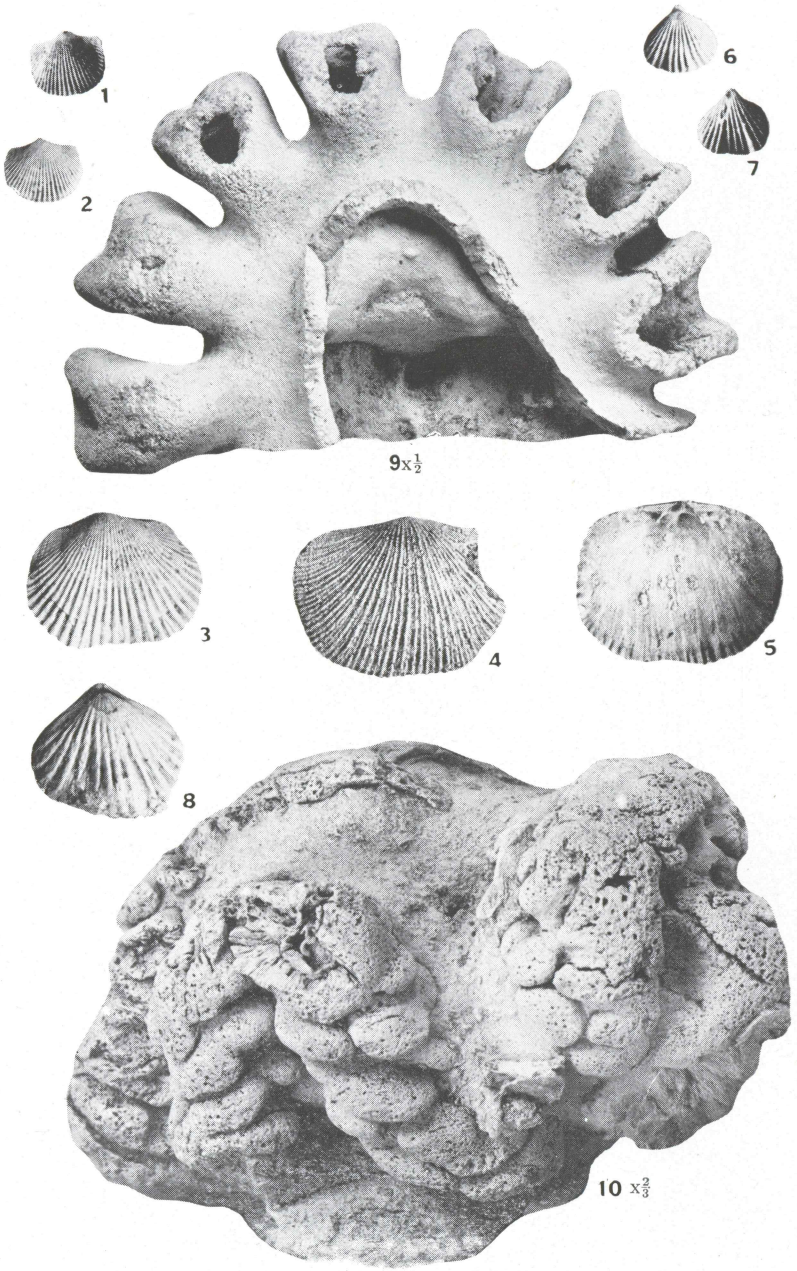
1- 3. *Hebertella frankfortensis* Foerste. Figs. 1, 2 (2054) Cornishville member of Perryville, Burdett Knob, Garrard County, Ky. Fig. 3 (533) Benson, Franklin County, Ky.

4- 5. *Dinorthis ulrichi* Foerste. (1725b) Top of Benson, three miles south of Lexington on Tates Creek Pike.

6- 8. *Rhynchotrema increbescens* (Hall) Figs. 6, 7, (2063) Jessamine, 70-80 feet above Tyrone limestone, Chenault bridge section, Lexington-Danville Road. Fig. 8, (2055) Faulconer, railroad cut northwest of Danville.

9. *Brachispongia digitata* (Owen). (2336) x ½ Brannon formation, Franklin County, Kentucky. (See IV, 1, 2).

10. *Pattersonia aurita* (Beecher) (599b) x ⅔ Brannon, A. M. Peter farm, northern Fayette Co., Kentucky.



Fossils of the Lexington Limestone—Ordovician

Explanation of Plate IV

(Lexington)

Figure

1- 2. *Brachiospongia digitata* (Owen) (2052) 1, view of specimen sawed in half, X 0.6 fig. 2, photomicrograph X 20 of section tangential to one of the arms. (See III, 9).

3- 4. *Platystrophia colbiensis* Foerste. (2059) Woodburn, Duncan station on Lexington-Frankfort Interurban, northern Woodford County. (See VII, 4, 5).

5. *Columnaria halli* Nicholson. (2096) Woodburn, Downing Lane and Tates Creek Pike, Fayette County.

6. *Columnaria alveolata* Goldfuss, showing the septa in longitudinal section. (2338) Woodburn Armstrong Mill road, ½ mile east of Tates Creek Pike, Fayette Co., Ky. (See XVI, 13).

7. *Hindia parva Ulrich.* (2058) Woodburn, Duncan Station on Lexington-Frankfort Interurban northern Woodford County.

8. *Bellerophon troosti* D'Orbigny (818) Faulconer member of the Perryville, Woodford Co., Ky.

9. *Lophospira medialis* Ulrich and Scofield. (2080), Faulconer member of Perryville formation, railroad cut three miles southeast of Versailles.

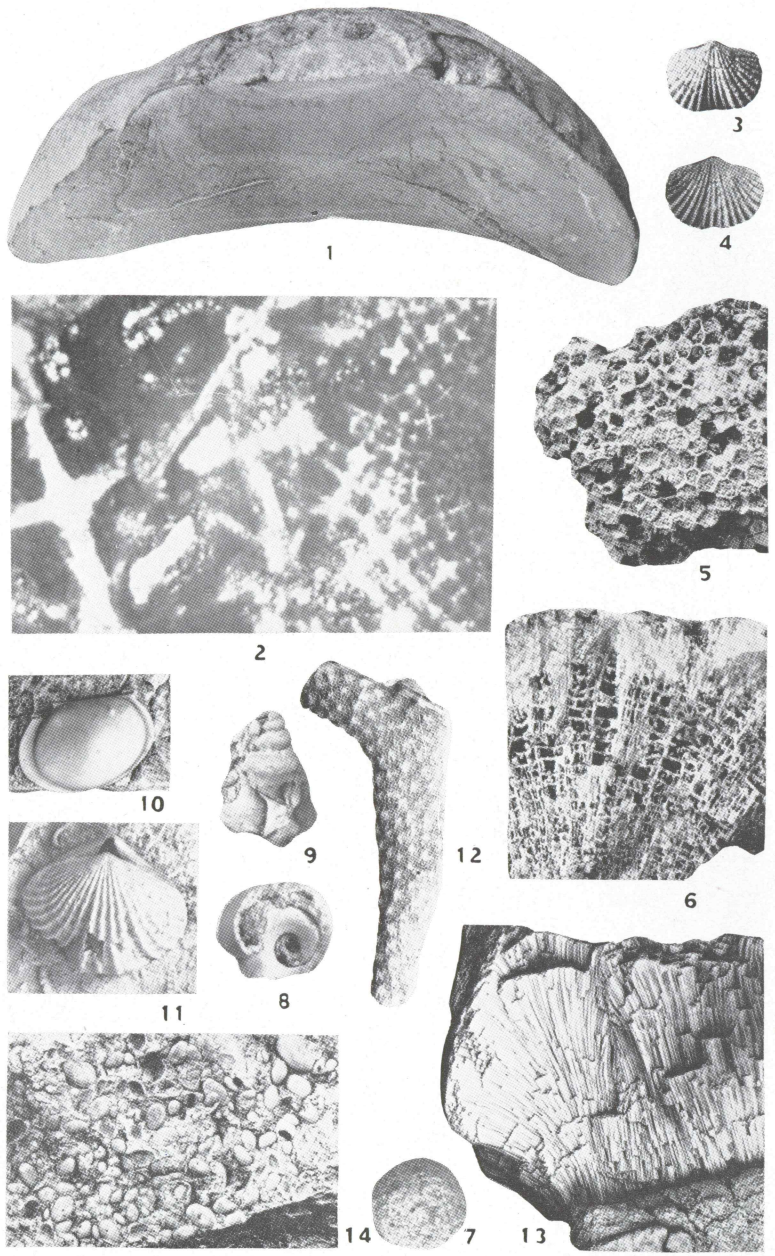
10. *Isochilina jonesi* Wetherby. (2087) Salvisa member of the Perryville, Woodford County, Kentucky.

11. *Orthorhynchula linneyi* (James) (2060). Salvisa member of Perryville, Jonesboro, three miles south of Lexington on Tates Creek Pike. (See XI, 13).

12. *Constellaria teres* Ulrich and Bassler. (2093) Woodburn, Old Crow Distillery section about four miles southeast of Frankfort.

13. *Cyphotrypa frankfortensis* Ulrich and Bassler. (2082) Top of Benson, quarry at Bryan Station about four miles northeast of Lexington.

14. *Leperditia caecigena* var. *frankfortensis* Ulrich. (956) Salvisa member of Perryville, Mercer County, Kentucky.



Fossils of the Lexington Limestone—Ordovician

Explanation of Plate V

(Cynthiana)

Figure

1- 2. *Hebertella occidentalis* Hall (2009) Cynthiana formation, Colby Station, C. and O. R.R. West of Winchester.

3- 4. *Hebertella subjugata* (Hall) (2009) Cynthiana, Nicholas Co., Ky.

5. *Eridotrypa briareus* (Nicholson) (1975) Cynthiana (Greendale), Southern RR. cut at Stone Road crossing three miles south of Lexington.

6. *Cyclonema varicosum* Hall. (1988) Cynthiana (Greendale), L. and E. RR. cut, Lexington.

7. *Rafinesquina alternata* (Emmons) (1999) Cynthiana, near Buckeye, Garrard County, Ky.

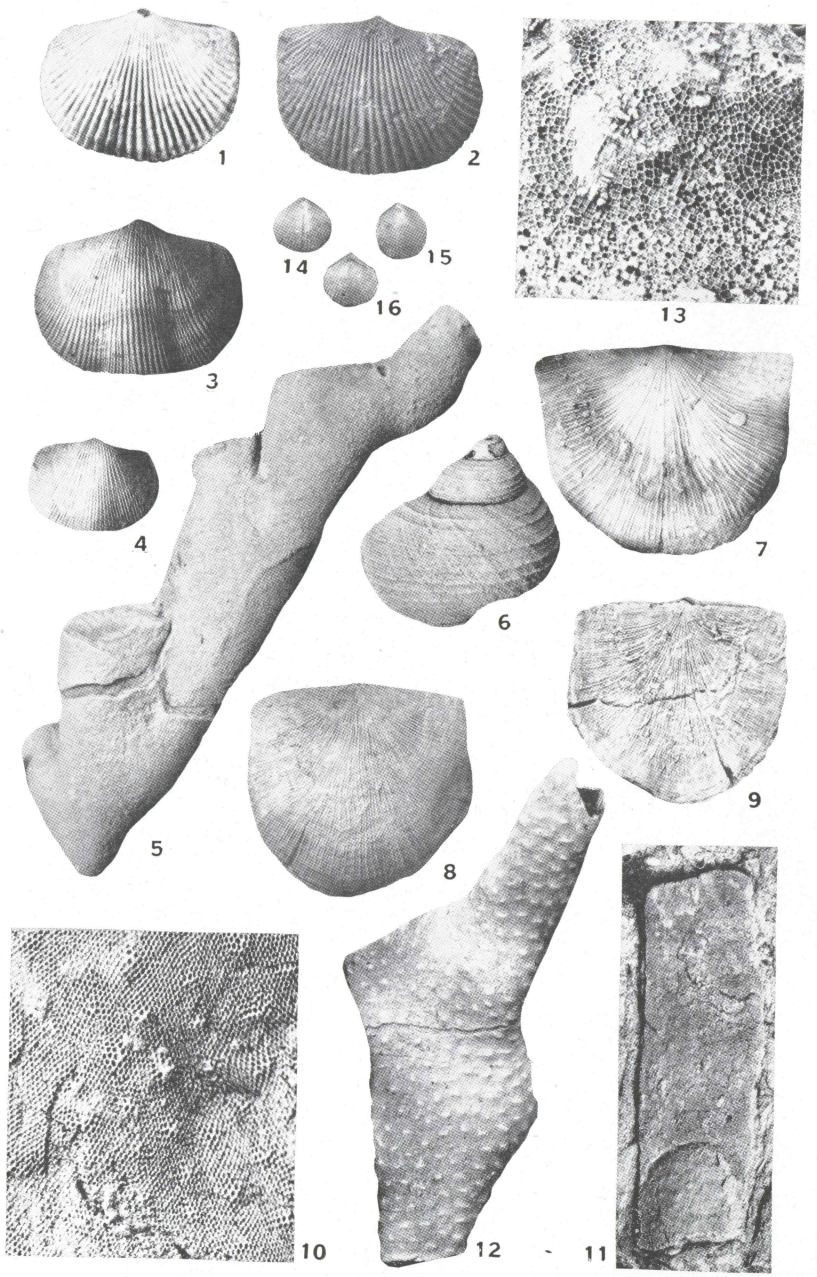
8- 9. *Rafinesquina winchesterensis* Foerste. (2237) Cynthiana, near Camp Nelson, Jessamine County. (See VIII, 14).

10-11. *Escharopora maculata* (Ulrich) (1981) Cynthiana, quarry 6½ miles east of Winchester on Mt. Sterling Road. Fig. 10, x3. (See XI, 18).

12. *Homotrypa norwoodi* (Nickles) (1982) Cynthiana, quarry 6½ miles east of Winchester on Mt. Sterling road.

13. *Tetradium fibratum* Safford (1992) Cynthiana, upper part of quarry, Cynthiana, Harrison County, Ky.

14-16. *Zygospira modesta* Hall (2008) Cynthiana, northern Garrard County, Kentucky.



Fossils of the Cynthiana Limestone—Ordovician

Explanation of Plate VI

(Cynthiana)

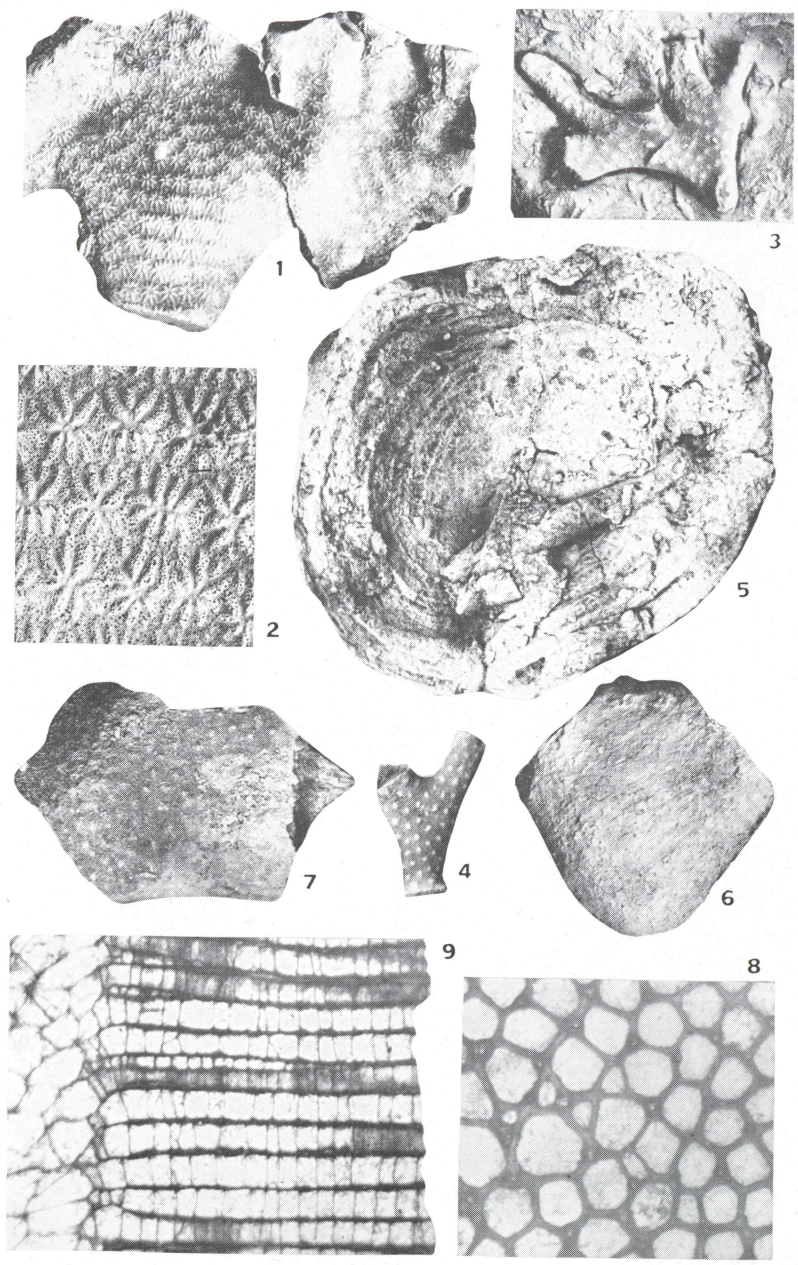
Figure

1- 2. *Constellaria florida* Ulrich (475) Cynthiana. Colby Station C. and O. RR., Clark Co., Ky. Fig. 2, X 3. (See X, 1).

3- 4. *Constellaria fischeri* Ulrich (1994) Cynthiana (Greendale), L. and E. RR. cut, Lexington. These specimens show the small size of the maculae but in the typical forms these are commonly not elevated and the species has a frondescent growth.

5. *Prasopora sp.* (1974) Basal Cynthiana, 1½ miles south of Ambrose (Sulphur Well), Jessamine Co.

6- 9. *Dekayella milleri* sp. nov. (1997) Cynthiana, from small quarry just west of Muir Station, L. and N. RR., Fayette County, Ky. Fig. 6 shows the characteristic base. Fig. 9, X 20, fig. 8, X 30.



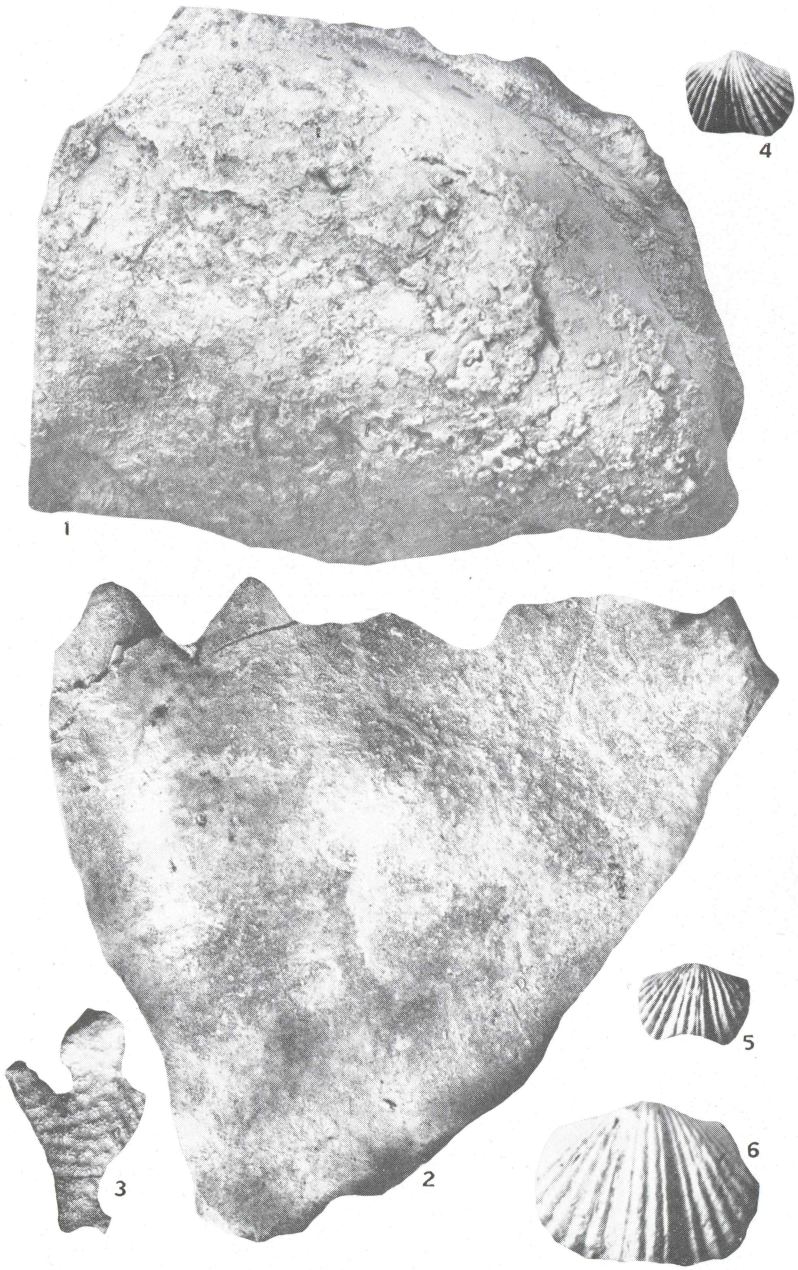
Fossils of the Cynthiana Limestone—Ordovician

Explanation of Plate VII

(Cynthiana)

Figure

1. *Allonychia flanaganensis* Foerste. (1991) Cynthiana (Millersburg). Quarry five miles west of Winchester on Lexington road.
2. *Heterotrypa parvulipora* Ulrich and Bassler. (950) Cynthiana, L. and E. RR. cut near Lexington.
3. *Constellaria emaciata* (Ulrich and Bassler) (2002) Cynthiana, (Greendale) Southern RR. cut at Stone Road, about three miles south of Lexington.
4- 5. *Platystrophia colbiensis* Foerste. (2005) Cynthiana (Greendale). L. and E. RR. cut, Lexington, Kentucky. (See IV, 3, 4).
6. *Platystrophia colbiensis* var. precursor Foerste (2004) Cynthiana (Greendale), Colby Station, C. and O. RR., west of Winchester, Clark County, Ky.



Fossils of the Cynthiana Limestone—Ordovician

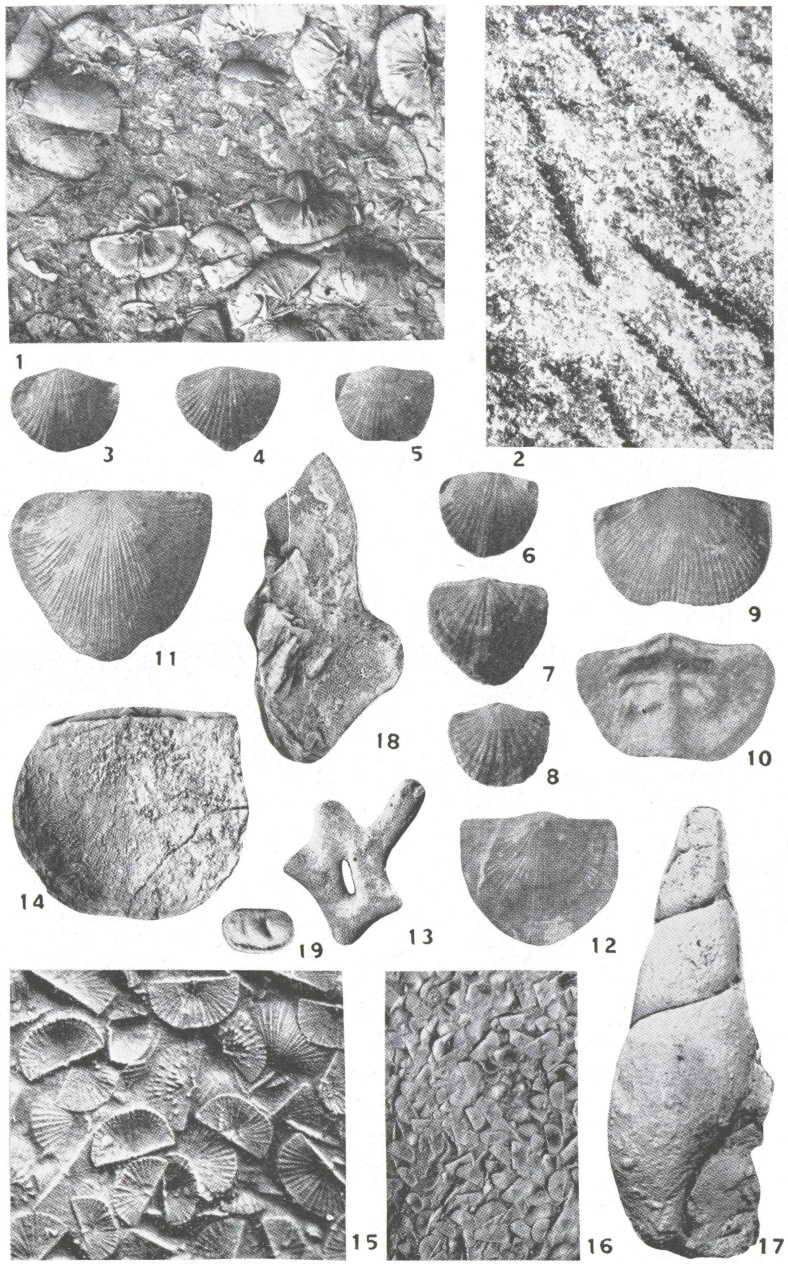
Explanation of Plate VIII

(Rogers Gap and Eden)

Figure

1. *Plectambonites rugosus* (Meek) (2027) Basal Million, one mile west of Hubble, Lincoln County. (See XVI, 3, 4).
2. *Diplograptus sp.* (2030) Eden (Million) shale, two miles east of Brannon Station, Jessamine County. X 3.
3- 5. *Eridorthis nicklesi* Foerste After Foerste, Bul. Sci. Lab., Denni-son Univ. Vol. XIV, Pl. IV, figs. 3a-b. 1909.
6- 8. *Eridorthis rogersensis* Foerste After Foerste, ibid. figs. 4a, b.
9-10. *Clitambonites rogersensis* (Foerste) After Foerste, ibid. Pl. VIII, figs. 14a, b.
11-12. *Strophomena hallie* (Miller) After Foerste, ibid. Vol. XVII, 1912, Pl. II figs. 1a 1d.
13. *Eridotrypa aedilis* (Eichwald) (2034) Rogers Gap?, five miles east of Winchester on Mt. Sterling Road. (See II, 13-15).
14. *Rafinesquina winchesterensis* Foerste (2029) Cynthiana, nine miles east of Winchester on road to Mt. Sterling. (See V, 8, 9).
15-16. *Plectambonites plicatellus* (Ulrich) (Coll. Chas. L. Faber) Fulton bed. Union Bridge, Cincinnati, Ohio. Fig. 15, X 3.
17. *Fusispira sulcata* Ulrich (2028) Rogers Gap, five miles east of Winchester on road to Mt. Sterling.
18. *Hallopora onelli* var. *communis* (James) (2033) Basal Million, five miles east of Winchester on road to Mt. Sterling.
19. *Ctenobolbina ciliata* (Emmons) (2342) McMicken member of the Eden, Cincinnati, Ohio.

NOTE Through central Kentucky the appearance of *Plectambonites rugosus* in large numbers marks the base of the Million.



Fossils of the Rogers Gap and Eden—Ordovician

Explanation of Plate IX
(EDEN)

Figure

1- 2. *Bythopora arctipora* (Nicholson) (2360) Eden, Cincinnati, Ohio. Fig. 2, X 3.

3- 7. *Aspidopora eccentrica* (James) (2361) Southgate member of the Eden, Cincinnati, Ohio. Figs. 6, 7, X 3.

8. *Aspidopora newberryi* (Nicholson) (2362) Eden, Cincinnati, Ohio.

9. *Triarthus becki* Green. Southgate member of the Eden about 150 feet above low water. Rapid Run Creek, Cincinnati, Ohio. Collection Chas. L. Faber.

10-12. *Hallopora onealli* (James) (2363) Eden, Cincinnati, Ohio. Fig. 12, X 3.

13-14. *Hallopora onealli* var. *sigillaroides* (James) (2364) Eden, Cincinnati, Ohio.

15-18. *Dalmanella emacerata* (Hall) (2032) McMicken member of the Eden, Drennen Creek, Henry County, Ky.

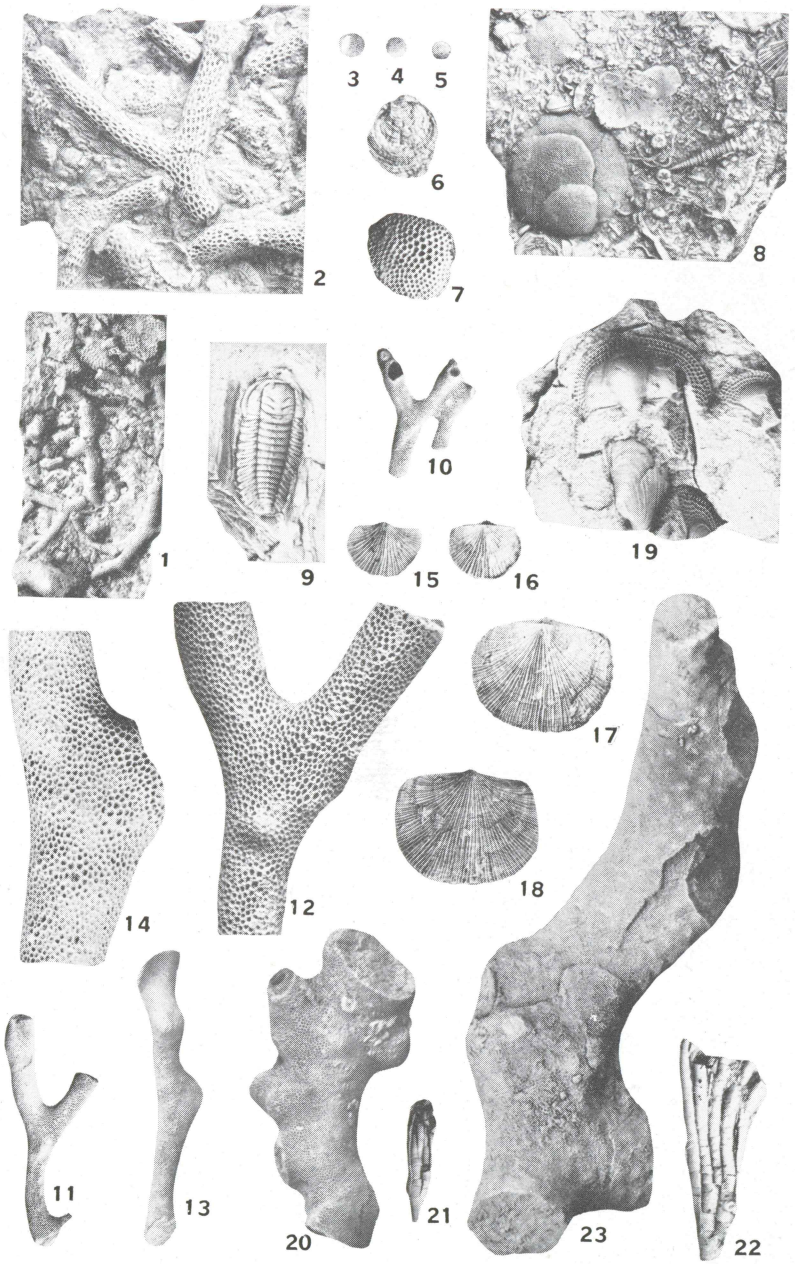
19. *Cryptolithus tessalatus* Green (957e) This specimen is labeled "Upper Trenton," Cincinnati, Ohio.

20. *Batostoma jamesi* (Nicholson) (2230). Eden Cincinnati, Ohio.

21. *Ectenocrinus simplex* (Hall) (332c). Eden, Newport, Ky.

22. *Ectenocrinus grandis* (Meek) (1841). McMicken member of the Eden, Cincinnati, Ohio.

23. *Dekayella ulrichi* (Nicholson) (2031). McMicken member of the Eden, Drennen Creek, Henry County, Ky.



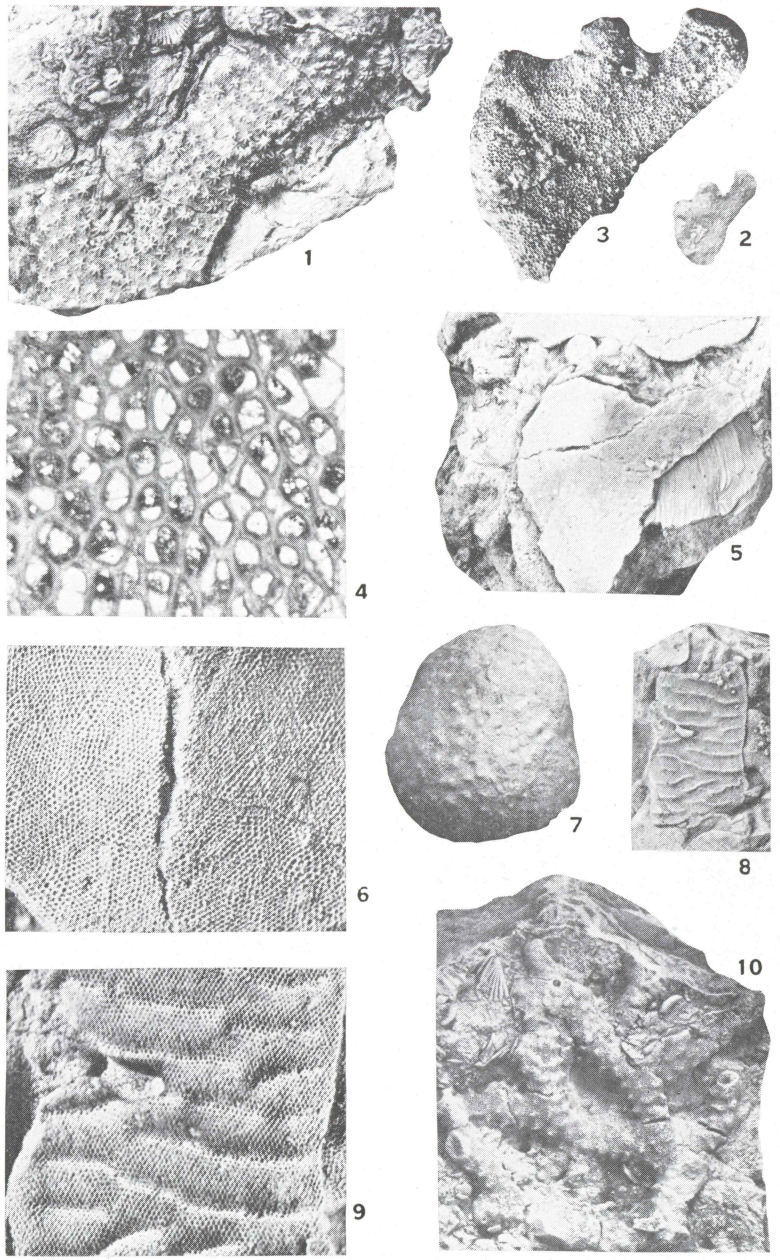
Fossils of the Eden Shale—Ordovician

Explanation of Plate X

(Fairview)

Figure

1. *Constellaria florida* Ulrich (2012) Fairmount, one mile north of Hubble in northern edge of Lincoln County. (See VI, 1, 2).
2- 4. *Homotrypa cincinnatiensis* Bassler (2017) Fairmount, at Dix River bridge on Lancaster-Danville road via Hedgeville. Fig. 3, X 3, fig. 4 tangential section X 30.
5- 6. *Escharopora pavonia* (D'Orbigny) (2369). Cincinnati, Ohio. Fig. 6, X 3.
7. *Monticulipora mamulata* D'Orbigny (2022). Fairmount, quarry one and one half miles north of Lancaster on Lexington road. The specimen is much smaller than normal.
8- 9. *Escharopora hilli* (James) (2025) Fairmount, quarry two miles north of Lancaster on Lexington road.
10. *Hallopora dalei* (M-E and H) (2026) Fairmount one mile north of Hubble in northern edge of Lincoln County.



Fossils of the Fairview—Ordovician

Explanation of Plate XI
(FAIRVIEW)

Figure

1- 2. *Platystrophia laticosta* Meek, after Foerste, Bul. Sci. Lab. Dennison Univ., Vol. XVI, 1910, Pl. III, figs. 1a, b. Fairmount, Cincinnati, Ohio.

3- 4. *Plectorthis plicatella* Hall, after Foerste, Bul. Sci. Lab. Denn. Univ., Vol. XVI, Pl. VI, figs. 5a, b. Fairmount, Cincinnati, Ohio. From Gurley Collection, Univ. of Chicago 8127.

5. *Plectorthis fissicosta* Hall ibid. Pl. VI, fig. 4, Fairmount, Cincinnati, Ohio. Gurley Coll., Univ. of Chicago 8127.

6- 7. *Strophomena planoconvexa* Hall (1884a) Base of Fairmount, Cincinnati, Ohio.

8- 9. *Strophomena maysvillensis* Foerste (2015), lower Fairmount. two and one half miles S-SE of Burdett Knob, Garrard County, Ky.

10. *Strophomena sinuata* James (1890a) Fairmount Cincinnati, Ohio.

11-12. *Plectorthis neglecta* James, after Foerste Bul. Sci. Lab. Dennison Univ., Vol. XVI 1910, Pl. VI, figs. 1d. e. Mt. Hope, Cincinnati, Ohio. James Coll., Univ. of Chicago, 2399.

13. *Orthorhynchula linneyi* (James) Fairmount 9½ miles SE of Lancaster on Cartersville road, Garrard County, Ky. (See IV, 11).

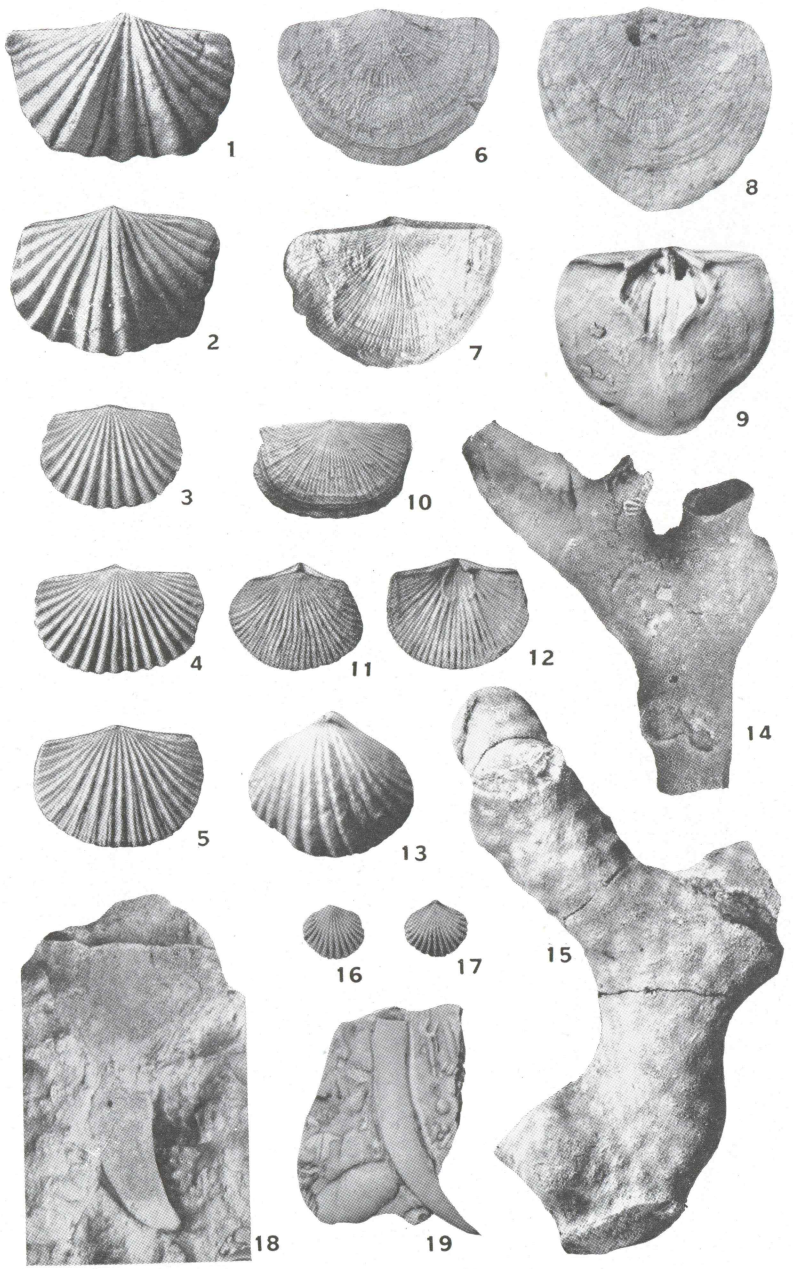
14. *Amplexopora septosa* (Ulrich) (2374) Fairmount, Cincinnati, Ohio.

15. *Dekayia aspera* M-E and H. (2368) Fairmount, Cincinnati, Ohio.

16-17. *Plectorthis sordida* (Hall) (557) Cincinnati, Ohio.

18. *Escharopora maculta* (Ulrich) (2370) Fairmount, Cincinnati, Ohio. (See V, 10, 11).

19. *Escharopora falciformis* (Nicholson) (543a) Fairmount, Cincinnati, Ohio.



Fossils of the Fairview—Ordovician

Explanation of Plate XII

(McMillan)

Figure

1- 2. *Chiloporella flabellata* (Ulrich) (2394). Corryville, Cincinnati, Ohio. Fig. 2, X 3.

3. *Platystrophia ponderosa* Foerste (1943) Oregonia member of the Arnheim formation near Preachersville, Lincoln Co., Ky. (See XIV, 15).

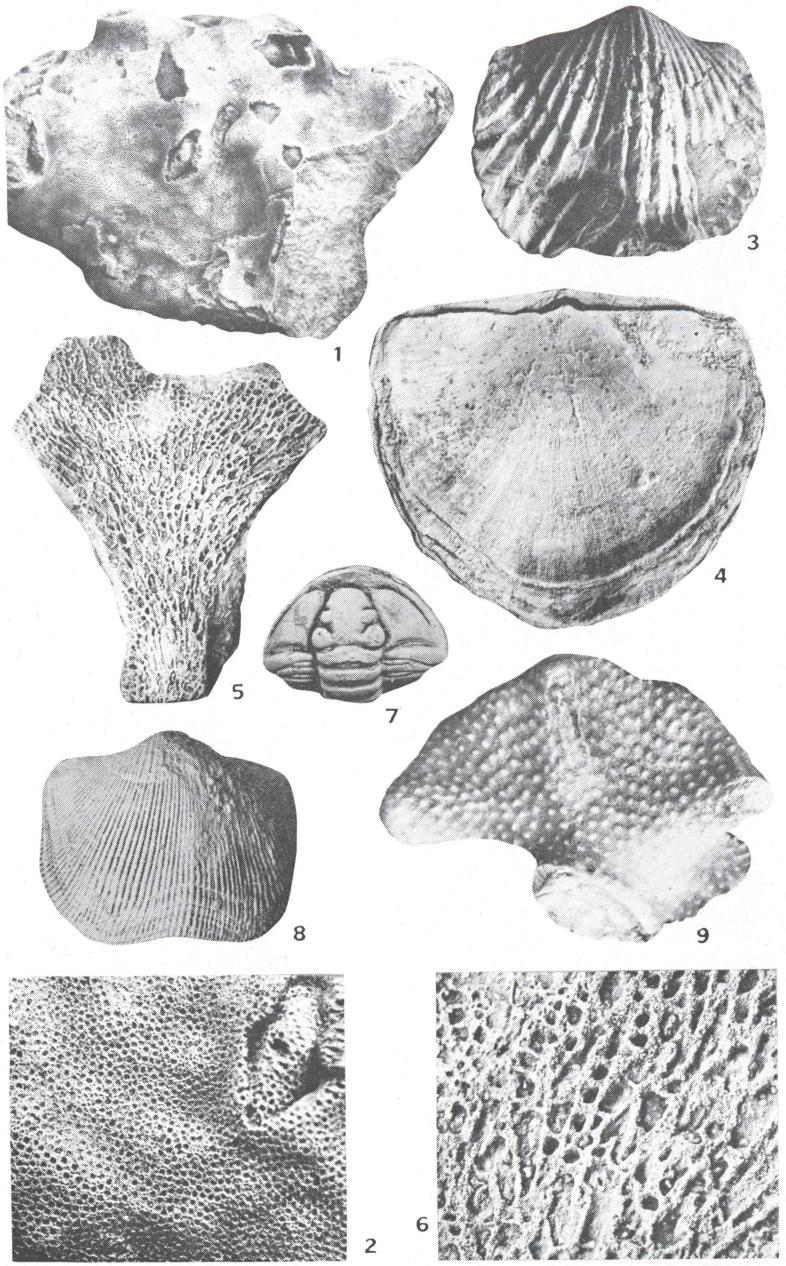
4. *Rafinesquina alternata* var. *ponderosa* Ulrich (1961) Cincinnati, Ohio.

5- 6. *Heterospongia subramosa* Ulrich (1972) Mt. Aburn from near Hubble, northern Lincoln County. Fig. 6, a portion of Fig. 5, X 3.

7. *Calymene meeki* Foerste (955) Maysville, Cincinnati, Ohio.

8. *Hebertella sinuata* Hall (1964). Bellevue, Madison, Indiana.

9. *Monticulipora molesta* Nicholson, (2393) Bellevue, from region east of Cincinnati, Ohio.



Fossils of the McMillan—Ordovician

Explanation of Plate XIII

(McMillan)

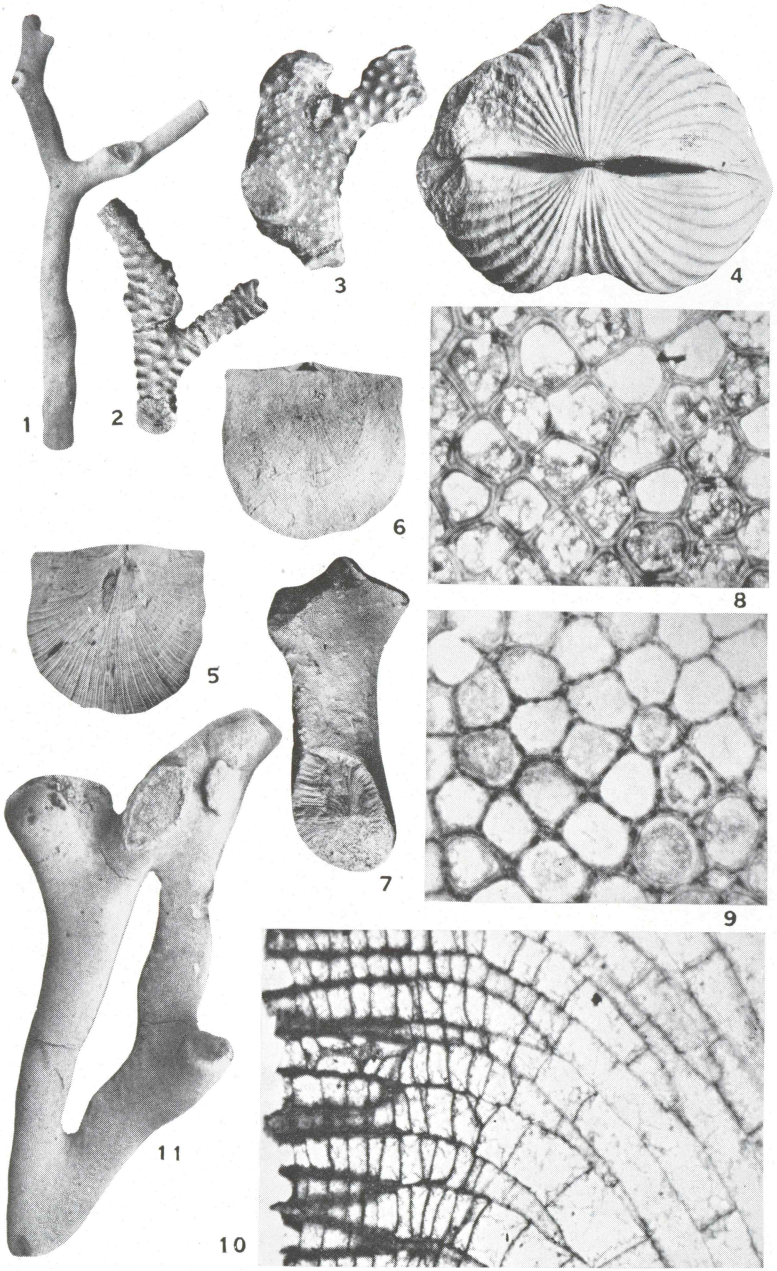
Figure

1. *Bythopora gracilis* (Nicholson) (2373) From vicinity of Cincinnati, Ohio.
2. *Hallopora rugosa* (M-E and H) (1962) Cincinnati, Ohio.
3. *Hallopora ramosa* (D'Orbigny) (1963) Cincinnati, Ohio.
4. *Platystrophia ponderosa* var. *auburnensis* Foerste (1965) Mt. Auburn, Cincinnati, Ohio.

5- 6. *Rafinesquina alternata* var. *fracta* (Meek) Coll. Chas. L. Faber. Bellevue from top of Frenchman's quarry, Cincinnati, Ohio.

7-10. *Amplexopora robusta* Ulrich (1968) Mt. Auburn from between Stanford and Preachersville, Lincoln County. Figs. 8, 9 tangential sections X 30, fig. 10 longitudinal section X 20. Fig. 9 (1967) is a tangential section not quite as deep as in fig. 8 showing the development of numerous small acanthopores. It is from a specimen from the same horizon one half mile N. W. of Gilberts Creek in the northern edge of Lincoln County.

11. *Hallopora andrewsi* (Nicholson) (2366) Cincinnati, Ohio.



Fossils of the McMillan—Ordovician

Explanation of Plate XIV

(Richmond)

Figure

1- 3. *Leptaena richmondensis precursor* Foerste. Figs. 1, 3 (1941) Upper Arnheim, Little Kentucky River, two miles north of Jericho, Henry County. Fig. 2 (1939) Oregonia member of the Arnheim, three miles west of Lebanon, Marion County, Kentucky.

4. *Platystrophia clarksvillensis* Foerste (1946) Oregonia member of Arnheim, RR. cut three miles west of Lebanon, Marion County, Kentucky.

5- 7. *Platystrophia clarksvillensis* Foerste (1945) Oregonia member of Arnheim formation one mile southwest of Stanford, Lincoln County, Ky.

8 *Heterospongia knotti* Ulrich (1937) Arnheim, Burdett Knob, Garrard County, Ky.

9-10. *Rhynchotrema dentatum* var. *arnheimense* Foerste Fig. 9 (1949) Arnheim formation, Little Kentucky River, two miles north of Jericho, Henry County, Ky. Fig. 10 (1948) Oregonia member of Arnheim formation, six miles southeast of Lancaster, Ky.

11-12. *Zygospira kentuckiensis* James (2037) Waynesville, Eastwood, Jefferson County Ky.

13. *Heterospongia subramosa* Ulrich (1940) Oregonia member of the Arnheim, near Hubble, northern Lincoln Co., Ky. (See XII, 5,6).

14. *Cyphotrypa clarksvillensis* Ulrich (1953) Upper Arnheim, exposures along Rolling Fork, one mile N. E. of Bradfordville, Marion County, Ky. (See XV, 6).

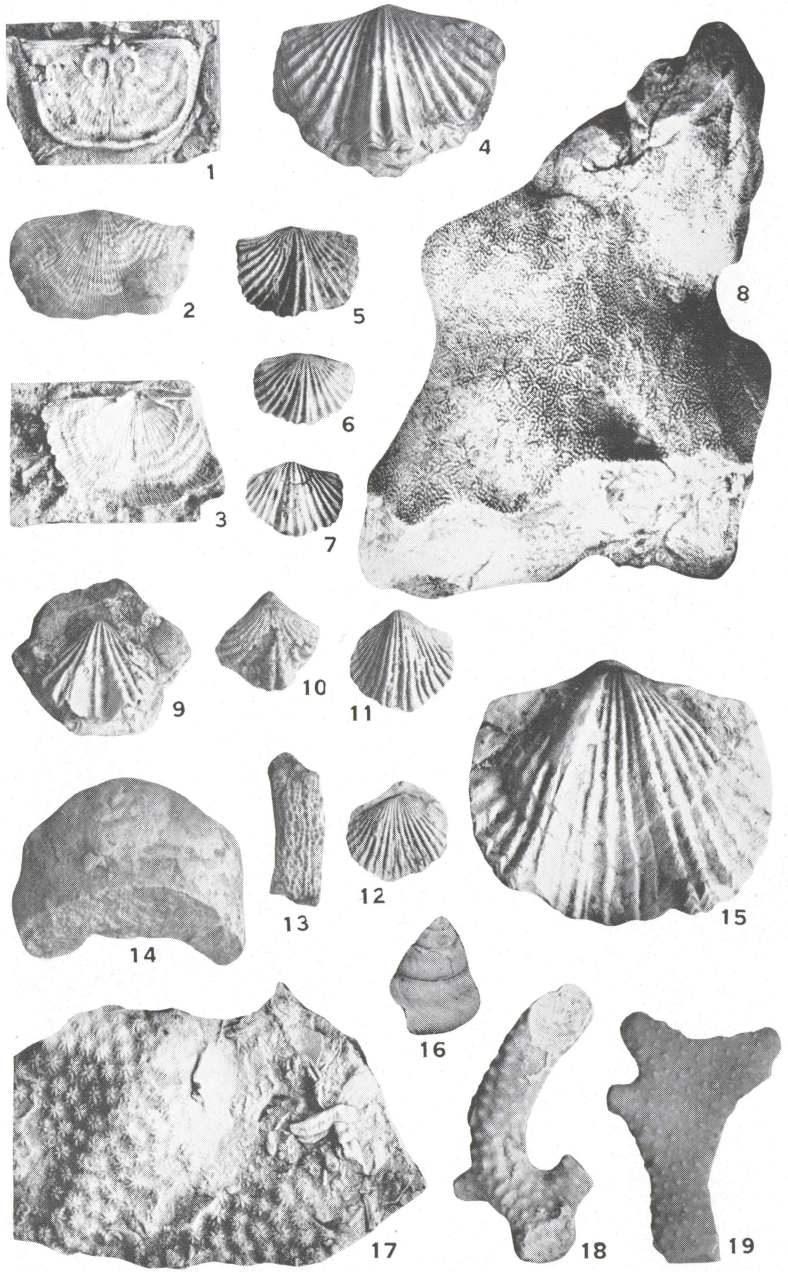
15. *Platystrophia ponderosa* Foerste (1943) Oregonia member of the Arnheim, near Preachersville. Lincoln County, Ky. (See XII, 3).

16. *Cyclonema bilix fluctuatum* (James) (1855) Waynesville, Weisberg, Indiana.

17. *Constellaria polytomella* Nicholson (1950) Upper Arnheim (C. polystomella zone), one mile north of Boston, Jefferson Co., Ky.

18. *Homotrypa wortheni* (James) (1955) Oregonia member of the Arnheim formation, three miles west of St. Mary along Prather Creek, Marion Co., Ky.

19. *Homotrypa bassleri* Nickles (1954) Upper Arnheim (C. polystomella zone), one mile north of Boston, Jefferson Co., Ky.



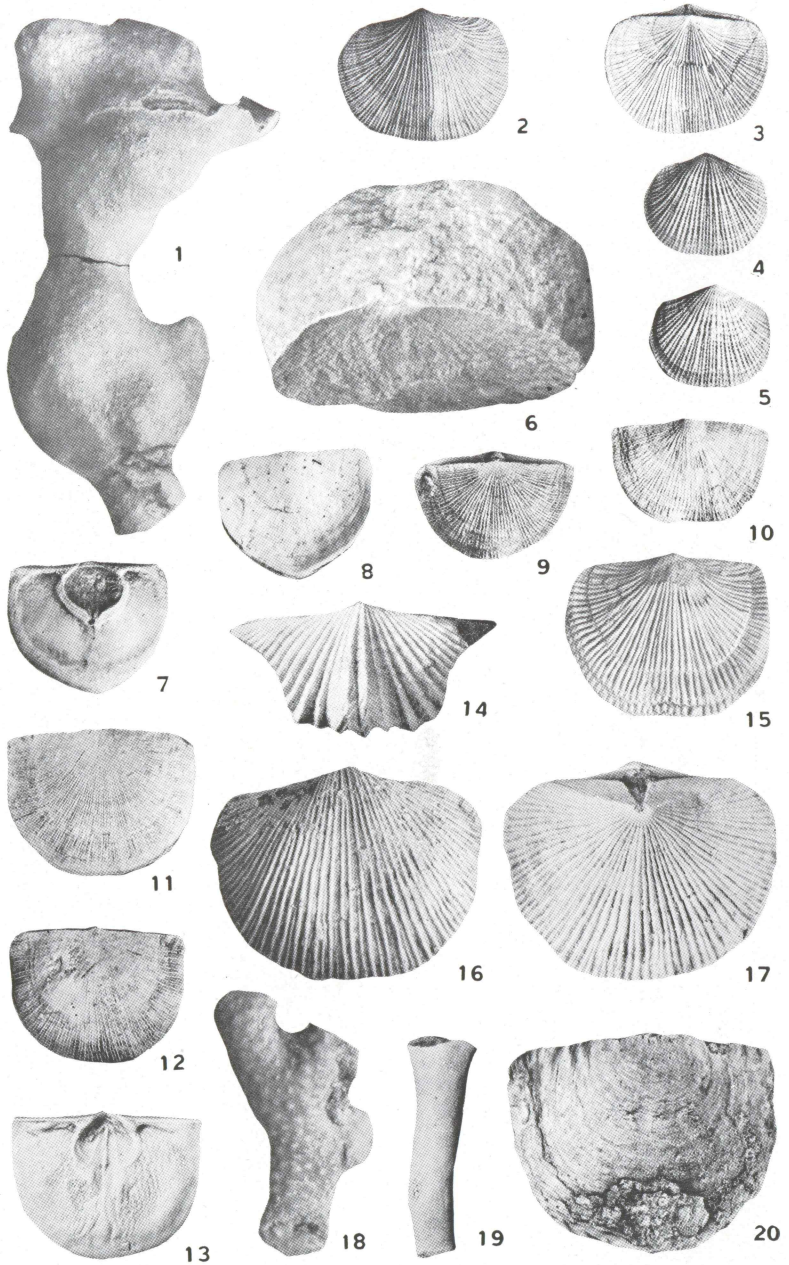
Fossils of the Richmond—Ordovician

Explanation of Plate XV

(Richmond)

Figure

1. *Stigmatella dychei* (James) (2367) from vicinity of Cincinnati, Ohio.
2- 3. *Dalmanella meeki* (Miller) (2391) Waynesville, near Oxford, Ohio.
4- 5. *Hebertella insculpta* (Hall) (535) Butler County, Ohio.
6. *Cyphotrypa clarksvillensis* Ulrich (2035) Waynesville, Eastwood, Jefferson County, Ky. (See XIV, 14).
7- 8. *Strophomena nutans* (Meek) (2392) Waynesville formation, Jacksonburg, Ohio.
9-10. *Strophomena sulcata* (Verneuil) (2390) Whitewater formation, southern Ohio.
11-13. *Strophomena planumbona* (Hall) Figs. 11, 12 (567) Butler County, Ohio. Fig. 13 (2045) Liberty, Eastwood, Jefferson County, Ky.
14. *Platystrophia cypha* James, after Foerste, Bul. Sci. Lab. Dennison Univ. Vol. XVI. 1910, Pl. IV, fig. 10a. Specimen from Warren County, Ohio. James Coll., Univ. of Chicago 2326 (one of the types).
15. *Dinorthis subquadrata* (Hall) (2047) Liberty, Eastwood, Jefferson County Ky.
16-17. *Dinorthis carleyi* (Hall) (512) Madison, Indiana.
18. *Hallopora subnodosa* (Ulrich) (2372) Whitewater, southern Ohio.
19. *Bythopora meeki* (James) (2371) Waynesville, Oxford, Ohio.
20. *Strophomena vetusta* (James) (2375) Whitewater, Oxford, Ohio.



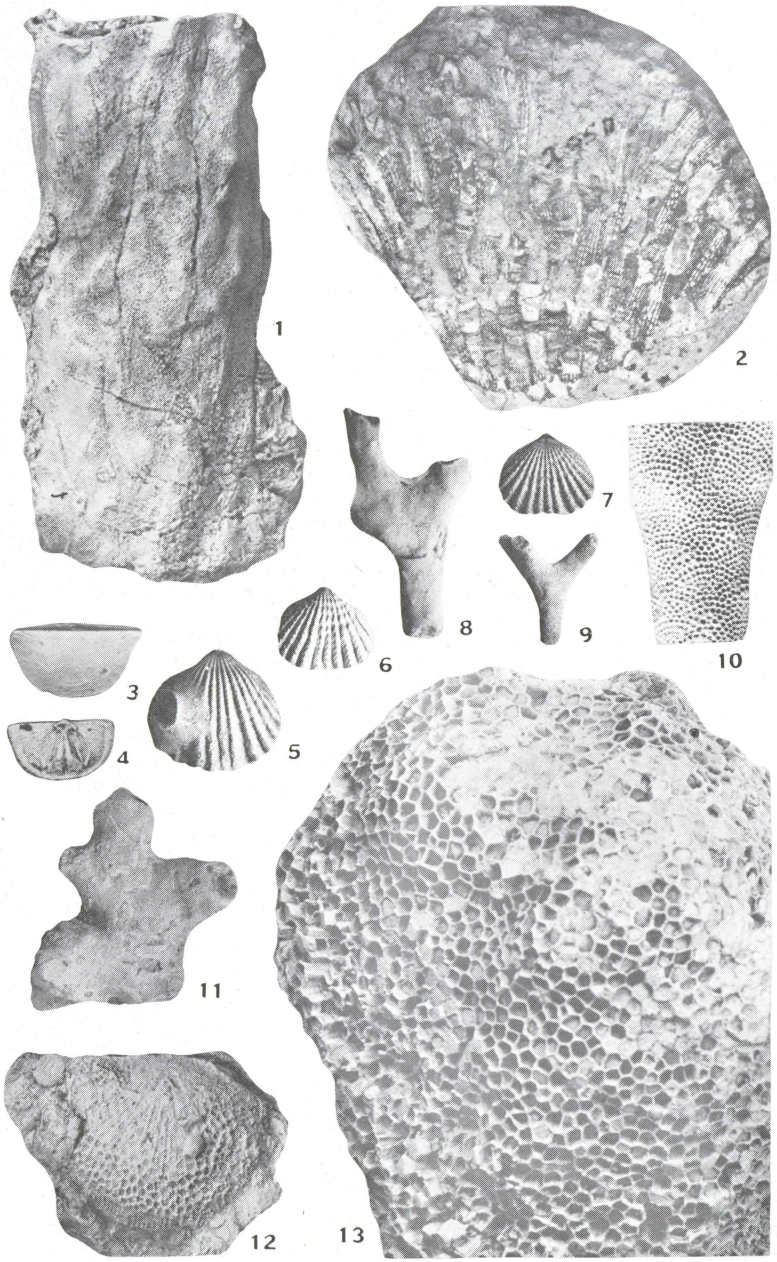
Fossils of the Richmond—Ordovician

Explanation of Plate XVI

(Richmond)

Figure

1. *Beatricia nodulifera* var. *intermedia* Foerste (2051) A variety intermediate between the typical B. undulata and B. nodulifera. Liberty, Eastwood, Jefferson County, Ky.
2. *Calapoecia cribriformis* (Nicholson) (2050) Liberty, Eastwood, Jefferson County.
3- 4. *Plectambonites rugosus* (Meek) (2395) Liberty, Four Mile Creek, Creek near Oxford, Ohio. (See VIII, 1).
5- 7. *Rhynchotrema capax* (Conrad) (2041) Liberty, Eastwood, Jefferson County.
8. *Homotrypa austini* Bassler (2040) Liberty, Eastwood Jefferson County.
9-10. *Rhombotrypa subquadrata* (Ulrich) (2039) Waynesville, Oxford, Ohio.
11. *Rhombotrypa quadrata* (Rominger) (2046) Liberty, Eastwood, Jefferson County, Ky.
12. *Protarea richmondensis* Foerste (2044) Liberty, Eastwood, Jefferson County, Ky.
13. *Columnaria alveolata* (2094) X 0.6 Basal Liberty, Eastwood, Jefferson County, Ky. (See IV, 6).



Fossils of the Richmond—Ordovician

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III

SILURIAN FAUNA

By

August F. Foerste

THE SILURIAN FAUNA OF KENTUCKY

By

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THE SOURCE AND AFFINITIES OF THE SILURIAN FAUNAS

In prehistoric times the North American continent was invaded by oceanic faunas from various directions. The tilting of the continent toward the south permitted the invasion of oceanic faunas from the Gulf of Mexico, and tilting toward the east permitted invasions from the North Atlantic. There have been invasions also from the Arctic and Pacific.

Some of these invasions extended far inland. Some from the Gulf of Mexico spread northward along the Mississippi embayment as far as the southern part of Canada, and some from the North Atlantic reached Ohio and Kentucky. As far as known, none of the invasions from the Arctic or Pacific reached Kentucky.

In most Silurian faunas, the brachiopod element predominates. Three of the southern invasions—the Brassfield, Osgood, and Waldron—are characterized by the abundance of bryozoans, in addition to the brachipods. The Brassfield and Waldron contain also a considerable number of gasteropods, pelecypods, cephalopods, and trilobites, all of which are relatively scarce in the Osgood and Louisville. In the Osgood, on the contrary, there are numerous cystids, though almost all of these were described originally under the single generic name *Holocystites*. The Waldron is characterized by the considerable variety of crinoids.

In the Laurel and Louisville bryozoans are rare. The Laurel is now characterized by numerous species of crinoids, a considerable number of which show affinities with crinoids occurring in Gotland and England. Possibly these invaded the American continent from some North Atlantic source. The Louisville fauna is characterized by the great number of species of its corals, the corals and brachiopods far exceeding in num-

ber all other elements. The Louisville fauna shows distinct relationship to the Brownsport fauna of western Tennessee, and probably represents a southern invasion, though not from precisely the same source as the Brassfield, Osgood, and Waldron faunas. The Louisville coral fauna is closely related also to that of the Lockport in the northern part of Lake Huron, on Drummond and Manitoulin Islands.

The Brassfield fauna belongs to the upper part of the Medinan, and its areal distribution extends from Alabama, Georgia, and western Tennessee northward to southern Ontario and western New York. The Centerville fauna belongs to a distinctly older part of the Medinan, and is correlated provisionally with the Edgewood fauna of southwestern Illinois and Missouri. Both the Brassfield and Edgewood faunas are of southern origin.

In the Dayton fauna, the corals and brachiopods predominate. Although about equal in the number of species included, the corals predominate greatly in the number of specimens preserved. The Dayton limestone is correlated provisionally with the Walcott, at the top of the Lower Clinton. According to Ulrich and Bassler (Silurian, Maryland Geol. Survey, 1923, p. 333), the Walcott fauna contains no ostracods nor *Anoplothecas*, and is made up chiefly of types of bryozoans and brachiopods that, elsewhere in America, occur only in faunas that invaded the continent from the south.

The Euphemia, Springfield, and Cedarville may be regarded as successive incursions of essentially the same fauna, of which only the Cedarville element includes an abundance of species; among these are cystids and other species characteristic of the Racine of Wisconsin and Illinois. As in the case of the Laurel fauna, a considerable number of Cedarville and Racine crinoids are related to Silurian forms in Gotland and England, apparently having invaded the American continent from some North Atlantic source.

Among Silurian faunas confined to the eastern side of the Cincinnati anticline, the Oldham is referred to the middle part of the Lower Clinton, on account of the presence of *Zygobolba rectangula*. This suggests an age older than that of the Dayton limestone.

The Waco fauna is similar to the Dayton in the predominance of corals, the latter exceeding the brachiopods greatly both in the number of species and in that of the individual specimens present. The occurrence of *Calostylis* in both faunas suggest that both were derived from the same general source, and provisionally both are regarded as of southern origin.

The Ribolt and Bisher are the only Silurian faunas in Kentucky which are known definitely to be of Atlantic origin. By means of their included ostracods, the Ribolt is correlated with the middle of the upper Clinton in Pennsylvania and Maryland, while the Bisher is correlated with the upper part of the upper Clinton of those states. This upper part of the upper Clinton is correlated in turn with the Rochester of New York and the Osgood of Indiana.

The Lilley fauna is correlated provisionally with the coral zone of the Louisville. The Peebles fauna is related closely to the Guelph of southern Ontario and southeastern Wisconsin. It is regarded as of later age than the Cedarville, and probably invaded from some North Atlantic source. The Greenfield fauna also is of northern distribution, and may have been derived from one of the later middle Silurian faunas already present in the epicontinental seas of North America.

Distribution of Silurian Fauna.

Some of the Silurian geologic formations can be traced only for relatively short distances. Even in those which can be traced by lithological characteristics for much longer distances, their included faunas often are very local in distribution, except in the case of a few species which have a very wide geographic range, but which occur at so many horizons that in the present state of our knowledge they have but little value in discriminating faunas.

This is true especially in Kentucky. For instance, in Indiana the Osgood, Laurel, and Waldron faunas are abundantly developed within more or less overlapping restricted areas. In Kentucky, however, the corresponding horizons contain few of the diagnostic fossils. The Louisville fauna is rich only in the vicinity of Louisville; farther south the corresponding fauna is relatively poor. In a similar manner, the Brassfield

fauna becomes impoverished the farther south it is traced in Kentucky. Southwestward, however, at Newsom, Tennessee, the Waldron fauna is richly developed, and still farther southwestward, south of Duck River, in the area bordering on the Tennessee, the Louisville fauna is richly represented by the Brownsport.

Among the faunas typically developed in Ohio, the Centerville, Euphemia, Springfield, Cedarville, and Lilley fail to reach northern Kentucky. The Dayton, Ribolt, Bisher, Peebles and Greenfield faunas reach Lewis County, Kentucky. The Bisher is known also in the northern half of the eastern part of Fleming County. The Ribolt has been identified with certainty only in Lewis County, but it may extend farther southward.

On the other hand, the Oldham and Waco faunas are developed typically in east-central Kentucky and are not known in Fleming or Lewis counties, nor in any part of Ohio. There is a possibility that the Estill clay is represented in Lewis County, Kentucky, and in Adams and Highland counties, Ohio, by those unfossiliferous clays which intervene between the Dayton limestone at their base and the Ribolt fossiliferous clays at their top. Without the assistance of fossils this can not be determined with confidence.

Owing to the local distribution of most of the Silurian faunas it is impossible to get a clear conception of their significance without taking into consideration not only those species which are found in Kentucky, but also those which occur in adjoining states, especially in case of those faunas which have their major development outside of this State.

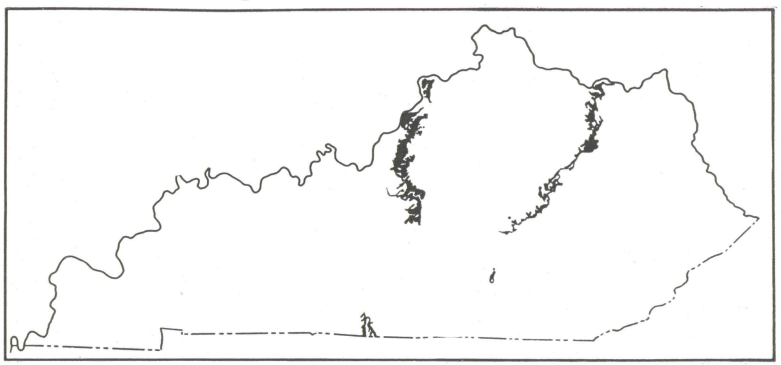


Fig. 26. Map of Kentucky showing outcrop of Silurian rocks.

Distribution of Silurian Formations Along The Cincinnati Anticline.

In Kentucky, the geologic formations of the entire State are elevated into a broad arch or anticline, the crest of which extends in a north and south direction through the central part of the State. This anticline is known among geologist as the Cincinnati anticline. Northward it extends into Ohio, and southward it connects with a similar elevation extending through Tennessee. In west-central Kentucky, this structure is shown best in Nelson and Marion counties. In east-central Kentucky it has been described in detail in the report on *The Silurian, Devonian and Irvine Formations of East-Central Kentucky*, published by the Geological Survey of Kentucky in 1906. Apparently this anticline was already well developed in Silurian times.

Table of Silurian Strata of Kentucky, Indiana, and Ohio.

GEOLOGIC SERIES	SOUTHERN INDIANA WESTERN KENTUCKY	WESTERN OHIO	SOUTHERN OHIO EASTERN KENTUCKY
CAYUGAN	----------	----------	Greenfield
LOCKPORT	----------	----------	Peebles
	----------	Cedarville	----------
	----------	Springfield	----------
	----------	Euphemia	----------
	Louisville	----------	Lilley
	Waldron	Waldron	----------
	Laurel	Laurel?	----------
CLINTON	Osgood	Osgood?	
	----------	----------	Bisher
	----------	----------	Ribolt
	----------	----------	Estill
	----------	----------	Waco
	Basal Osgood	Dayton	Lulbegrud
			Oldham
MEDINAN	----------	----------	(Plum Creek)
	Brassfield	Brassfield	Brassfield
	----------	Centerville	----------

In consequence, the Devonian rests on successively younger Silurian formations in passing from the crest of the anticline either westward or eastward. Moreover, the outcrops of all

the Silurian formations, where directly overlain by the Devonian, thin out toward the anticline. For instance, in Jefferson and Oldham counties, the Louisville limestone thins out eastward, and at Hanover, Indiana, the Devonian rests on the top of the Laurel limestone. This is due to a continuation of the eastward thinning of the Louisville, but at a more northern location. Evidently, the Cincinnati anticline existed already in times preceding the middle Devonian. In fact, the striking differences between the Silurian faunas east and west of the anticline suggests the presence of the latter already in Clinton times, and possibly, to a less prominent degree, in the Medinan.

Possibly, the direction of the crest of the Cincinnati anticline in early times did not coincide precisely with its crest at present. In the western part of Ripley County, and in the adjacent parts of Jennings and Decatur counties, in Indiana, the Brassfield is missing, and the Osgood rests directly on the Richmond. According to Prof. Walter H. Bucher, the local uplift resulting in the formation of Jeptha Knob, in Shelby County, suggests a disturbance taking place after part of Brassfield time and before part of the Osgood. Possibly there is a connection between these dissimilar occurrences. In Nelson County, the Devonian limestone is absent in an area extending from Balltown southward to New Haven and Gethsemene, the Devonian black shale resting here directly on the Silurian, but the area of direct contact between the Devonian and Richmond lies farther eastward, extending from Loretta and Raywick to Stanford. Possibly the crest of the Cincinnati anticline shifted from points as far west as those mentioned in Indiana, eastward to its present location, with increasing age.

At any rate, beginning with Clinton, times, the Cincinnati anticline appears to have dominated the distribution of the Silurian faunas of Kentucky, separating those east of the anticline from those west. There is a possibility that this anticline existed already in Medinan times, and that the Brassfield fauna crossed the anticline in southern Ohio and invaded east-central Kentucky from the north.

BRASSFIELD FAUNA
Plates XVII, XVIII, XIX

The Brassfield limestone is the most widely distributed of those Silurian formations whose faunas invaded from the South. It occurs in Oklahoma, Arkansas, Alabama, Tennessee, Illinois, Indiana, Ohio, southern Ontario, and western New York. The Brassfield is the only Silurian fauna of southern invasion which in Ohio crosses from the western to the eastern side of the Cincinnati anticline, and which therefore is known in east-central Kentucky as well as in the west-central part of that State.

The close agreement between the Brassfield fauna in east-central Kentucky with that in west-central Kentucky is shown in the following list, in which the species found in east-central Kentucky as well as in west-central Kentucky are printed with an asterik (*), while those found so far only in west-central Kentucky are printed without such a mark. It is probable that if the Brassfield area in east-central Kentucky were subjected to the same careful search as that employed in west-central Kentucky, little difference in their faunas would be noted. *Plectatrypa marginalis, Plectatrypa multistriata, Autolichas clintonensis, Bellerophon exiguus, Bellerophon opertus, Bucania fiscellostriata, *Calymene niagarensis, Camarotoechia convexa, *Camarotoechia scobina, *Chasmatopora angulata, *Clathrodictyon vesiculosum, *Clathropora frondosa clintonensis, Crania dubia, *Dalmanella elegantula, Dalmanitina pulchellus, *Diaphorostoma daytonense, Encrinurus thresheri, *Enterolasma facetum, Enterolasma geometricum, Favosites favosus, Favosites niagarensis, *Hallopora magnopora, Heliolites interstinctus, *Heliolites subtubulatus, Homotrypa confluens, Bumastus ambiguus, Illaenus daytonensis, *Leptaena rhomboidalis, Lindstroemia gainesi, Orthis flabellites dinorthis, *Orthis flabellites euorthis, Oxydiscus youngi, Pachydictya bifurcata, Pachydictya crassa, Phaenopora expansa, Phaenopora multifida, *Platystrophia daytonensis, *Platystrophia reversata, *Sowerbyella prolongatus, Peterinea brista, Ptilodictya expansa, *Ptychophyllum ipomoea, *Rhinopora verrucosa, Rhipidomella hybrida, *Schuchertella daytonensis, Stricklandinia triplesiana, *Strophonella daytonensis, *Strophonella hanoverensis, *Triplesia ortoni, *Zaphrentis daytonensis, *Zaphrentis obliquus.*

Four species occurring in the Brassfield of east-central Kentucky, are known also from Ohio, but not from west-central Kentucky; these four are *Aspidopora parmula*, *Calymene vogdesi*, *Hemitrypa ulrichi*, and *Orthis fissiplicata*.

In general, the Brassfield is most fossiliferous farther northward, in Ohio and Indiana, and in the immediately adjacent parts of Kentucky; but farther southward in Kentucky, and in Tennessee, it is much less fossiliferous. This feature it shares with the Osgood and Laurel formations.

The Brassfield fauna is a relatively large one. It consists of 34 species of brachiopods, 27 bryozoans, 22 cephalopods, 17 gasteropods, 14 trilobites, 13 corals, 9 pelecypods, 6 echinoderms (3 crinoids, 2 starfish, and 1 cystid), 2 hydrozoans, 2 graptolites, and 1 ostracod.

An interesting outlier of Brassfield limestone occurs 3 miles southwest of Mitchellsburg, in the western part of Boyle County, Kentucky. The top of this outcrop contains the large crinoid beads characteristic of the top of the Brassfield in eastern Kentucky. It contains also *Stricklandinia triplesiana* and *Whitfieldella subquadrata*. Another outlier is exposed in the northern edge of Wayne County, along the Cumberland River, at the mouths of Forbush and Little Cub Creeks. Here the top of the Brassfield limestone also contains the large crinoid beads and the *Whitfieldella subquadrata*. The clay shale overlying the horizon containing the large crinoid beads is regarded as the basal part of the Crab Orchard clay shale series. Evidently it is that phase of the Brassfield which is characteristic of east-central Kentucky which is present at the outliers here mentioned.

OSGOOD FAUNA
Plate XXIII

The Osgood formation can be traced from Fayette County, in southeastern Indiana, to the western part of Nelson County, in west-central Kentucky. It reappears in Sumner County, in north-central Tennessee and reaches the southern part of that State, at Iron City. It is most fossiliferous in Ripley County and in the adjacent part of Jefferson County, in Indiana, especially in the vicinity of Osgood in the former county, and along Big Creek in the latter.

In Jefferson County, Kentucky, the following species were found: *Atrypa reticularis*, *Calymene niagarensis*, *Camarotoechia whitii*, *Dalmanella elegantula*, *Dawsonoceras americanum*, *Diaphorostoma niagarense*, *Dictyonella reticulata*, *Enterolasma calyculum*, *Eucalyptocrinus cf. caelatus*, *Favosites cristatus*, *Hallopora elegantula*, *Holocystites cf. parvulus*, *Leptaena rhomboidalis*, *Orthis flabellites*, *Orthis interplicata*, *Pachydictya crassa*, *Sowerbyella transversalis*, *Rhipidomella hybrida*, *Rhynchotreta cuneata americana*, *Schuchertella subplana*, *Spirifer crispus*, *Spirifer niagarensis*, *Spirifer radiatus*, *Stephanocrinus gemmiformis*, and *Striatopora flexuosa*. Farther south, the fauna becomes even more impoverished, as may be noticed in the list of species found in the vicinity of Bardstown, after careful search: *Atrypa reticularis*, *Calymene niagarensis*, *Diaphorostoma niagarense*, *Leptaena rhomboidalis*, *Schuchertella subplana*, *Spirifer crispus*, and *Spirifer radiatus*. Many species found farther north have dropped out, and no new ones have made their appearance. In most of Tennessee, fossils are exceedingly rare in the Osgood formation, with the exception of *Pisocrinus gemmiformis* and *Stephanocrinus osgoodensis*. At Clifton, however, the following additional species were found: *Lechritrochoceras cinctutum*, *Diaphorostoma cliftonensis*, *Hebertella tenax*, *Hyolithes cliftonensis* and *Platyceras pronum*.

Considering the restricted area within which the Osgood formation is abundantly fossiliferous, the fauna is fairly large. It consists almost entirely, however, of echinoderms, bryozoans, and brachiopods, as may be seen from the following tabulation of species: 44 cystids, 9 crinoids, 31 bryozoans, 22 brachiopods, 6 corals, 4 gasteropods, 3 trilobites, and 1 cephalopod.

The most striking feature of this Osgood fauna is the large number of species of cystids present, most of which, namely 40 out of 44 species, belong to the single order Diplorita; in fact, 38 species were described originally under the single generic name *Holocystites*. In a similar manner, all of the species of crinoids, except *Pisocrinus gemmiformis*, belong to the single genus *Stephanocrinus*. In other words, the Osgood echinoderm fauna is rich in species but poor in genera.

Another striking feature is the large number of species of bryozoans occurring both in the Osgood formation in Indiana and in the Rochester formation of New York, 29 of the 31 species found in Indiana occurring also in New York. This demonstrates the Rochester age of the Osgood formation. They apparently represent local manifestations of the same widespread southern faunal invasions. According to Ulrich, they form the top of the Clinton division of the Niagaran.

Since the Osgood represents a southern invasion, its fauna shows striking similarity with the Brassfield fauna beneath, and the Waldron fauna above, the latter also being southern invasions.

The nearest approach to the Osgood formation on the east side of the Cincinnati anticline appears to be the Bisher formation, but faunally this Bisher formation is related more closely to the Rochester of New York, Pennsylvania, and Maryland, than to the Osgood of Indiana. In other words, the fauna of the Bisher presents distinctly Atlantic elements. Among the few species occurring also in the Osgood formation of Indiana are *Stephanocrinus gemmiformis*, *Stephanocrinus hammelli*, isolated plates with diplopores apparently belonging to *Holocystites*, and a large species of *Bumastus* resembling *Bumastus ioxus*. In addition, *Whitfieldella cylindrica* of the Bisher formation is represented in the Osgood formation by a smaller form, more similar to the typical forms of this New York species. *Spirifer niagarensis* also appears common to the Bisher and Osgood.

LAUREL FAUNA

Plate XXIII

The Laurel limestone may be traced from Fayette County, Indiana, to the southwestern part of Nelson County, in west-central Kentucky. It outcrops again in Sumner County, in north-central Tennessee, and may be traced southward as far as Wayne County, in the southern part of that state. At its type locality, west of Laurel, Indiana, only the lower part of the Laurel limestone is exposed, but between St. Paul and Dupont, in that state, there is a higher horizon, 5 to 15 feet in thickness, which is much more fossiliferous.

Almost all fossils listed as coming from the Laurel limestone come from this upper zone at St. Paul. From this one locality 61 species of echinoderms have been described, including 56 crinoids, 4 cystids, and 1 blastoid. In addition this upper horizon has furnished 7 species of brachiopods, 5 of cephalopods, 5 corals, 1 gasteropod, 1 pelecypod, and 1 trilobite. In contrast with this upper zone, the remainder of the Laurel limestone has furnished but few fossils. It is not known from what horizons *Trochurus byrnesanus* and *Trochurus hanoverensis* were obtained, but they are assumed to have come from beneath that furnishing the numerous species listed from St. Paul. The basal parts of the Laurel limestone have furnished, so far, only *Pisocrinus gemmiformis*, *Pisocrinus campana*, *Atrypa reticularis*, *Spirifer crispus*, and *Dalamanites limulurus*.

Southward, in Kentucky and Tennessee, fossils in the Laurel limestone are relatively rare. Charles Butts listed *Striatopora gorbyi*, *Atrypa reticularis*, and *Dalmanella elegantula* from the exposures in Jefferson County. In the western part of Nelson County, in the vicinity of Boston, the following species were found in the upper part of the Laurel formation: *Atrypa reticularis*, *Calymene niagarensis*, *Camarotoechia whitii*, *Dalmanites limulurus*, *Dawsonoceras americanum*, *Diaphorostoma niagarense*, *Eucalyptocrinus crassus*, *Schuchertella subplana*, *Spirifer crispus*, *Stephanocrinus gemmiformis*, and *Uncinulus stricklandi*. These fossils indicate merely that the fauna, as known from Kentucky, belongs to the Lockport division of the Niagaran strata.

Much more can be learned from the fauna of the upper part of the Laurel formation as exposed at St. Paul, Waldron, and Hartsville, Indiana, localities within 10 miles from each other. The crinoids, for instance, show a closer relationship to the Beech River division of the Brownsport formation than to the Racine of northern Illinois and southwestern Wisconsin. One third of the genera are represented also in the Silurian of Gotland and of England. Those occurring in both of the European countries include *Callicrinus*, *Carpocrinus*, *Desmidocrinus*, *Gissocrinus*, *Mariacrinus*, *Marsipocrinus*, *Melocrinus*, *Myelodactylus*, *Pisocrinus*, and *Pycnosaccus*. To this should be added

Patelliocrinus and *Petalocrinus*, which in Europe are known only from Gotland. In the Waldron shale the following additional European genera make their appearance: *Botryocrinus*, *Cyathacrinus*, *Dimerocrinus*, *Eucalyptocrinus*, *Ichthyocrinus*, *Lecanocrinus*, and *Lyriocrinus*. The latter continue into the Racine, where the genera *Corymbocrinus*, *Crotalocrinus*, and *Habrocrinus* are added. In the Racine, 20 out of 36 echinoderm genera are known also from the Silurian of Gotland and England. This Racine fauna has an approximately east and west distribution, extending from eastern Iowa, northern Illinois, and southeastern Wisconsin, through northern Indiana and southern Ontario, to western Ohio and northwestern New York. It appears to be a northern fauna, possibly of north Atlantic origin, entering from some area farther east than Hudson Bay.

The upper Laurel fauna, as revealed at St. Paul, Indiana, also appears to be of northern distribution. It contains *Petalocrinus* and *Goniophyllum*, two Gotlandian genera known in this country only from the St. Paul area in Indiana, and from Jones and Dubuque Counties in eastern Iowa. Among the cephalopods found in the upper Laurel of Indiana, *Elrodoceras indianense* and *Gigantoceras elrodi* are represented at Joliet, Illinois, by closely similar, if not identical, forms. Moreover, *Nautilus* (?) *oceanus appears* to be related to the *Gigantoceras* group of cephalopods, though not congeneric with typical *Gigantoceras*. These cephalopods evidently belong to the same invasion as the Joliet, Waukesha, and Racine faunas.

WALDRON FAUNA
Plate XXIII

The Waldron shale may be traced from the southern part of Shelby County, in Indiana, to Clifton, in the southern part of west Tennessee. It is richly fossiliferous in the vicinity of Waldron, Hartsville, Vernon, and Dupont, in Indiana, but south of Dupont the fossils become few or even scarce, not only in Indiana, but also across Kentucky, and in the northern part of Tennessee. It is very fossiliferous again in the vicinity of Newsom, Tennessee, and fairly fossiliferous at Clinton and Iron City, but elsewhere in Tennessee it often is relatively poor in fossils.

From Jefferson County, Kentucky, Charles Butts listed *Atrypa reticularis*, *Calymene breviceps*, *Camarotoechia acinus*, *Camarotoechia neglecta*, *Dalmanella elegantula*, *Dictyonema* sp., *Pachydictya crassa*, *Rhynchotreta cuneata americana*, *Spirifer crispus simplex*, and *Spirifer radiatus*. From 3 miles east of Bardstown, in Nelson County, the following were obtained: *Atrypa reticularis*, *Retzia evax*, *Spirifer eudora*, and *Whitfieldella nitida*.

The Waldron fauna includes 53 species of brachiopods, 49 bryozoans, 39 crinoids, 12 trilobites, 12 pelecypods, 12 gasteropods, 8 cephalopods, 8 corals, 7 sponges, 4 ostracods, 3 worms, 2 so-called fucoids, 1 cystid, and 1 graptolite. The brachiopods, bryozoans, and crinoids together form two-thirds of the entire Waldron fauna. This fauna represents a southern invasion, as did the Brassfield and Osgood faunas.

A clay shale, resembling the Waldron shale, occurs in the gorge west of Cedarville, Ohio, and contains *Atrypa reticularis newsomensis*, *Dalmanella elegantula*, *Dalmanites verrucosus*, *Dictyonella reticulata*, *Eucalyptocrinus crassus*, *Leptaena rhomboidalis*, *Sowerbyella transversalis*, *Schuchertella subplana*, *Spirifer radiatus*, *Streptelasma radicans*, and *Strophostylus* cf. *cyclostomus*. This is a typical Waldron fauna, those species having an extended vertical range being represented by their Waldron forms. West of Cedarville, this Waldron shale is overlaid directly by the Springfield and Cedarville dolomites. Farther westward in Ohio these dolomites rest directly on strata apparently equivalent to the Laurel of Indiana.

JEPTHA KNOB FAUNA
Plate XXIII

In the chert fragments at the top of Jeptha Knob, in Shelby County, Kentucky, the following species were found: *Calymene cedarvillensis*, *Camarotoechia indianensis*, *Cypricardinia jepthaensis*, *Dalmanella elegantula*, *Dalmanella elegantula parva*, *Favosites favosus*, *Hallopora sp.*, *Hormotoma sublaxa*, *Illaenus daytonensis*, *Lophospira bucheri*, *Lyellia thebesensis*, *Pachydictya cf. bifurcata*, *Platystrophia daytonensis*, *Rhipidomella hybrida*, *Schuchertella cf. subplana*, *Strophonella milleri*, *Strophonella cf. hanoverensis*, and *Trochonema sp.*

According to Prof. Walter H. Bucher (Oil Shales of Kentucky, Kentucky Geol. Survey, Series VI, vol. 21, pp. 209, 212, 215; 1925) the thickness of the dolomitic limestone, between the fossil breccia containing Brassfield fossils and the overlying chert containing the fauna listed above, is 90 feet. Unfortunately no trace of the Waldron shale, at least in an identifiable form, was discovered. Hence it is impossible to determine definitely whether the fossils listed belong to the top of the Laurel or at the bottom of the Louisville, especially in the absence of any information as to the fossil content of the lower part of the Louisville limestone. However, the fauna listed does not suggest Laurel age, and 90 feet exceeds any known interval between the Brassfield and the base of the Louisville limestone in any area relatively near to Jeptha Knob. Therefore, the reference of these fossils to the lower part of the Louisville limestone, as done by Prof. Bucher, here is accepted.

LOUISVILLE FAUNA

Plates XXIV-XXVI

The Louisville limestone is typically developed in Jefferson and Oldham counties in west-central Kentucky. It may be traced southward, through Bullitt County, to the southwestern part of Nelson County, and it reappears in Sumner County, in north-central Tennessee. It is well exposed in Clark County, Indiana, and may be traced as far north as Shelby and Rush counties. It is most fossiliferous in Jefferson and Oldham counties in Kentucky and in the immediately adjacent parts of Indiana. Most of the fossils actually collected and described were obtained in the immediate vicinity of Louisville. These are listed by Charles Butts, in his Geology of Jefferson County, published in 1915 by the Kentucky Geological Survey. This list includes 110 species of corals, 60 brachiopods, 8 gasteropods, 8 echinoderms (including 3 crinoids recently published by Frank Springer), 3 bryozoans, 3 hydrozoans, 2 sponges, 2 trilobites, 1 cephalopod, and 1 graptolite.

The corals occur chiefly in the upper 8 feet of the Louisville limestone, as exposed within the limits of Louisville. Thirty of the species of corals found at this horizon occur also in the Lobelville division of the Brownsport formation, as exposed in

west-central Tennessee, and the two horizons are regarded as equivalent by Pate and Bassler (Proc. U. S. Nat. Mus., vol. 34, 1908, p. 424). *Conchidium nysius* and *Pentamerus cylindricus* occur at or immediately below this coral horizon, southeast of Charlestown, Indiana; *Pentamerus oblongus* and *Astraeospongia meniscus* were found 20 feet farther down. Possibly the strata immediately beneath the coral horizon correspond approximately to the *Conchidium* zone which forms the upper part of the Bob member of the Brownsport formation in west-central Tennessee. The few echinoderms known from the Louisville limestone suggest relationship with the Beech River member of the Brownsport formation as exposed in west-central Tennessee. *Anisocrinus greenei*, *Macrostylocrinus meeki*, and *Troostocrinus reinwardt* actually occur there. *Caryocrinites kentuckiensis*, *Dimerocrinus halli* and *Gissocrinus lyoni* are represented in west-central Tennessee only by congeneric species, and these are known only from the Beech River division of the Brownsport. *Melocrinus oblongus* occurs also in the Bob division of the Brownsport. *Saccocrinus cuspidatus* has relatives in the Laurel limestone of Indiana, but not, as far as known, in the Brownsport. These echinoderms suggest that the Louisville limestone is equivalent approximately to the Brownsport formation of Tennessee as a whole, rather than to its Lobelville division alone. However, in the absence of any definite knowledge of the character of the fauna in the lower and middle parts of the Louisville limestone, no definite correlation of these lower zones is possible.

In case the fauna of the Lilley formation, at Hillsboro, Ohio, should prove to be of upper Louisville age, the Cedarville fauna would definitely be established as of later age than the Louisville, but the relationship of this Lilley fauna still remains to be proved.

The lowest known formation of Niagaran age in northern Indiana is the Mississinewa shale. This contains an abundant graptolite fauna many species of which occur also in the lower Lockport of Hamilton, in Ontario. The cephalopods of the Liston Creek and Huntington formations suggest relationship with Racine and Cedarville faunas rather than with the Louisville. Apparently the Niagaran faunas of northern Indiana

were derived from the same northern Atlantic source as the Lockport and Racine, while the Louisville and Brownsport formations are regarded as invasions from the south. Being invasions from different directions they are not likely to be contemporaneous and, unless found somewhere in contact, their relative age can only be surmised. The surmise here adopted is that the Louisville is older than the Cedarville, the latter being the Ohio phase of the Racine.

CENTERVILLE FAUNA
Plate XIX

Until recently, the Brassfield limestone was regarded as the oldest Silurian formation in the area traversed by the Cincinnati anticline. The term Belfast, proposed for an arenaceous limestone in Highland and Adams counties in Ohio, was dropped when it was learned that it could be traced laterally into limestone strata containing a typical Brassfield fauna. The Belfast is merely a local phase of the base of the Brassfield.

In Indiana, and Ohio the base of the Brassfield is underlaid by a clay shale, all of which, until recently, was referred to the Elkhorn member of the Richmond. Several years ago, however, a Silurian fauna was discovered locally in the uppermost part of this clay. At the quarry east of Centerville, for instance, the following fauna was found, in which the species printed with an asterick (*) indicate distinctly Silurian relationship: *Bellerophon centervillensis*, **Brachyprion sp.*, *Ctenodonta cf. simulatrix*, **Dalmanites* apparently of the **D. limulurus* type, *Hormotoma centervillensis*, *Hormontoma trilineata*, *Liospira (?) depressum*, *Lophospira centervillensis*, *Lophospira ehlersi*, *Loxoceras husseyi*, **Schuchertella subplana brevior*, *Spyroceras microtextile*, and * *Whitfieldella cf. ovoides*. At a similar horizon southwest of West Union, Ohio, Prof. W. H. Shideler found a small form of **Whitfieldella*, a **Rhynchotreta* resembling **R. thebesensis*, and a *Hormotoma* resembling *H. trilineata*. Such an association of fossils having a Silurian aspect with others having an Ordovician aspect is known also in the Edgewood formation of southwestern Illinois and in the adjacent part of Missouri. Hence the Ohio faunules here mentioned are correlated provisionally with the Edgewood, although no species known to be diagnostic of the Edgewood have been found. However, the presence of *Platymerella manniensis* at the base of the Brassfield, at Lawshe, in Adams County, appears to confirm such a correlation. Provisionally the term Centerville formation is proposed for the supposed Ohio equivalent of the Edgewood.

The presence of a possible Edgewood horizon at West Union, Ohio is of interest in the present connection since this locality is only 6 miles from the northern margin of Kentucky. It is needless to remark that the Richmond age of the typical Elkhorn clay shale is not affected by these discoveries.

DAYTON FAUNA
Plate XIX

The Dayton limestone is exposed typically at Dayton, Ohio. Southward it ranges as far as Ribolt, in Lewis County, Kentucky, and westward it almost reaches Richmond, Indiana. It has been correlated provisionally with the relatively thin limestone at the base of the Osgood formation in southern Indiana, but the latter is practically unfossiliferous, so that exact correlation is impossible.

At Ribolt, the Dayton limestone contains *Calostylis cf. spongiosa*, *Clathrodictyon vesiculosum*, *Ptychophyllum ribolteense*, and *Zaphrentis cf. intertexta*. In Adams, Highland, and Clinton counties, in southern Ohio, the following additional species are found: *Alveolites sp.*, *Camarotoechia neglecta*, *Coenites sp.*, *Cyathophyllum sp.*, *Discosorus cf. conoideus*, *Drymopora sp.*, *Euomphalopterus sp.*, *Favosites cf. niagarensis*, *Gypidula sp.*, *Halysites catenularia*, *Heliolites sp.*, *Homoeospira sp.*, *Illaenus cf. daytonensis*, *Lyellia sp.*, *Orthis flabellites*, *Pentamerus cf. oblongus*, *Platystrophia reversata*, *Rhinopora verrucosa*, *Rhipidomella hybrida*, *Spirifer niagarensis*, *Strombodes mammilaris wilmingtonensis*, *Syringolites sp.*, and *Whitfieldella cf. nitida*. In the vicinity of Dayton, Ohio, the following species are added: *Chasmatopora angulata*, *Clidochirus ulrichi*, *Coelospira sp.*, *Enterolasma calyculum*, *Favosites favosus*, *Leptaena rhomboidalis*, several species of *Orthoceras*, and *Platystrophia daytonensis*. In the vicinity of Eaton, Ohio, the following species are added: *Atrypa reticularis*, *Sowerbyella transversalis*, and *Spirifer radiatus*. The total Dayton lime-

stone fauna therefore includes 15 species of corals and 15 of brachiopods, with 1 or 2 species of hydrozoans, bryozoans, crinoids, gasteropods, and trilobites, and also several cephalopods.

The chief interest in the Dayton limestone consists, however, in the presence of a species of *Pentamerus* which resembles the form found at the mill on Second Creek, near Sodus Bay, north of Alton, New York. The Dayton limestone evidently is of Lower Clinton age, and provisionally is correlated with the Walcott limestone, at the top of the Lower Clinton.

OLDHAM FAUNA
Plate XIX

In east-central Kentucky, the typical Brassfield limestone it overlaid in ascending order by the Plum Creek clay, Oldham limestone, Lulbegrud clay, Waco limestone, and Estill clay. The typical Plum creek clay is not fossiliferous, but it's sparsely fossiliferous northern extension appears to be more nearly related to the preceding Brassfield than to the following limestone.

The typical exposures of the Oldham limestone lie along the railroad between Panola and Brassfield in the southern margin of Madison County. In the eastern parts of Madison and Clark counties, the top of this limestone is characterized by relatively numerous specimens of *Stricklandinia norwoodi*. Three miles southwest of Clay City, in the western part of Powell County, this *Stricklandinia* is associated with *Dalmanella elegantula*, *Enterolasma calyculum*, *Halysites catenularia*, *Leptaena rhomboidalis*, *Platystrophia daytonensis*, and *Strophonella cf. patenta*. A quarter of a mile south of Indian Fields, near the southwestern margin of Clark County, *Heliolites subtubulata* and a *Zaphrentis* similar to one in the Dayton limestone are added to this list.

A much larger fauna occurs at the Rose Run mine, about 4 miles east of Owingsville, in Bath County, Kentucky. Here a limestone, assumed to be equivalent to the Oldham limestone, though no *Stricklandinia* is present, contains: *Alveolites sp.*, *Atrypa reticularis*, *Calostylis cf. spongiosa*, *Calymene niagarensis*, *Camarotoechia whitii*, *Chonetes sp.*, *Clathropora frondosa*, *Hallopora sp.*, *Helopora sp.*, *Phacops sp.*, *Rhinopora verrucosa*, *Strophonella cf. patenta*, *Syringolites sp.*, and *Zygobolba rectangula*. Among these, the *Zygobolba rectangula* Ulrich and Bassler (Silurian, Maryland Geological Survey, 1923, pp. 372, 560) is characteristic of the middle part of the Lower Clinton. The type specimens are from the upper part of the Gun River formation on Anticosti, and additional specimens occur in the purple shale above the *Pentamerus oblongus* zone in the Reynales limestone; at Cumberland, Maryland, 60 feet above the base of the Clinton; and at Hagans, Virginia, in the purple shale and iron ore of the lower Clinton. The *Calostylis* also is indicative of Clinton age, occurring both in the Dayton limestone and in the Waco formation.

WACO FAUNA
Plate XX

The Waco limestone is exposed at numerous localities in the eastern part of Madison and Clark counties, in east-central Kentucky, but can not be identified farther north. It consists of a moderate number of magnesian limestone layers interbedded with a greater quantity of clay, abundantly fossiliferous. One of these limestone layers locally attains a thickness of 1 to 2 feet, but the remaining layers usually are thin-bedded. It contains the following fauna:

Atrypa reticularis, *Brachyprion cf. profundus*, *Bumastus cf. imperator*, *Calostylis spongiosa*, *Calymene niagarensis*, *Chonophyllum solitarium*, *Corynotrypa dissimilis*, *Cyathophyllum densiseptatum*, *Cyathophyllum sedentarium*, *Cystiphyllum spinulosum*, *Dalmanella elegantula*, *Diaphorostoma niagarensis*, *Encrinurus ornatus*, *Favosites declinatus*, *Favosites gothlandicus*, *Favosites hisingeri aplatus*, *Halysites catenularia*, *Hebertella sp.*, *Heliolites spongiosa*, *Heliolites subtubulata*, *Isochilina panolensis*, *Lindstroemia lingulifera*, *Lyellia eminula*, *Meekopora bassleri*, *Orthis flabellites*, *Parastrophia sp.*, *Pholidops ovalis*, *Platystrophia reversata*, *Polyorophe radicula*, *Strombodes granulosus*, *Strombodes mammilaris distans*, *Strophonella cf. tenuistriata*, *Strophostylus cf. cancellatus*, *Syringolites huronensis*, *Zaphrentis charaxata*, and *Zaphrentis intertexta*.

This fauna consists of 19 species of corals, 9 brachiopods, 2 bryozoans (others not identified), 3 trilobites, 2 gasteropods, and 1 ostracod. It is regarded provisionally as of early upper Clinton age, chiefly on account of the presence of *Meekopora bassleri*, since that species, or one closely similar, is stated by Ulrich and Bassler to occur in strata containing a Rochester fauna at Clinton, New York. *Syringolites huronensis* is cited by Prof. M. Y. Williams from the Lockport of Manitoulin Island, in Ontario; *Calostylis* and *Polyorophe* are genera originally described from the Silurian of Gotland; but no correlation can be based on these corals. Provisionally, the Waco fauna is regarded as a southern invasion.

RIBOLT FAUNA
Plate XXI

The clay shale which overlies the Waco limestone has been called the Estill clay. Its typical exposure is about a mile north of Irvine, along a road ascending a hill south of White Oak Creek. Here the Estill clay is 56 feet thick and is overlaid directly by Devonian limestone.

In Lewis County, Kentucky, no trace of the Waco limestone can be identified. Here a clay shale, at least 100 feet thick, directly overlies the Dayton limestone. At Peebles, Ohio, it is 85 feet thick; at Hillsboro, Ohio, it is 75 feet thick. At all of the three localities named, the upper part of the clay shale is interbedded with thin indurated layers, often only a quarter of an inch thick, which are characterized by a distinctively Clinton fauna.

In the western part of Lewis County, Kentucky, the following species have been identified: *Anoplotheca cf. obsoleta, Brachyprion mundula, Bucaniella cf. trilobata, Camarotoechia congruens, Camarotoechia neglecta, Chonetes vetustus, Dalmanites clintonensis*, and *Liocalymene clintoni.* Associated with the latter were the following ostracods: *Mastigobolbina typus, M. triplicata, M. trilobata, M. glabra, Plethobolbina sp.*, and *Zygosella vallata.*

One-half mile west of Peebles, Ohio, the following additional species appear: *Pterinea emacerata, Schuchertella cf. subplana, Mastigobolbina arguta, M. modesta, M. punctata*, and *Plethobolbina typicalis.* One and one-half miles north of Elmville, in the southeastern part of Highland County, the following additional species are found: *Atrypa reticularis, Brachyprion cf. planus, Calymene niagarensis, Gyronema sp., Leptaena rhomboidalis, Pholidops squamiformis, Schuchertella cf. prosseri*, and *Spirifer radiatus.* Near Jacksonville, south of Peebles, Ohio, a species occurs which closely resembles *Sowerbyella tennesseensis* in size and in the number and elevation of the more prominent striae.

The ostracods of the preceding lists are characteristic of the middle part of the upper Clinton of New York, Pennsylvania, Maryland and Virginia (Ulrich and Bassler, in the volume on the Silurian, Maryland Geol. Survey, 1923, p. 377).

That part of the clay shale section which includes the indurated layers containing this middle-upper Clinton fauna is here named the Ribolt shale, to distinguish it from the underlying Estill shale, which is not known to be fossiliferous.

BISHER FAUNA
Plate XXI

The Bisher formation is typically exposed along the eastern margin of Hillsboro, Ohio. It may be traced southward as far as Lewis County, Kentucky, where the following fauna is found at Martin's Store, 3 miles southwest of Carr's station: *Brachyprion planus, Calymene niagarensis, Camarotoechia pisa, Camarotoechia subrhomboidalis, Dalmanites brevicaudatus, Diaphorostoma cf. cliftonense, Homolanotus delphinocephalus, Bumastus cf. depressus, Leptaena rhomboidalis, Schuchertella confertus*, and *Spirifer radiatus.* At Harin Hill, 4 or 5 miles southwest of Martins store, the following additional species are found: *Dalmanella elegantula, Spirifer harinensis, Spirifer nanus*, and *Spirifer repertus.* At Glen Springs, 4 or 5 miles south of Harin Hill, the following were obtained: *Atrypa cf. rugosa, Clathropora frondosa, Cornulites clintoni, Rhipidomella magnicardinalis, Rhynchotreta americana, Spirifer radiatus obsoletus*, and *Whitfieldella cf. cylindrica.*

Among other species found in the Bisher formation in southern Ohio are: *Atrypa elongata, Bumastus ioxus, Camarotoechia neglecta, Camarotoechia roadsi, Chasmatopora angu-*

lata, *Cheirurus niagarensis*, *Cyphaspis sp.*, *Cyrtia myrtia*, *Diaphorostoma niagarensis*, *Encrinurus sp.*, *Pholidops subelliptica*, *Platyceras angulatum*, *Platystrophia pauciplicata*, *Sowerbyella transversalis*, *Rhipidomella hybrida*, *Schuchertella prosseri*, and *Spirifer eudora*.

From the Crooked Creek quarry, four and one-half miles south of Sinking Spring, in the northern part of Adams County, Ohio, the following ostracods were identified by Ulrich and Bassler: *Dizygopleura asymmetrica*, *D. lacunosa*, *D. loculosa*, *D. symmetrica*, *Paraechmina spinosa*, *and Primitiella aequilateralis*. These species are characteristic of the upper part of the upper Clinton as exposed in Juniata County, in central Pennsylvania. This is the only part of the Clinton of Pennsylvania and Maryland correlated by Ulrich and Bassler with the Rochester of New York. Hence, the Bisher formation of Ohio and Kentucky also is regarded as of Rochester age. In Kentucky, this formation has not been traced farther south than Plummer's Mill, in the eastern part of Fleming County.

LILLEY FAUNA
Plate XXII

The Lilley formation is exposed typically along the eastern margin of Hillsboro, Ohio, and there are traces of this formation also several miles southeast of Marshall and immediately north of Crooked Creek about four and a half miles south of Sinking Spring. At Hillsboro, this formation contains the following fauna: *Acervularia paveyi*, *Anastrophia internascens*, *Atrypa reticularis hillsboroensis*, *Brachyprion newsomensis*, *Calymene cf. vogdesi*, *Camarotoechia indianensis*, *Camarotoechia neglecta*, *Coenites verticillatus*, *Cyathophyllum roadsi*, *Dalmanites brevigladiolus*, *Diaphorostoma hillsboroensis*, *Encrinurus cf. ornatus*, *Halysites labyrinthicus*, *Holophragma calceoloides*, *Leptaena rhomboidalis*, *Plasmopora follis*, *Poleumita paveyi*, *Poleumita prosseri*, *Proetus collinodosus*, *Rhipidomella hybrida*, *Rhynchotreta cuneata americana*, a stromatoporoid, *Strombodes striatus*, *Trochonema fatuum*, *Zaphrentis digoniata*. At Crooked Creek, the following species are added to this list: *Cyathophyllum radicula*, *Cystiphyllum niagarense*, *Favosites spinigerus*, *Heliolites subtubulatus*, *Omphyma cf. verrucosa*, and *Striatopora cf. flexuosa*.

The chief interest in this Lilley horizon is the presence of corals suggesting a Louisville or Lockport age; these include *Coenites verticillatus*, *Cystiphyllum niagarense*, *Omphyma verrucosa*, *Plasmopora follis*, and *Strombodes striatus*. This coral zone, moreover, lies directly beneath the Peebles formation, the latter correlating most readily with the Guelph of Canada and adjacent New York, and less readily with the Cedarville of Ohio.

Two species of corals found in the Lilley formation are of special interest. One of these is *Holophragma calceoloides*, a species occurring also in Gotland. The other is *Zaphrentis digoniata*, which can not be distinguished from specimens less abundantly represented in the upper third of the quarry at Cedarville, Ohio. The presence of the Gotlandian genus *Calostylis* in the Waco formation of east-central Kentucky has been noted already. Possibly the Waco and Lilley faunas invaded east-central Kentucky from the same direction, presumably from the south, but along the eastern shore of the Mississippi embayment.

PEEBLES FAUNA
Plate XXII

The Peebles formation is exposed typically at Peebles, Ohio. It includes at this locality that part of the Niagaran which intervenes between the top of the Bisher west of town and the base of the Greenfield 2 or 3 miles eastward. At Hillsboro, the Lilley formation intervenes between the Bisher and the Peebles.

At Hillsboro, *Pentamerus oblongus* is abundant at the base of the Peebles formation. The general character of the fauna of this formation, as exhibited in Highland and Adams counties is shown by the following list: *Amphicyrtoceras cf. pettiti*, *Amphicyrtoceras tantalum*, *Coelocaulus macrospira*, *Dinobolus conradi*, *Eccyliomphalus circinatus*, *Eotomaria areyi*, *Eotomaria halei*, *Goniophora crassa*, *Hormatoma whiteavesi*, *Megalomus canadensis*, *Monomorella sp.*, *Pentamerus oblongus*, *Poleumita crenulata*, *Poleumita scamnata*, *Pycnostylus guelphensis*, *Straparollus paveyi*, a globose stromatoporoid, *Trimerella acuminata* and *Trimerella grandis*. This is a Guelph

fauna, comparable to that exposed in the southern part of Ontario and western New York. It differs distinctly from the Cedarville as exposed in Clinton, Greene, Clark, Montgomery, Miami, Peebles and Darke counties, in western Ohio. The Cedarville fauna is more like that of the Racine as exposed in Wisconsin and northern Illinois.

The Peebles formation can be traced southward as far as the Ohio River, in Adams county, where *Trimerella acuminata* and other characteristic Guelph fossils occur on the hills facing the river. Evidently, the strata overlying the Bisher formation in that part of Lewis County, Kentucky, which lies west of Vanceburg is to be correlated with the Peebles, though the species found so far are not strictly diagnostic of this horizon: *Anastrophia internascens*, *Atrypa reticularis*, *Camarotoechia indianensis*, *Favosites niagarensis*, *Halysites labyrinthicus*, *Rhynchotreta cuneata americana*, *Spirifer cf. niagarensis*, and *Straparollus paveyi*. The species named last was found at Clarksburg, west of Vanceburg. The Peebles formation is not exposed south of Lewis County.

GREENFIELD FAUNA

Plate XXII

The Greenfield dolomite is exposed typically at Greenfield, in the northeastern corner of Highland County. Exposures are fairly continuous, at the proper horizon, as far south as the middle of Adams County. However, in the southern half of Adams County, the Greenfield dolomite often is absent between the top of the Peebles formation and the base of the Ohio black shale.

The only exposure of the Greenfield dolomite known in Kentucky is exposed along the bank of the Ohio River, at Vanceburg, Ohio. Here, the ostracod typical of this dolomite, namely *Leperditia ohioensis*, is fairly abundant in certain layers.

From Greenfield, Ohio, the following fauna has been described: *Camarotocchia hydraulica*, *Hindella? (Greenfieldia) rostralis*, *Hindella? (Greenfieldia) whitfieldi*, *Leperditia angulifera*, *Leperditia ohioensis*, *Rhynchospira praeformosa*, *Schuchertella hydraulica*, *Whitfieldella rotundata*, and *Whitfieldella subsulcata*. To this list should be added *Pentamerus pesovis*, described from some unknown locality in Adams County, Ohio.

According to Ulrich and Bassler, the Greenfield dolomite belongs somewhere near the base of the upper half of the Cayugan division of the Silurian. It has been identified by Grabau in southern Michigan and the adjacent part of Ontario. Its nearest relatives are to be found in New York, Pennsylvania, and thence southward along the Appalachian Valley. This suggests invasion from some Atlantic source.

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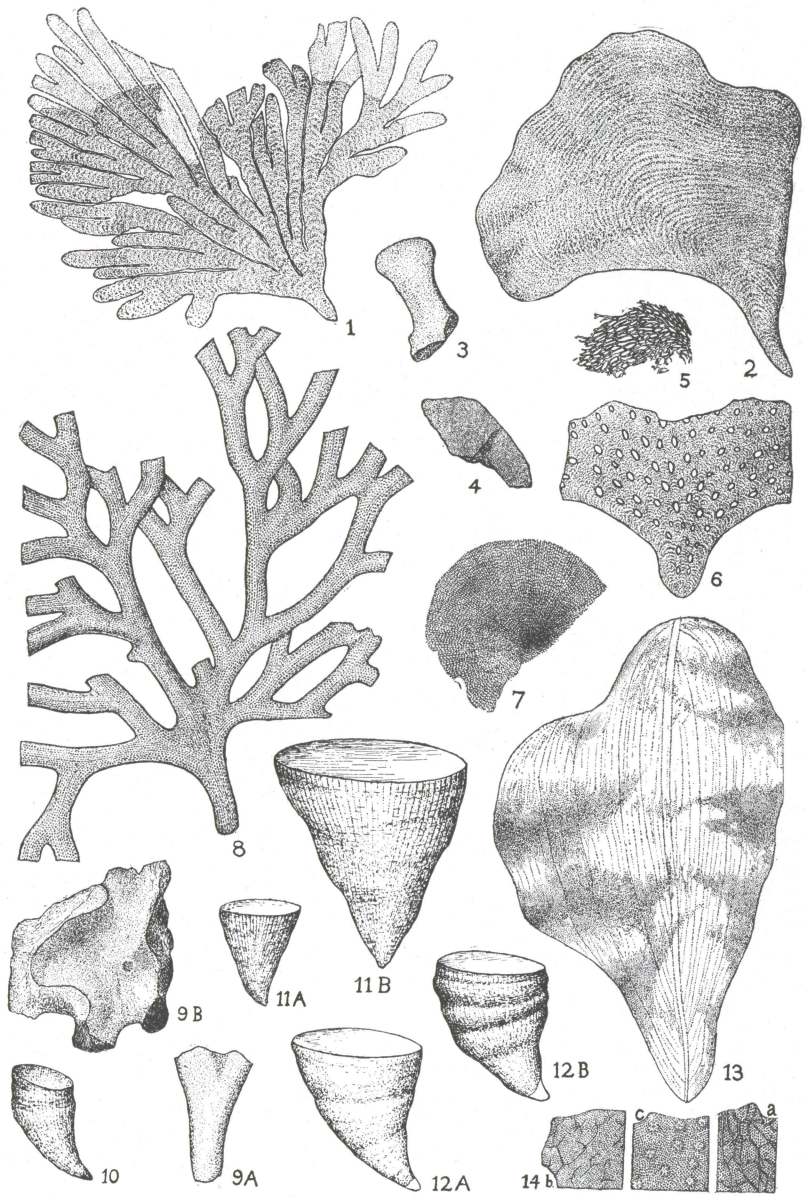
Explanation of Plate XVII

BRASSFIELD FOSSILS

Figure

1. *Phaenopora multifida* (Van Cleve) Hall. Dayton, Ohio.
2. *Phaenopora expansa* (Hall and Whitfield). Dayton, Ohio.
3. *Hallopora magnopora* (Foerste). Centerville, Ohio.
4. *Aspidopora parmula* Foerste. Dayton, Ohio.
5. *Chasmatopora angulata* (Hall). Dayton, Ohio.
6. *Clathropora frondosa clintonensis* (Hall and Whitfield). Dayton, Ohio.
7. *Hemitrypa ulrichi Foerste.* Brown's quarry, west of New Carlisle, Ohio.
8. *Pachydictya bifurcata* (Hall). Dayton, Ohio.
9. *Homotrypa* (?) *confluens* (Foerste). Dayton, Ohio.
10. *Enterolasma facetum* Foerste. Dayton, Ohio.
11. *Zaphrentis* (?) *geometrican* Foerste. Dayton, Ohio.
12. *Enterolasma* (?) *daytonense* Foerste. Dayton, Ohio.
13. *Ptilodictya expansa* Hall. Dayton, Ohio.
14. *Rhinopora verrucosa* Hall. Dayton, Ohio.

PLATE XVII



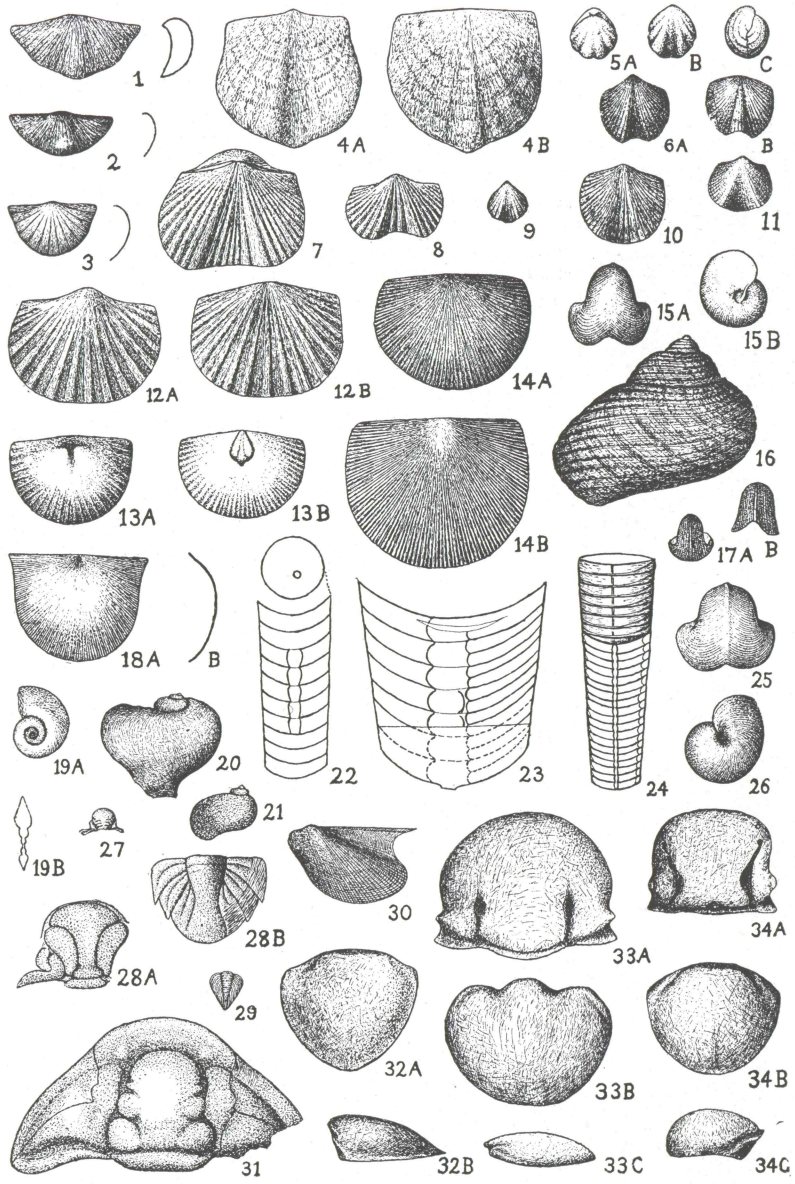
Fossils of the Brassfield—Silurian

Explanation of Plate XVIII

BRASSFIELD FOSSILS

Figure

1. *Sowerbyella prolongatus* Foerste. Dayton, Ohio.
2. *Sowerbyella prolongatus* Foerste. Wildwood Station, Georgia.
3. *Sowerbyella elegantulus* (Hall). Hanover, Indiana.
4. *Stricklandinia triplesiana* Foerste. Dayton, Ohio.
5. *Camarotoechia convexa* Foerste. Hanover, Indiana.
6. *Plectatrypa marginalis* (Dalman). New Carlisle, Ohio.
7. *Platystrophia reversata* Foerste. Dayton, Ohio.
8. *Platystrophia daytonensis* Foerste. Dayton, Ohio.
9. *Camarotoechia* (*Stegerhynchus*) *neglecta* (Hall). Hanover, Indiana.
10. *Plectatrypa marginalis* (Dalman). Dayton, Ohio.
11. *Plectatrypa multistriata* Foerste. Hanover, Indiana.
12. *Orthis evorthis* Foerste. Dayton, Ohio.
13. *Orthis dinorthis* Foerste. Hanover, Indiana.
14. *Schuchertella daytonensis* Foerste. Dayton, Ohio.
15. *Bellerophon opertus* Foerste. Hanover, Indiana.
16. *Cyclonema daytonense*. Foerste. New Carlisle, Ohio.
17. *Bucania fiscellostriata* (Foerste). Dayton, Ohio.
18. *Strophonella hanoverensis* (Foerste). Hanover, Indiana.
19. *Oxydiscus youngi* (Foerste). Hanover, Indiana.
20. *Diaphorostoma daytonense* Foerste. Brown's quarry, west of New Carlisle, Ohio. Type.
21. *Diaphorostoma daytonense* Foerste. Dayton, Ohio. Not the type.
22. *Orthoceras ignotum* Foerste. Hanover, Indiana.
23. *Ormoceras youngi* (Foerste). Hanover, Indiana.
24. *Orthoceras hanoverense* Foerste. Hanover, Indiana.
25, 26. *Bellerophon exiguus* (Foerste). North of Wilmington, Ohio.
27. *Dalmanitina pulchellus* Foerste. Brown's quarry, west of New Carlisle, Ohio.
28. *Autolichas clintonensis* Foerste. Brown's quarry, west of New Carlisle, Ohio.
29. *Encrinurus thresheri* Foerste. Dayton, Ohio.
30. *Pterinea brisa* Hall. Brown's quarry, west of New Carlisle, Ohio.
31. *Calymene vogdesi* Foerste. Centerville, Ohio.
32. *Bumastus depressus* Foerste. Dayton, Ohio.
33. *Illaenus daytonensis* Hall and Whitfield. Dayton, Ohio.
34. *Bumastus ambiguus* Foerste. Dayton, Ohio.



Fossils of the Brassfield—Silurian

Explanation of Plate XIX

BRASSFIELD FOSSILS

Figure

1. *Strophonella daytonensis* Foerste. Dayton, Ohio.
2. *Triplecia ortoni* (Meek). Dayton, Ohio.
3. *Camarotoechia* (*Stegerhynchus*) *scobina* (Hall and Whitfield). Dayton, Ohio.
4. Segment of crinoid or cystid column, characteristic of top of Brassfield formation, at Centerville, Ohio.
5. *Whitfieldella subquadrata* Foerste. Four miles west of Berea, Kentucky.
6. *Orthis bucheri* Foerste. Jeptha Knob, Shelby county, Kentucky.
7. *Whitfieldella quadrangularis* Foerste. Northeast of Duncansville, Adams County, Ohio.
8. *Leptaena centervillensis* Foerste. Centerville, Ohio.

BISHER FOSSIL

9. *Whitfieldella cylindrica* (Hall). Hillsboro, Ohio; figured for comparison with the Brassfield species of *Whitfieldella*.

DAYTON FOSSILS

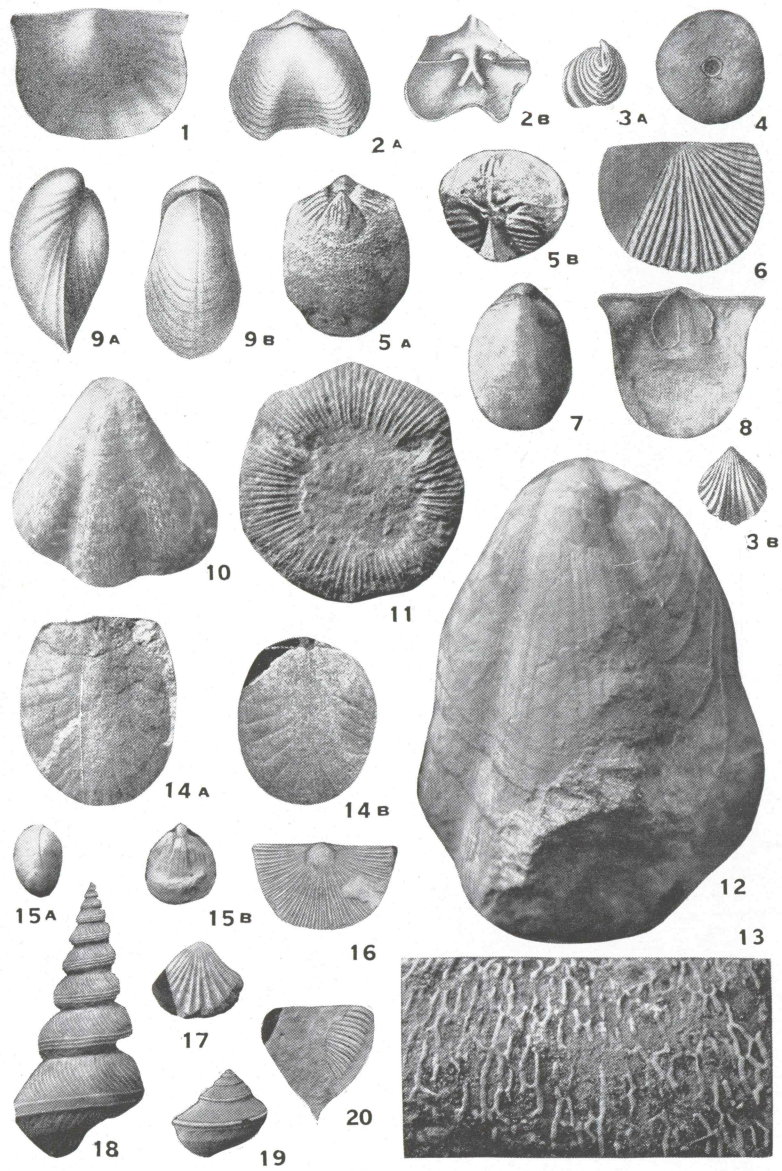
10. *Pentamerus peeblesensis* Foerste. Apparently a young stage of the species as typified by figure 12. West of Peebles, Ohio.
11. *Ptychophyllum riboltense* Foerste. Ribolt, Lewis county, Kentucky. Type specimen.
12. *Pentamerus peeblesensis* Foerste. Type specimen. Two miles west of Peebles, Ohio.
13. *Syringopora* cf. *retiformis* Billings. Baker creek, Adams county, Ohio.

OLDHAM FOSSIL

14. *Stricklandinia norwoodi* Foerste. Five and a half miles south of Indian Fields, Madison county, Kentucky.

CENTERVILLE FOSSILS

15. *Whitfieldella* cf. *ovoides* Savage. Centerville, Ohio
16. *Schuchertella subplana brevior* Foerste. Centerville, Ohio.
17. *Rhynchotreta* cf. *thebesensis* Foerste. Centerville, Ohio.
18. *Hormotoma trilineata* Foerste. Natural size, Centerville, Ohio.
19. *Lophospira ehlersi* Foerste. Slightly magnified. Centerville, Ohio.
20. *Dalmanites* sp. Figured to show the Silurian facies of this species. Centerville, Ohio.



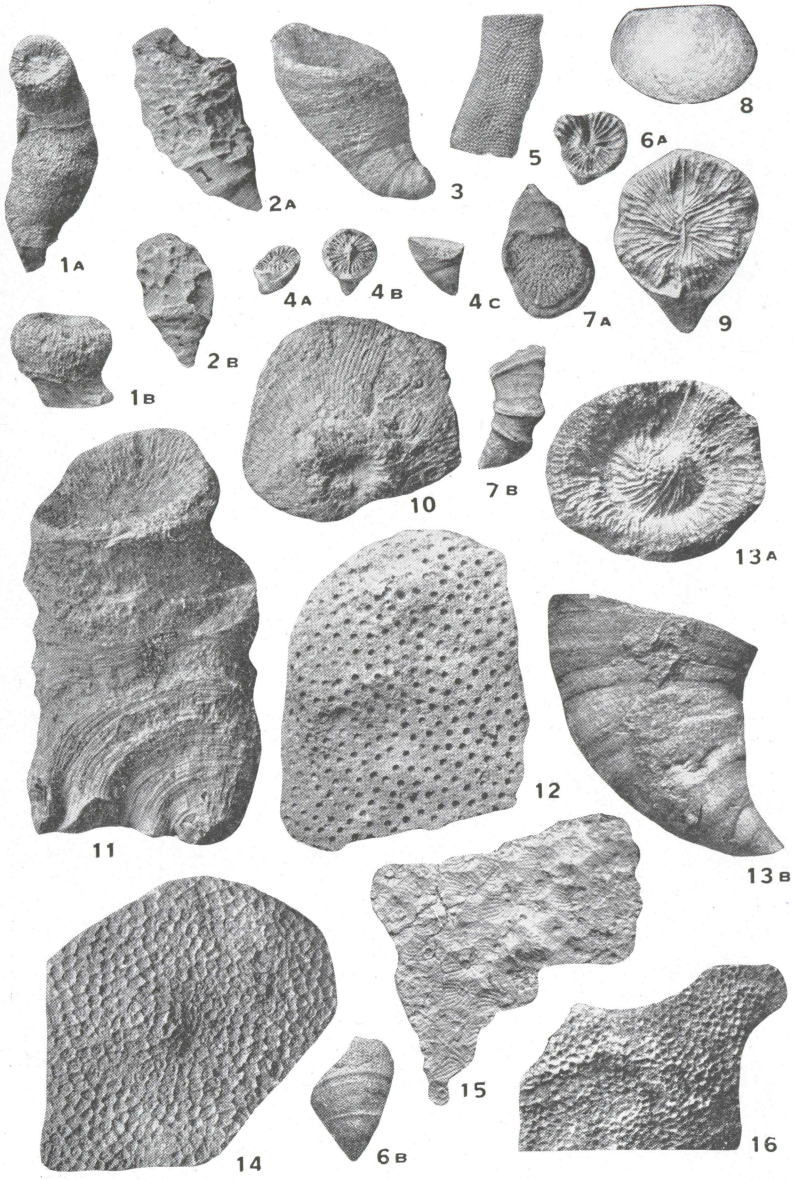
Fossils of the Brassfield, Bisher, Dayton, Oldham and Centerville—Silurian

Explanation of Plate XX

WACO FOSSILS

Figure

1. *Calostylis spongiosa* Foerste. North of Irvine, Kentucky.
2. *Cystiphyllum spinulosum* Foerste. North of Irvine, Kentucky.
3. *Cyathophyllum densiseptatum* Foerste. North of Irvine, Kentucky.
4. *Lindstroemia lingulifera* Foerste. North of Irvine, Kentucky.
5. *Meekopora bassleri* Foerste. North of Irvine, Kentucky.
6. *Zaphrentis charaxata* Foerste. North of Irvine, Kentucky.
7. *Polyorophe radicula* Foerste. A, from north of Irvine; B, half a mile east of Waco, Kentucky Figure A is magnified.
8. *Isochilina panolensis* Foerste. Panola, Madison county, Kentucky.
9. *Zaphrentis irvinensis* Foerste. North of Irvine, Kentucky.
10. *Chonophyllum solitarium* Foerste. North of Irvine, Kentucky.
11. *Cyathophyllum sedentarium* Foerste. North of Irvine, Kentucky.
12. *Heliolites spongiosa* Foerste. North of Irvine, Kentucky.
13. *Zaphrentis intertexta* Foerste. North of Irvine, Kentucky.
14. *Syringolites huronensis* Hinde. Tipton Ferry, Powell county, Kentucky.
15. *Strombodes granulosus* Foerste. Waco, Madison county, Kentucky.
16. *Favosites declinata* Foerste. North of Irvine, Kentucky.



Fossils of the Waco—Silurian

Explanation of Plate XXI

RIBOLT FOSSILS

Figure

1. *Mastigobolbina typus* Ulrich and Bassler; magnified Lewis county, Kentucky.
2. *Mastigobolbina triplicata* Foerste; magnified Lewis county, Kentucky.
3. *Mastigobolbina trilobata* Ulrich and Bassler; magnified Lewis county, Kentucky.
4. *Zygosella vallata* Ulrich and Bassler; magnified Lewis county, Kentucky.
5. *Plethobolbina typicalis* Ulrich and Bassler; magnified Lewis county, Kentucky.
6. *Chonetes vetustus* Foerste. West of Valley, Lewis county, Kentucky. Magnified.
7. *Anoplotheca* (?) *congruens* Foerste. Between Poplar Flats and Martins, Lewis county, Kentucky. Magnified.
8. *Brachyprion mundula* Foerste. Between Poplar Flats and Martins, Kentucky.
9. *Liocalymene clintoni* (Vanuxem). Between Poplar Flats and Martins, Kentucky.

UPPER CLINTON

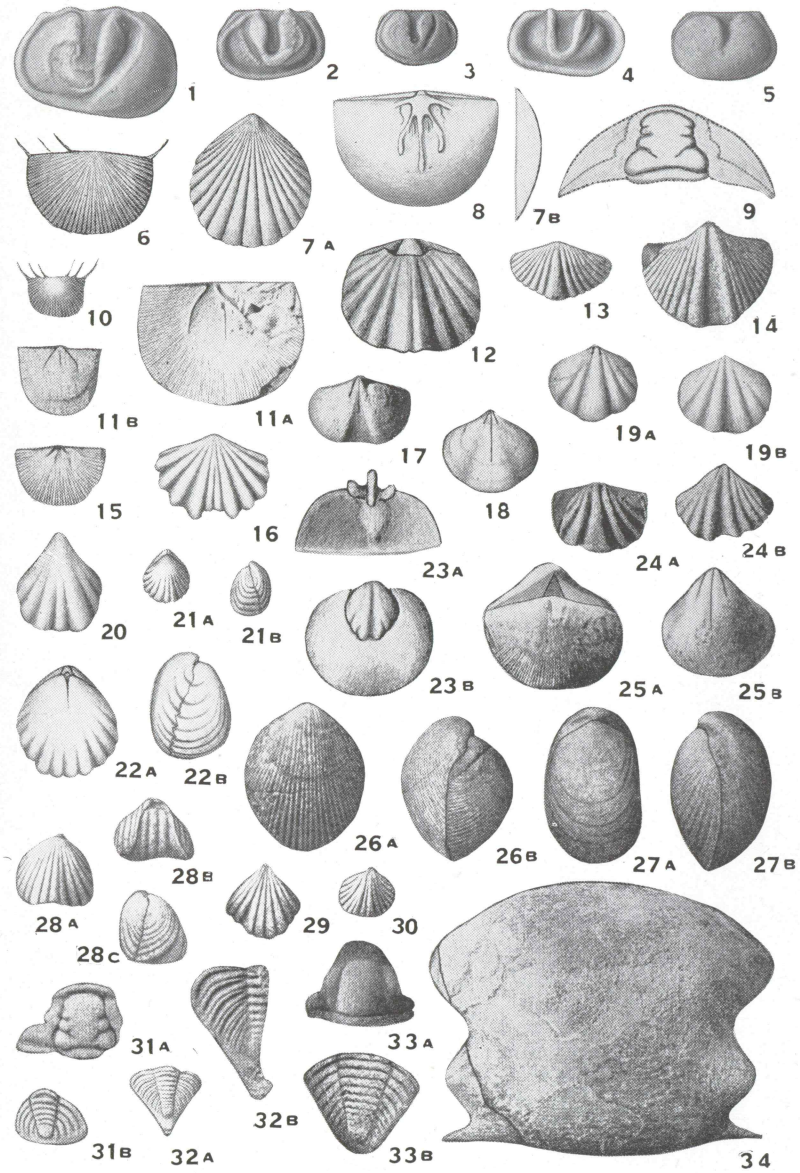
10. *Chonetes cornutus* (Hall) Sodus Bay, New York.

BISHER FOSSILS

11. *Brachyprion planus* Foerste. One mile south of Glen Spring Lewis county, Kentucky.
12. *Platystrophia pauciplicata* Foerste. West Union, Ohio.
13. *Spirifer* (*Eospirifer*) *repertus* Foerste. Harin Hill, 4 miles west of Valley, Lewis county, Kentucky.
14. *Spirifer* (*Eospirifer*) *niagarensis* (Conrad). Sanderson farm, 8 miles southwest of Hillsboro, Ohio
15. *Schuchertella conferta* Foerste. Martins, Lewis county, Kentucky.
16. *Trematospira pauciplicata* Foerste. West Union, Ohio. Magnified.
17. *Spirifer* (*Eospirifer*) *radiatus* (Sowerby). Martins, Kentucky.
18. *Spirifer* (*Delthyris*) *nanus* Foerste. One mile south of Glen Spring, Lewis county, Kentucky.
19. *Spirifer* (*Eospirifer*) *harinensis* Foerste. Harin Hill, 4 miles west of Valley, Lewis county, Kentucky. Magnified.
20. *Camarotoechia subrhomboidea* Foerste. Martins, Lewis county, Kentucky. Magnified.
21. *Camarotoechia pisa*. (Hall and Whitfield). Danville, Highland county, Ohio, Type.
22. *Camarotoechia pisa* (Hall and Whitfield). Martins, Kentucky.
23. *Rhipidomella magnicardinalis* Foerste. One mile south of Glen Spring, Lewis county, Kentucky.
24. *Spirifer* (*Eospirifer*) *eudora* (Hall). West Union, Ohio.
25. *Spirifer* (*Eospirifer*) *obsoletus* Foerste. One mile south of Glen Spring, Lewis county, Kentucky.
26. *Atrypa elongata* Foerste. Hillsboro, Ohio.
27. *Whitfieldella cylindrica* (Hall). One mile north of Danville, Ohio.
28. *Camarotoechia roadsi* Foerste. Hillsboro, Ohio.
29. *Rhynchotreta americana* (Hall). Hillsboro, Ohio.
30. *Atrypa rugosa* Hall. West Union. Ohio.
31. *Calymene* cf. niagarensis Hall. West Union, Ohio
32. *Dalmanites limulurus brevicaudatus* Foerste. Martins, Kentucky.
33. *Homalonotus delphinocephalus* (Green). Martins, Kentucky.
34. *Bumastus ioxus* Hall. Hillsboro, Ohio.

(This plate has been reduced so that the notes on magnification in most cases are no longer correct.)

PLATE XXI



Fossils of the Ribolt and Bisher—Silurian

Explanation of Plate XXII

LILLEY FOSSILS

Figure

1. *Zaphrentis digoniata* Foerste. Hillsboro, Ohio.
2. *Holophragma calceoloides* Lindstroem. Hillsboro, Ohio.
3. *Cyathophyllum roadsi* Foerste. Hillsboro, Ohio.
4. *Dalmanites brevigladiolus* Foerste. Hillsboro, Ohio.
5. *Proetus collinodosus* Foerste. Hillsboro, Ohio.
6. *Trochonema fatuum* (Hall). Hillsboro, Ohio.
7. *Diaphorostoma hillsboroensis* Foerste. Hillsboro, Ohio.
8 *Poleumita prosseri* Foerste. Hillsboro, Ohio.
9. *Poleumita paveyi* Foerste. Hillsboro, Ohio.
10. *Plectatrypa hillsboroensis* Foerste. Hillsboro, Ohio.

PEEBLES FOSSILS

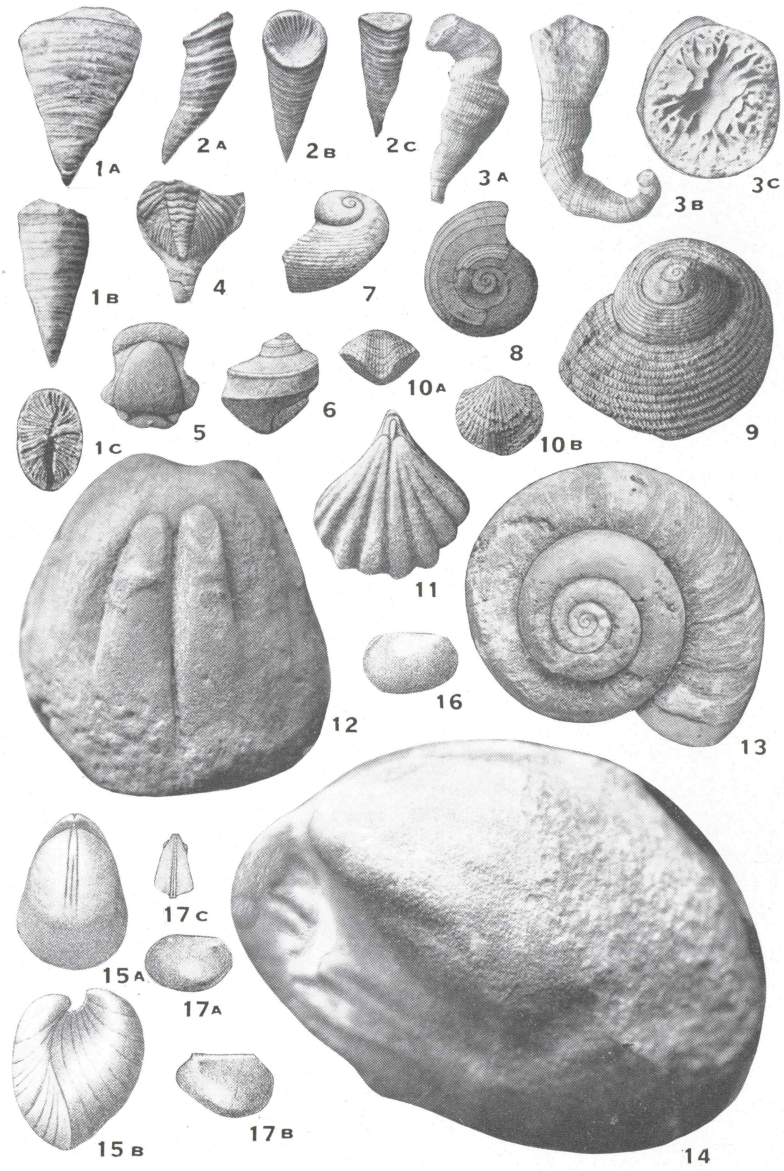
11. *Rhynchotreta americana* (Hall). South of Carrs station, Lewis county, Kentucky.
12. *Trimerella grandis* Billings. North of Bacon Flat school, Adams county, Ohio.
13. *Straparollus paveyi* Foerste. Hillsboro, Ohio; also at Clarksburg, Lewis county, Kentucky.
14. *Megalomus canadensis* Hall. Two miles southeast of Marshall, Highland county, Ohio.

CEDARVILLE FOSSIL

15. *Pentamerus pergibbosus* Hall and Whitfield. Greenville, Darke county, Ohio.

GREENFIELD FOSSILS

16. *Leperditia ohioensis* Bassler. Greenfield, Ohio; also at Vanceburg, Kentucky.
17. *Leperditia angulifera* Whitfield. Greenfield, Ohio.



Fossils of the Lilley, Peebles, Cedarville, and Greenfield—Silurian

Explanation of Plate XXIII

OSGOOD FOSSILS

Figure

1. *Caryocrinites indianensis* (Miller). Jefferson county, Indiana.
2. *Holocystites subovatus* Miller. Jefferson county, Indiana.
3. *Holocystites parvulus* Miller. Jefferson county, Indiana.
4. *Troostocrinus sanctipaulensis* Foerste. St. Paul, Indiana.
5. *Allocystites hammelli* Miller. Jefferson county, Indiana.
6. *Pisocrinus gemmiformis* Miller. Osgood, Indiana.
7. *Stephanocrinus osgoodensis* Miller. Osgood, Indiana.
8. *Stephanocrinus hammelli* Miller. Big Creek, Jefferson county, Indiana.
9. *Stephanocrinus elongatus* Miller. Near Madison, Indiana.
10. *Stephanocrinus obpyramidalis* Miller. Near Madison, Indiana.

LAUREL FOSSILS

11. *Trochurus hanoverensis* (Miller and Gurley). Hanover, Indiana.
12. *Trochurus byrnesanus* (Miller and Gurley). Madison, Indiana.

WALDRON FOSSILS

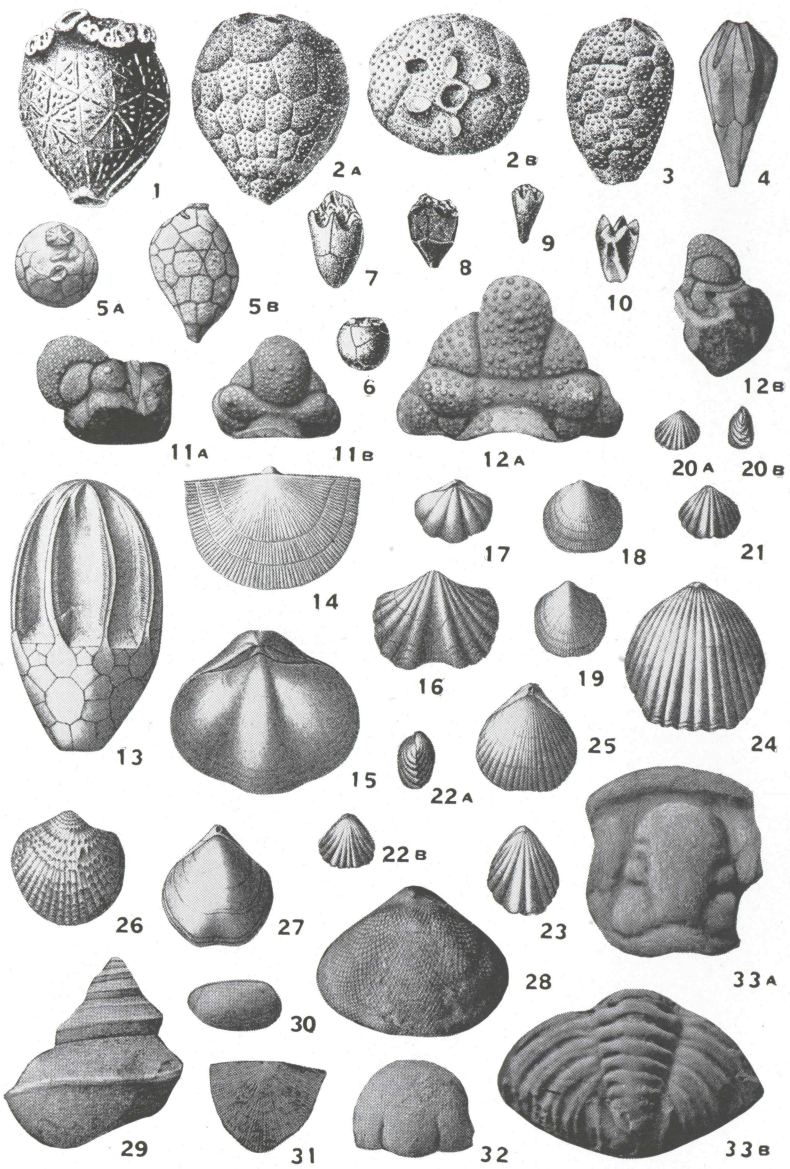
All of the specimens figured are from Waldron, Indiana. Similar specimens occur in the Waldron fauna of Kentucky.

13. *Eucalyptocrinus crassus* Hall.
14. *Schuchertella subplana* (Conrad).
15. *Spirifer (Eospirifer) radiatus* (Sowerby).
16. *Spirifer (Eospirifer) eudora* (Hall).
17. *Spirifer (Delthyris) crispus simplex* (Hall).
18. *Rhipidomella hybrida* (Sowerby).
19. *Dalmanella elegantula* (Dalman).
20. *Camarotoechia (Stegerhynchus) neglecta* (Hall).
21. *Camarotoechia (Stegerhynchus) whitii* (Hall).
22. *Camarotoechia (Stegerhynchus) indianensis* (Hall).
23. *Camarotoechia (Stegerhynchus) acinus* (Hall).
24. *Uncinulus stricklandi* (Sowerby).
25. *Homoeospira evax* (Hall).
26. *Atrypa newsomensis* Foerste.
27. *Whitfieldella nitida* (Hall).
28. *Dictyonella reticulata* (Hall).

JEPTHA KNOB FOSSILS

(Probably from lower part of Louisville formation)

29. *Lophospira bucheri* Foerste.
30. *Cypricardinia jepthaensis* Foerste.
31. *Strophonella milleri* Foerste.
32. *Illaenus cf. daytonensis* Hall and Whitfield.
33. *Calymene cf. cedarvillensis* Foerste.



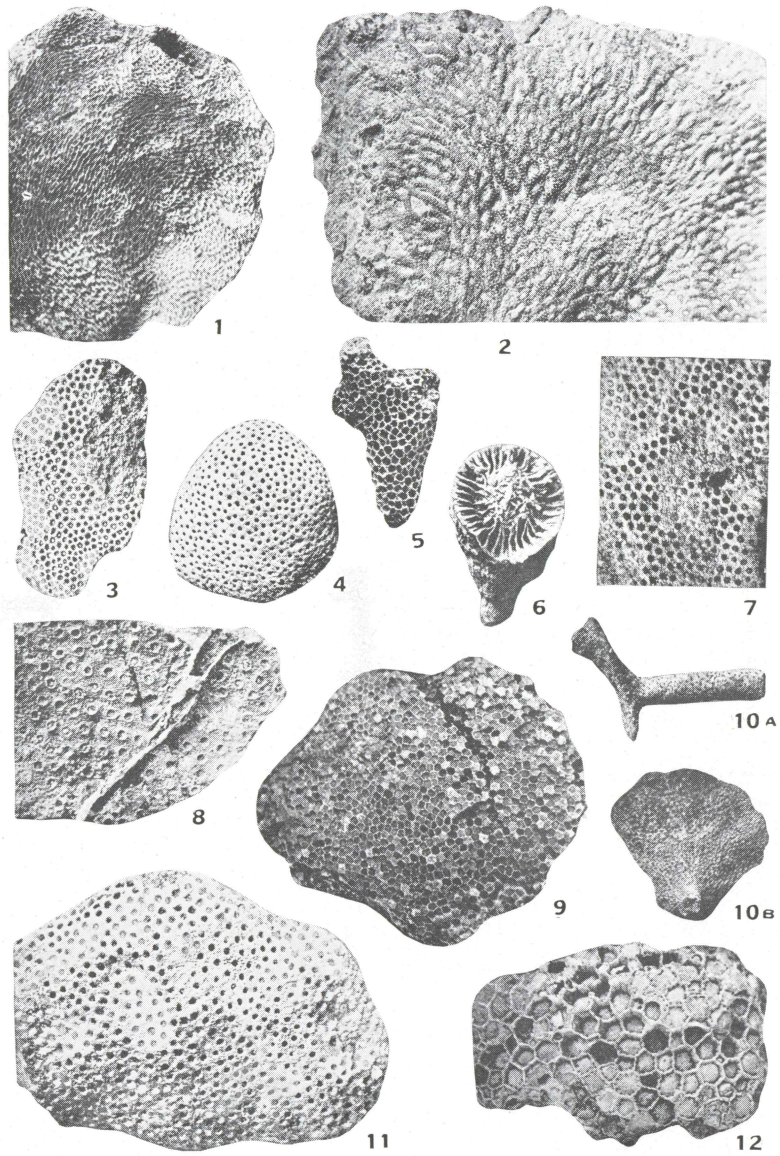
Fossils of the Osgood, Laurel, and Waldron—Silurian

Explanation of Plate XXIV

LOUISVILLE FOSSILS FROM LOUISVILLE, KENTUCKY.

Figure

1. *Alveolites louisvillensis* Davis.
2. *Cladopora reticulata* Hall.
3. *Thecia major* Rominger. Point au Barques, Michigan; also Louisville, Kentucky.
4. *Heliolites subtubulatus* (McCoy).
5. *Favosites cristatus* Edwards and Haime.
6. *Streptelasma spongiaxis* Rominger.
7. *Lyellia papillata* Rominger.
8. *Heliolites megastoma* (McCoy).
9. *Favosites niagarensis* Hall.
10. *Coenites verticillatus* (Winchell and Marcy).
11. *Plasmopora follis* Edwards and Haime.
12. *Favosites favosus* (Goldfuss).



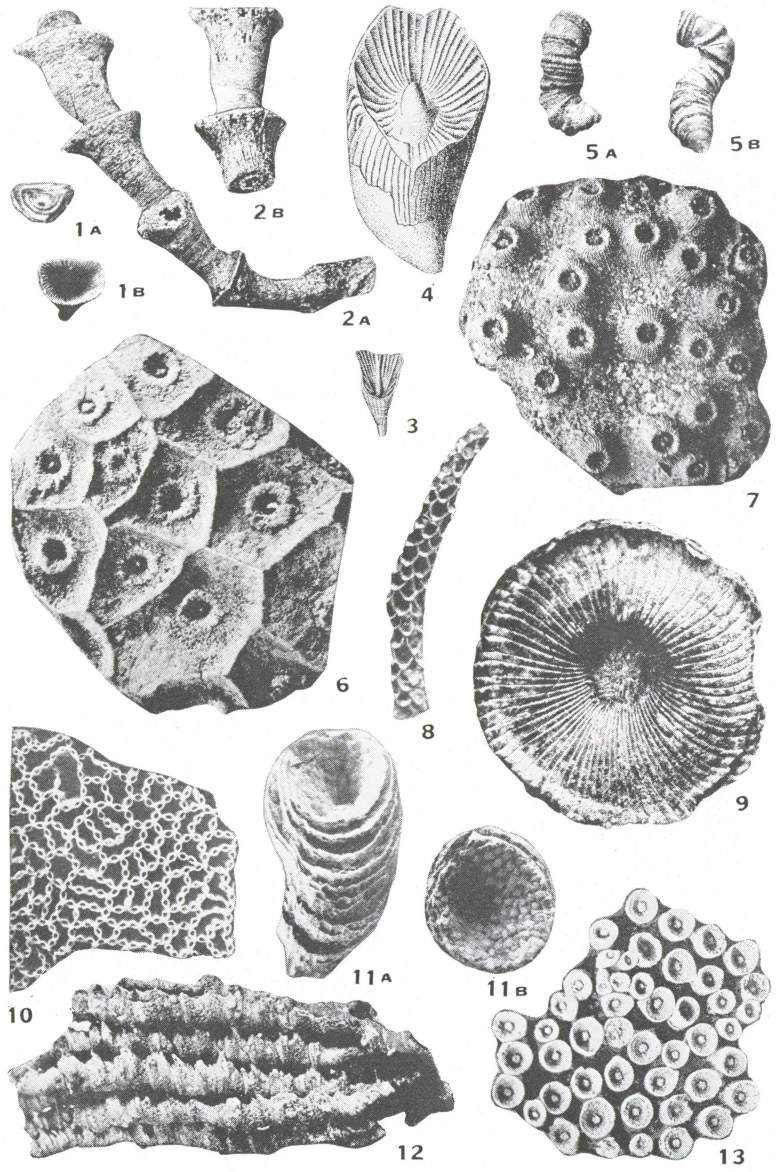
Fossils from the Louisville—Silurian

Explanation of Plate XXV

LOUISVILLE FOSSILS FROM LOUISVILLE, KENTUCKY.

Figure

1. *Calceola* (*Rhizophyllum*) *corniculum* (Lyon).
2. *Amplexus davisi* Foerste. (*Amplexus shumardi* of Davis).
3. *Anisophyllum unilargum* Hall.
4. *Lindstroemia* (?) *herzeri* (Hall).
5. *Cyathophyllum radicula* Rominger.
6. *Strombodes striatus* (D'Orbigny). Drummond Island, Lake Huron; also at Louisville, Kentucky.
7. *Strombodes mamillaris* (Owen).
8. *Striatopora huronensis* Rominger. Point Detour, Michigan; also at Louisville, Kentucky.
9. *Ptychophyllum ipomoea* Davis.
10. *Halysites catenularia* (Linnaeus).
11. *Cystiphyllum niagarense* (Hall). A, from Masonville, Iowa; B, from Drummond Island; also from Louisville, Kentucky.
12. *Eridophyllum rugosum* Edwards and Haime.
13. *Eridophyllum sentum* Davis.



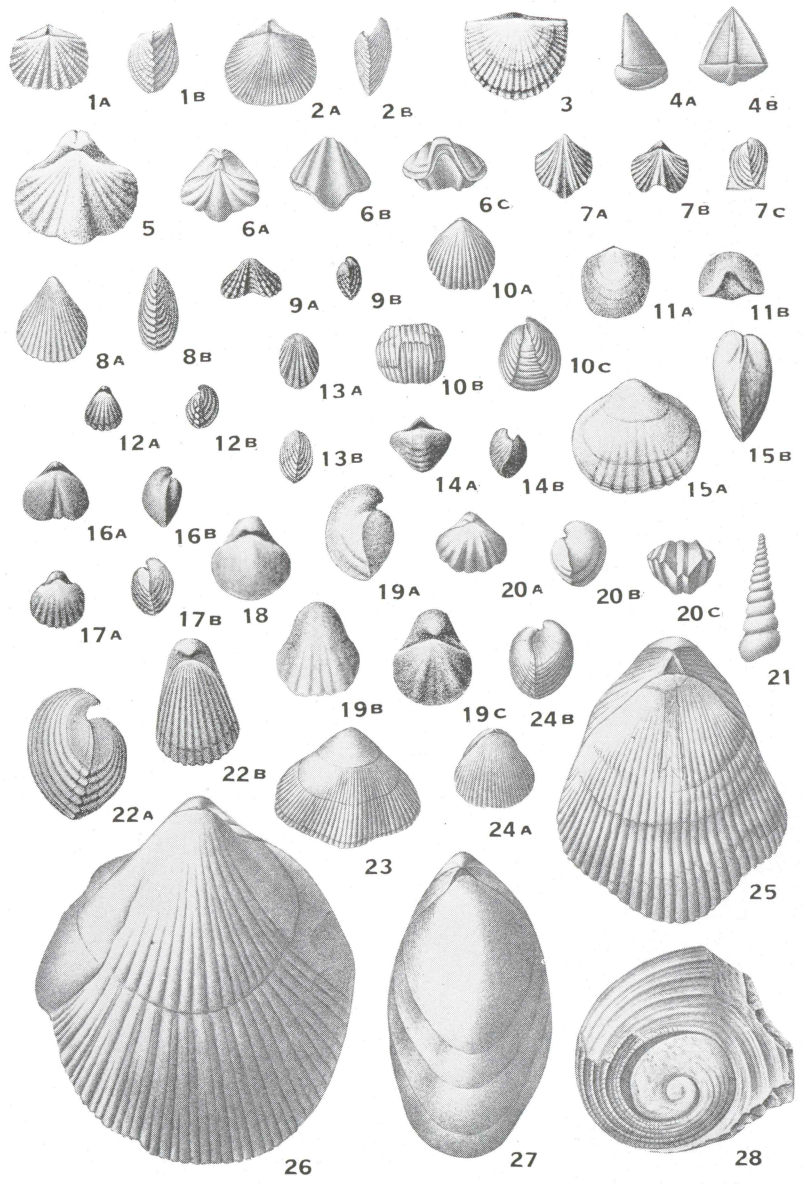
Fossils from the Louisville—Silurian

Explanation of Plate XXVI

LOUISVILLE FOSSILS FROM LOUISVILLE, KENTUCKY.

Figure

1. *Herbertella* (*Glyptorthis*) *rugiplicata* (Hall and Whitfield).
2. *Hebertella nisis* (Hall and Whitfield).
3. *Orthis nettelrothi* Foerste.
4. *Cyrtia exporrecta myrtia* (Billings).
5. *Spirifer* (*Eospirifer*) *foggi* (Nettelroth).
6. *Spirifer* (*Eospirifer*) *rostellum* (Hall and Whitfield).
7. *Atrypa calvini* Nettelroth.
8. *Wilsonia depressa* (Nettelroth).
9. *Rhynchonella rugicosta* Nettelroth.
10. *Wilsonia saffordi* (Hall).
11. *Atrypa niagarensis* (Nettelroth).
12. *Rhynchospira* (?) *helena* (Nettelroth).
13. *Camarotoechia nettelrothi* Nov. Sp. Foerste (Described by Nettelroth under *Rhynchonella pisa*).
14. *Reticularia dubia* (*Nettelroth*).
15. *Stricklandinia* (?) *louisvillensis* Nettelroth.
16. *Gypidula* (*Sieberella*) *uniplicata* (Nettelroth).
17. *Gypidula knotti* (Nettelroth).
18. *Clorinda ventricosa* (Hall).
19. *Gypidula* (*Sieberella*) *nucleus* (Hall and Whitfield).
20. *Gypidula* (*Sieberella*) *nucleus* (Hall and Whitfield).
21. *Coelocaulus petila* (Hall and Whitfield).
22. *Conchidium nettelrothi* Hall and Clarke.
23. *Conchidium tenuicostatum* (Hall and Whitfield).
24. *Conchidium littoni* (Hall).
25. *Conchidium nysius* (Hall and Whitfield).
26. *Conchidium knappi* (Hall and Whitfield).
27. *Pentamerus cylindricus* (Hall and Whitfield).
28. *Poleumita rugaelineata* (Hall and Whitfield).



Fossils from the Louisville—Silurian

IV

DEVONIAN FAUNA

By

THOMAS EDMUND SAVAGE

THE DEVONIAN FAUNA OF KENTUCKY

By

THOMAS EDMUND SAVAGE

INTRODUCTION

THE DEVONIAN FAUNAS OF KENTUCKY.

The Devonian faunas known in Kentucky represent middle and upper Devonian time, and correspond in age with a part of the Onondaga, Hamilton, Tully, and Genesee divisions of the New York section as shown in the table given below. It seems almost certain that lower Devonian seas submerged portions of western Kentucky, for sediments and faunas of Helderberg and Oriskany time are known to the south in Tennessee and to the north and west in Illinois and Missouri. However, if these early Devonian seas did spread over parts of western Kentucky, the sediments and fossils that were deposited in them were all removed by erosion before the middle Devonian and younger strata that are now found in the region were laid down. It is possible that patches of lower Devonian sediments and fossils may still be present in western Kentucky, but if they are, such places are covered and concealed by younger strata.

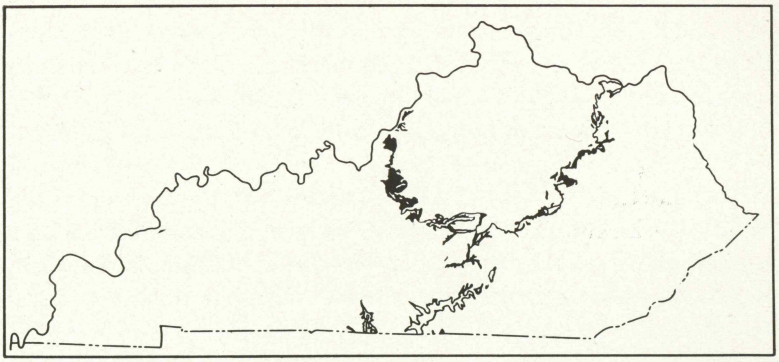


Fig. 27. Map showing the distribution of the Devonian Strata in Kentucky. A narrow strip of the Devonian shale, too small to be shown at this scale is found on the north-west side of Pine Mountain.

The relative age of the Devonian formations present in Kentucky, and the relation of these faunas to those of the middle and upper Devonian in adjacent states, are shown on the comparative table given below:

Comparative Table of Devonian Formations

Equivalents in New York	Southern Illinois	Central Kentucky	Southern Indiana	Ohio
Genessee shale Tully limestone	Mountain Glen shale Alto Formation	New Albany shale Duffin limestone	New Albany shale	
Hamilton limestone Marcellus shale	Lingle limestone Misenheimer shale	Sellersburg limestone Casey Beechwood Silver Creek	Sellersburg limestone Silver Creek Beechwood	Delaware limestone
Onondaga limestone	Grand Tower limestone Dutch Creek sandstone Clear Creek chert	Jeffersonville limestone	Jeffersonville limestone	Columbus limestone

DISTRIBUTION OF THE DEVONIAN FAUNAS

Devonian strata and fossils occur in Kentucky immediately below the mantle rocks over a belt a few, to several, miles wide bordering the Blue Grass area on both sides of the Cincinnati anticline, from above Louisville south to Larue County on the west, thence east across Marion, Boyle, Lincoln and Garrard counties, and thence northeast towards the Ohio River in the vicinity of Vanceburg, in Lewis County. South of this main area they are found in patches of greater or less size along several of the streams as far as the Kentucky-Tennessee line.

It is not meant to be understood, however, that the Devonian faunas are the same everywhere in the areas above mentioned. The typical Jeffersonville fauna is found in abundance only in the vicinity of Louisville, near the north end of the belt on the west side of the Cincinnati anticline. The typical Sellersburg fauna is developed in the Louisville region, and farther north in southern Indiana, where it is separable into the Silver Creek fauna below and the Beechwood fauna above. The typical Silver Creek fauna, like the Jeffersonville, is found in Kentucky only in the vicinity of Louisville, but elements of the Beechwood fauna can be recognized along the west side of the Cincinnati anticline as far south as Allen County, on the south border of the State.

Along the east side of the Cincinnati anticline the middle Devonian fauna is not so typically Beechwood, nor does it closely resemble that of the Silver Creek or Jeffersonville as the latter faunas appear at Louisville. The species are dominantly Hamilton, although associated with the Hamilton forms are others that are frequently found in the Onondaga. Because of the somewhat mixed character of the Middle Devonian fauna on the east side of the Cincinnati axis, Foerste has called the strata in which this fauna occurs the Boyle limestone. On the east side of the Cincinnati anticline the Tully fauna has been recognized in Estill and Powell counties.

The Genesee fauna is much more widespread than the Tully, or even than the older middle Devonian faunas. It is found almost everywhere the New Albany shale is exposed in this region.

SOURCES AND RELATIONSHIPS OF THE DEVONIAN FAUNAS

The earliest middle Devonian sea that entered this region came up from the south, and brought with it a fauna from South America. This is the Clear Creek fauna of Illinois and the Camden fauna of Tennessee. Its southern origin is indicated by the presence in both regions of such brachiopod species as *Anoplia nucleata*, *Amphigenia elongata*. *Anoplotheca flabellites*, *Leptostrophia perplana*, and species of *Rhipidomella*. In the South American Devonian fauna there also occur species that are nearly related to those belonging to the genera *Actinopteria*, *Modiomorpha*, *Platyceras*, *Productella*, and *Spirifer* which are also found in the Clear Creek chert of southern Illinois.

The later Onondaga fauna of the lower Mississippi valley region includes that of the Grand Tower limestone of Illinois, and also that of the Jeffersonville limestone of Kentucky and Indiana. This fauna is thought to have been derived from the same source as that of the Clear Creek chert, and to have entered this region from the south, as did the chert fauna. Evidence of this is seen in the similarity of a number of the species of the middle Devonian faunas of South America and the lower Mississippi Valley areas.

Weller and Stauffer assumed that the coral and cephalopod elements of the Onondaga fauna came from western Europe around the north Atlantic basin, and entered the New York region by way of Hudson Bay.

However, it seems somewhat more probable to the writer that the sea which brought the Grand Tower and Jeffersonville faunas into the Illinois and Kentucky areas came up from the south, and covered southwest Illinois and adjacent portions of Missouri some time before it reached the vicinity of Louisville, Kentucky, as shown in the comparative table of the Devonian faunas in Kentucky and bordering States. In Kentucky the layers containing very numerous shells of *Spirifer gregarius* occur near the base of the Jeffersonville limstone, while in Illinois this *Spirifer gegarius* zone is found at the top of the Grand Tower limestone. In Kentucky the strata containing *Spirifer acuminatus* are present in the Jeffersonville limestone a number of feet above the *Spirifer gegarius* zone, while in Illinois the horizon of upper Jeffersonville strata containing *Spirifer acuminatus* is absent, but there are present in Illinois a thickness of 40 or more feet of Grand Tower (Onondaga) strata below the coral reef zone which are entirely absent in Kentucky. In these lower Grand Tower strata there occurs a zone containing abundant remains of the trilobite *Dalmanites* (*Odontocephalus*) *aegeria* which is scarcely found in Kentucky, indicating that the deeper part of the sea in this region during Onondaga time was to the west and northwest of Louisville, and that the Jeffersonville fauna of Kentucky represents late Onondaga time.

The Hamilton fauna in Kentucky is represented by that of the Sellersburg. It is thought to have been derived from the modification of the late Onondaga fauna mingled with another migration from a southern source. This migration is indicated by the presence in the Hamilton fauna of such species as *Tropidoleptus carinatus*, *Vitulina pustulosa*, in the Devonian of both regions, and of other species in the South American area that seem to be nearly related to *Chonetes scitula*, *Spirifer audaculus*, *Modiomorpha concentrica*, *Leda diversa*, *Pholadella paralella*, *Actinopteria boydi*, and *Cryphaeus boothi*.

The upper Devonian faunas represented in Kentucky are the Tully and the Genesee. The former is found in the Duffin layer, and the latter is present in the New Albany shale.

The Tully fauna is largely composed of modified holdovers of the Hamilton fauna, plus a number of immigrants of species like *Hypothyris cuboides* which probably came from western Europe where these species were common. However, *Hypothyris cuboides* was also present in the lower-upper Devonian fauna that came down the Mackenzie River basin from northern Asia. None of the Tully species appears to have near relatives in the Devonian of South America, which precludes the possibility of the migrant element of this fauna coming from that source.

This Euro-Asiatic fauna entered the interior of North America from the north either by way of Hudson Bay or the North Atlantic. If by the latter route, it may have entered through the Connecticut River gateway and spread southwestward from the New York area into Kentucky.

The Genesee fauna also probably had a European source, although John M. Clarke has called attention to a possible southern element in this fauna. It probably gained entrance to the Kentucky region by the same route as the preceding Tully fauna. It contains a relatively small number of species, many of which are inarticulate brachiopods as is common in such black shale deposits as the New Albany.

THE JEFFERSONVILLE FAUNA

The fauna of the Jeffersonville limestone in Kentucky is remarkable for its fine preservation, and for the great number and variety of the species it contains, more than 400 having been reported from the Louisville region. The waters of the Jeffersonville sea in this region were warm and clear, and reef building corals grew in great profusion, 178 species of these fossils have been reported from the Falls of the Ohio locality. These corals were figured by Davis in his report on Kentucky Fossil Corals. Brachiopods and mollusks are also numerous, and early attracted the attention of paleontologists. Nettleroth figured and described a large number of these in his report

entitled Kentucky Fossil Shells, published by the Kentucky Geological Survey. Hall and Ulrich have studied the bryozoa fauna. Ulrich has described the ostracods of this limestone; and Kindle has studied the trilobites.

Charles Butts[1] has compiled the following list of species that have been reported from the Jeffersonville limestone of this region, and several of the more common and characteristic species of this fauna are figured on Plates XXVII-XXIX of this paper.

List of Fossils from the Jeffersonville Limestone

CORALS

Acrophyllum clarki Davis
A. ellipticum Davis
A. oneidaense Billings
Alveolites constans Davis
A. minimus Davis
A. mordax Davis
A. squamosus Billings
Aulacophyllum conigerum Davis
A. insigne Davis
A. mutabile Davis
A. parvum Davis
A. sulcatum D'Orbigny
A. unguloideum Davis
Aulopora cornuta Billings
A. culmula Davis
A. edithana Davis
A. procumbens Davis
A. serpens Goldfuss
Blothropnyllum approximatum Nicholson
B. cinctutum Davis
B. corium Davis
B. decorticatum Billings
B. liratum Davis
B. louisvillense Davis
B. parvulum Davis
B. sessile Davis
B. zaphrentiforme Davis
Chonophyllum magnificum Billings
C. multiplicatum Davis
Cladopora acupicta Davis
C. alpenensis Rominger
C. aspera Rominger
C. billingsi? Rominger
C. bifurca Davis
C. crassa Davis
C. cryptodens Billings
C. dentata Davis
C. desquamata Davis
C. dispansa Davis
C. expatiata Rominger

[1]Kentucky Geol. Survey, Series IV, Vol. 3, pt. 2, pp. 106-115, 1915.

C. fibrata Davis
C. francisci Davis
C. gracilis Davis
C. imbricata Rominger
C. iowaensis Owen
C. labiosa Billings
C. pinguis Rominger
C. pulchra Rominger
C. radula Davis
C. ricta Davis
C. rimosa Rominger
C. robusta Rominger
C. roemeri?
C. tela Davis
Cyathophlium brevicorne Davis
C. coralliferum? Davis
C. corniculum Lesueur
C. (Acervularia) davidsoni Edwards and Haime
C. detextum Davis
C. fimbriatum Davis
C. flos Davis
C. greeni Davis
C. ligatum Davis
C. multigemmatum Davis
C. oedipus Davis
C. ovoideum Davis
C. pocillum Davis
C. pumilus Davis
C. robustum Hall
C. rugosum Hall
C. winchelli Davis
Cystiphyllum cicatriciferum Davis
C. cayugaense? Davis
C. edwinanum Davis
C. grande Billings
C. hispidum Davis
C. limbatum Davis
C. lineatum Davis
C. nettelrothi Davis
C. os Davis
C. plicatum Davis
C. squamosum Nicholson
C. sulcatum Hall
C. theissi Davis
C. tumidosum Davis
C. vesiculosum Goldfuss
Dendropora elegantula Billings
D. proboscidalis Rominger
Diphyphyllum bellis Davis
D. coagulatum Davis
D. coalescens Davis
D. conjunctum Davis
D. gigas Rominger
D. panicum Davis
D. strictum Edwards and Haime
D. verneuilianum Edwards and Haime
Drymopora (Syringopora) commensalis Davis
D. (Syringopora) fascicularis
D. (Syringopora) intermedia Nicholson

D. (Syringopora) nobilis Billings
Eridophyllum arundinaceum Billings
E. simcoense Billings
Favosites amplissimus Davis
F. arbor Davis
F. baculus Davis
F. canadensis Billings
F. cariosus Davis
F. clausus Rominger
F. clelandi Davis
F. convexus Davis
F. cymosus Davis
F. digitatus Rominger
F. emmonsi Rominger
F. epidermatus Rominger
F. frutex Davis
F. fustiformis Davis
F. hemisphericus and varieties Troost
F. impeditus Davis
F. intertextus Rominger
F. limitaris Rominger
F. mundus Davis
F. ocellatus Davis
F. pirum Davis
F. proximus Davis
F. quercus Davis
F. radiatus Rominger
F. radiciformis Rominger
F. ramulosus Davis
F. spiculatus Davis
F. tuberosus
Hadrophyllum d'Orbignyi Edwards and Haime
Heliophyllum (Cyathophyllum) colligatum Billings
H. (Cyathophyllum) exigum Billings
H. (Cyathophyllum) halli Edwards and Haime
H. (Cyathophyllum) infoveatum Davis
H. (Cyathophyllum) multicrena Davis
Michelinia clappi
M. corrugata Davis
M. cylindrica Edwards
Platyaxum (Cladopora, Pachypora) canadense Rominger
P. corioideum Davis
P. fischeri Billings
P. foliatum Davis
P. turgidum Billings
P. undosum Davis
Procteria michelinoidea Davis
P. papillosa Davis
Ptychophyllum coniferum Davis
P. diaphragma Davis
P. tropeum Davis
P. typicum Davis
Romingeria incrustans Davis
R. umbellifera Billings
R. uva Davis
Striatopora alba Davis
S. linnaeana Billings
Syringopora bouchardi Nicholson

S. hisingeri Billings
S. perelegans Billings
S. straminea Davis
S. tabulata Edwards and Haime
S. tubiporoides Yandell and Shumard
Thecia ramosa Rominger
Zaphrentis compressa Edwards
Z. (Cleisophyllum) conigera Billings
Z. exilis Davis
Z. gigantea Lesuer
Z. greenana Davis
Z. immanis Davis
Z. linneyi Davis
Z. macconathi Davis
Z. nodulosa Rominger
Z. prolifica Billings
Z. rafinesque Edwards and Haime
Z. romingeri Davis
Z. torquata Davis
Z. trigemma Davis
Z. yandelli E. and H.

ECHINODERMATA

Ancyrocrinus spinosus Hall
Codaster americanus Shumard
C. pyramidatus Shumard
Dolatocrinus lacus Lyon
D. marshi Lyon
Megistocrinus knappi Lyon and Casseday
M. spinulosus Lyon
Nucleocrinus angularis Lyon
N. greeni Miller and Gurley
N. venustus Miller and Gurley
N. verneuili Troost
Poteriocrinus cylindricus Lyon
P. simplex Lyon

BRYOZOA

Botryelopora socialis Nicholson
Buskopora bistriata Hall
B. dentata Ulrich
B. pyriformis Hall
Chaetetes ponderosus Hall
C. tenuis Hall
Clonopora semireducta Hall
Coscinium cribriforme Prout
Cystopora geniculata Hall
Cystodictya gilberti Meek
C. ovatipora Hall
C. vermicula Hall
Dekayia devonica Ulrich
Discotrypa devonica Ulrich
Eridopora clivulata Hall
E. denticulata Hall
Fenestella aequalis Hall
F. cultrata Hall
F. curvijunctura Hall
F. depressa Hall
F. perplexa Hall
F. proutana Miller

F. pulchella Ulrich
F. serrata Hall
F. singularitas Hall
F. stellata Hall
F. tenella Hall
F. variapora Hall
F. verrucosa Hall
Fenestrapora infraporosa Ulrich
Fistulipora alternata Hall
F. conulata Hall
F. geometrica Hall
F. granifera Hall
F. normalis Ulrich
F. ovata Hall
F. subcava Hall
F. substellata Hall
Glossotrypa paliformis Hall
Hederella adnata Davis
H. canadensis Nicholson
H. cirrhosa Hall
Helicopora ulrichi Claypole
Hemitrypa cribosa Hall
Hernodia humifusa Hall
Intrapora puteolata Hall
Lichenotrypa longispina Hall
Lioclema intercellatum Hall
Orthopora regularis Hall
O. rhombifera Hall
Phractopora cristata Hall
Phyllopora aspera Ulrich
Polypora aculeata Hall
P. blandida Ulrich
P. celsipora minor Hall
P. intermedia Prout
P. laevistriata Hall
P. levinodata Hall
P. quadrangularis Hall
P. striatopora Hall
P. shumardi Prout
P. submutans Hall
P. transversa Ulrich
Prismopora spasipora Hall
P. triquetra Hall
Ptiloporella bifurca Ulrich
Reteporidra adnata Hall
Rhombopora lineinoides Ulrich
R. lineinoides-humilis Ulrich
Scalaripora scalariformis Hall
S. subconcava Hall
Selenopora circincta Hall
S. complexa Hall
Semicoscinium biimbricatum Hall
S. biserrulatum Hall
S. interruptum Hall
S. latijuncturum Hall
S. lunulatum Hall
S. permarginatum Hall
S. planodorsatum Ulrich
S. rhomboideum Prout

S. semirotundum Hall
S. tortum Hall
S. tuberculatum Prout
Strotopora perminuta Ulrich
Thamniscus nanus Hall
Trematella annulata Hall
T. arborea Hall
Unitrypa acaulis Hall
U. anonyma Hall
U. fastigata Hall
U. tegulata Hall

BRACHIOPODA

Athyris fultonensis Swallow = A. vittata
Atrypa ellipsoida Nettelroth
A. reticularis Linnaeus
Camarotoechia carolina Hall
C. tethys Billings
Chonetes mucronatus Hall
Cranaena (Terebratula) romingeri Hall
Cyrtina crassa Hall
Eunella (Terebratula) harmonia Hall
E. (Terebratula) lincklaeni Hall
Meristella nasuta Conrad
Nucleospira concinna Hall
Parazyga (Trematospira) hirsuta Hall
Pentamerella arata Conrad
P. pavilionensis Hall
P. thusnelda Nettleroth
Pholidostrophia iowaensis Owen = Strophodonta nacrea
Productella semiglobosa. Nettelroth
Rhynchonella louisvillensis Nettelroth
R. tenuistriata Nettleroth
Schuchertella (Streptorhynchus) chemungensis arctistriata Hall
Spirifer acuminatus Conrad
S. arctisegmentum Hall
S. audaculus Conrad
S. davisi Nettelroth
S. divaricatus Hall
S. duodenarius Hall
S. fornacula Hall
S. gregarius Hall
S. grieri Hall
S. raricosta Hall
S. segmentum Hall
S. varicosus Hall
Stropheodonta demissa Conrad
S. hemispherica Hall
S. inequistriata Conrad
S. perplana Conrad
S. plicata Hall
Terebratula jucunda Hall

PELECYPODS

Actinopteria boydi Conrad
Aviculopecten fasciculatus Hall
A. pecteniformis Conrad

A. princeps Conrad
Conocardium cuneus Conrad
Cypricardinia cataracta Conrad
Glyptodesma cancellata Nettleroth
Glyptodesma occidentale Hall
Goniophora truncata Hall
Modiomorpha affinis Hall
M. mytiloides Conrad
Paracyclas elliptica Hall

GASTROPODS

Bucania devonica Hall and Whitfield
Callonema bellatulum Hall
C. clarki?
C. imitator Hall and Whitfield
Cyclonema multilirata Hall
Murchisonia desiderata Hall
Platyceras bucculentum Hall
P. compressum Nettelroth
P. conicum Hall
P. dumosum Conrad
P. dumosum var rarispinum Hall
P. erectum Hall
P. milleri Nettelroth
P. multispinosum Meek
P. rictum Hall
P. symmetricum Hall
P. thetis Hall
P. ventricosum Conrad
Platyostoma turbinatum Hall
Pleuronotus (Euomphalus) decewi Billings
Pleurotomaria arabella Nettelroth
P. lucina Hall
P. procteri Nettelroth
P. sulcomarginata Conrad
Strophostylus varians Hall
Trochonema rectilatera Hall
T. yandellana Hall and Whitfield
Turbo shumardi De Verneuil

CEPHALOPODS

Gomphoceras sp
Goniatites discoideus Hall
Gyroceras inelegans Meek

OSTRACODS

Leperditia subrotunda Ulrich
Isochilina rectangularis Ulrich
Aparchites inornatum Ulrich
Beyrichia lyoni Ulrich
B. kolmodini Jones
Ctenobolbina spinulosa Ulrich
C. armata Ulrich
C. cavimarginata Ulrich
C. insolens Ulrich
C. papillosa Ulrich
C. informis Ulrich
C. antespinosa Ulrich
Kirkbya subquadrata Ulrich

K. parallela Ulrich
K. semimuralis Ulrich
K. cymbula Ulrich
K. germana Ulrich
Bollia ungula Jones
B. obesa Ulrich
Halliella retifera Ulrich
Octonaria stigmata Ulrich
O. stigmata var. loculosa Ulrich
O. ovata Ulrich
O. clavigera Ulrich
Bythocypris devonica Ulrich
B. punctulata Ulrich
B. indianensis Ulrich
Pachydomella tumida Ulrich
B. punctostriata Ulrich
B. punctostriata var. curta Ulrich
B. pulchella Ulrich

TRILOBITES

Calymene platys Green
Dalamanites (Odontocephalus) aegeria Hall
D. anchiops Green
D. aspectans Conrad
D. helena Hall
D. pleuroptyx Green
D. selenurus Hall and Clarke
Lichas sp.
Phacops cristata Hall
P. cristata var. pipa Hall and Clarke
P. rana Green
Proetus canaliculatus Hall and Clarke
P. clarus Hall
P. crassimarginatus Hall
P. microgemma Hall and Clarke

The Sellersburg Fauna.

In the vicinity of Louisville the Sellersburg fauna is separable into the Silver Creek below and the Beechwood fauna above. The number of species in the Silver Creek fauna is much smaller than that in the Beechwood, but the number of individuals of the species is commonly more numerous.

The Silver Creek Fauna. The species making up the Silver Creek fauna in the vicinity of Louisville include the following: *Zaphrentis sp.*, a few fragmentary byrozoa, *Athyris vittata*, *Atrypa reticularis*, *A. spinosa*, *Chonetes yandellanus*, *Cyrtina hamiltonensis*, *C. hamiltonensis* var. *recta*, *Eunella lincklaeni*, *Glossina* (*Lingula*) *triangulata*, *Meristella haskinsi*, *Spirifer byrnesi*, *S. fornacula*, *S. oweni*, *S. varicosus*, *Stropheodonta concava*, *S.* (*Leptostrophia*) *perplana*, *Tropidoleptus*

carinatus, *Aviculopecten crassicostatus*, *Paracyclas elliptica*, *P. lirata*, *Polyphemopsis louisvillae*, and *Nautilus maximus*.

A few of the more common and diagnostic of these species are figured on Plate XXX of this paper.

THE BEECHWOOD FAUNA. The Beechwood fauna is much larger than that of the Silver Creek, although the thickness of the rocks from which it is obtained in this region is only about half as great, being less than 10 feet. Corals are much more numerous, as are crinoids; and practically all of the classes of fossils in the Silver Creek fauna are represented in the Beechwood by a considerably greater number of species. Charles Butts[2] has prepared the following list of fossils from the Beechwood limestone:

List of Fossils from the Beechwood Limestone Member

CORALS

Alveolites goldfussi Billings
A. scandularis Davis
Antholites speciosus
Aulacophyllum conigerum Davis
Aulopora cornuta Billings
Chonophyllum nanum Davis
Cladopora alicornis Davis
C. gulielmi Davis
C. pinguis Rominger
Cyathophyllum ethelanum Davis
C. insigne Davis
C. pustulosum Davis
C. scyphus Rominger
C. tornatum Davis
C. trauthanum Davis
Cystiphyllum americanum Edwards and Haime
C. ohioense Nicholson
Dendropora alternans Rominger
D. neglecta Rominger
D. ornata Rominger
D. osculata Davis
Diphyphyllum (Crepidophyllum) archiaci Billings
Drymopora auloporoidea Davis
D. frutectosa Davis
Favosites cavernosus
F. digitatus Rominger
F. goodwini Davis
F. eximius Davis
F. placenta Rominger
F. rotundituba Davis
Heliophyllum juvene Rominger
H. infoveatum Davis
Michelinia insignis Rominger
M. plana Davis

[2] Kentucky Geol. Survey, Series IV, Vol. 3, P. 2, pp. 126-128, 1915.

Zaphrentis cornalba Davis
Z. explanata Davis
Z. gallicalcar Davis
Z. nettelrothi Davis
Z. nodulosa Rominger
Z. reynoldsi Davis
Z. trigemma Davis
Z. ungula Rominger

CRINOIDS

Ancyrocrinus bulbosus Hall
Dolatocrinus bulbaceus Miller and Gurley
D. greeni Miller and Gurley
D. tuberculatus Wachsmuth and Springer
Gennaeocrinus kentuckiensis Shumard
Megistocrinus depressus Hall
M. rugosus Lyon and Casseday

BRACHIOPODS

Ambocoelia umbonata Conrad
Athyris fultonensis Swallow
Atrypa spinosa Hall
Camarotoechia sappho Hall
Centronella glansfagea Hall
Chonetes acutiradiatus Hall
Crania sheldoni White=C bordini Hall and Whitfield
Cyrtina hamiltonensis Hall
C. hamiltonensis var recta Hall
Delthyris (Spirifer) sculptilis Hall
Orbiculoidea (Discina) doria Hall
Pentagonia (Meristella) unisulcata Conrad
Pholidostrophia iowaensis Owen
Productella spinulicosta Hall
Rhipidomella (Orthis) goodwini Nettleroth
R. (Orthis) livia Billings
R. (Orthis) vanuxemi Hall
Schizophoria (Orthis) striatula Schlotheim
Schuchertella chemungensis arctistriatus Hall (Streptorhynchus arctostriata Nettelroth)
Spirifer audaculus Conrad
S. hobbsi Nettelroth
S. macconathi Nettelroth
S. oweni Hall = Spirifer granulosus
S. segmentum Hall
S. varicosus Hall
Stropheodonta concava Hall
S. demissa Conrad
S. perplana Conrad

PELECYPODS

Aviculopecten princeps
Clinopistha antiqua Meek
C. striata Nettelroth
C. subnasuta Hall and Whitfield
Grammysia gibbosa Hall and Whitfield
Limoptera cancellata Hall
Modiomorpha affinis Hall
M. alta Conrad
M. charlestowensis Nettelroth

M. concentrica Conrad
M. mytiloides Conrad
Nucula herzeri Nettleroth
N. neda Hall and Whitfield
N. niotica Hall and Whitfield
Paracyclas elongata Nettelroth
P. ohioensis Meek
Ptychodesma knappiana Hall
Yoldia valvulus Hall and Whitfield

GASTROPODS

Bellerophon leda Hall
Euomphalus sampsoni Nettelroth
Loxonema hamiltoniae Hall
L. hydraulicum Hall and Whitfield
L. laeviusculum Hall
L. rectistriatum Hall
Platyceras conicum Hall
P. dumosum Conrad
P. echinatum Hall
P. rarispinum Hall
P. lineatum Conrad

PTEROPODS

Tentaculites scalariformis Hall

CEPHALOPODS

Gomphoceras oviforme Hall
G. turbiniforme Meek and Worthen

OSTRACODS

Kirkbya sp.?

TRILOBITES

Dalmanites calypso Hall and Clarke
Phacops rana Green
Proetus macrocephalus Hall

THE BOYLE FAUNA

Foerste proposed the name Boyle limestone for the middle Devonian limestone along the east side of the Cincinnati anticline because this limestone appeared to furnish an equivocal fauna containing a mixture of Onondaga and Hamilton species. The following species have been reported as from the middle Devonian limestone on the east side of the Cincinnati axis and hence make up the Boyle fauna:

List of Fossils from the Boyle Limestone

CORALS

Amplexus yandelli Ed. and H.
Blothrophyllum cinctutum Davis
B. decorticatum Billings
B. houghtoni Davis
B. zaphrentiforme Davis

Cyathophyllum sp.
Cytiphyllum americanum Ed. and H.
Favosites epidermatus Rominger
F. eximius Davis
F. goodwini Davis
F. limitaris Rominger
F. placenta Rominger
Heliophyllum halli Ed. and H.
H. osculatum
Michelinia insignis Rominger
M. plana Davis
Phillipsastrea gigas Billings
Syringopora sp.
Trachypora ornata Davis
Zaphrentis gigantea Lesueur
Z. prolifica Billings
Z. sp.

CRINOIDEA

Dolatocrinus sp.
Megistocrinus sp.

BRACHIOPODA

Ambocoelia umbonata Conrad
Athyris spiriferoides Hall
A. vittata Hall
Atrypa reticularis Linn
Camarotoechia cf. carolina
C. horsfordi Hall
C. sappho Hall
Centronella glansfagea Hall
Chonetes coronatus Conrad
C. yandellanus Hall
Crania favincola
Cyclorhina nobilis Hall
Cyrtina hamiltonensis Hall
Delthyris sculptilis Hall
Eunella harmonia Hall
Lingula sp.
Orbiculoidea cf. doria Hall
O. cf. media Hall
Pentagonia unisulcata Conrad
Pentamella arata Conrad
P. pavilonensis Hall
Productella spinulicosta Hall
Reticularia fimbriata Conrad
Rhipidomella cf. livia Billings
R. vanuxemi Hall
Schuchertella chemungensis var arctistriata Hall
Spirifer byrnesi Nettelroth
S. fornacula Hall
S. granulosus Conrad
S. grieri Hall
S. manni Hall
S. segmentum Hall
S. varieosus Hall
Stropheodonta concava Hall
S. demissa Conrad

S. (Leptostrophia) perplana Conrad
Tropidoleptus carinatus (Conrad)

PELECYPODA

Actinopteria cf. boydi Conrad
Aviculopecten cf. princeps Conrad
Conocardium sp.
Cypricardinia cf. indenta Conrad
Platyceras bucculentum Hall
P. carinatum Hall
P. conicum Hall
P. sp.
Platyostoma lineatum Conrad
Strophostylus varians Hall

PTEROPODA

Tentaculites bellulus Hall

CEPHALPODA

Orthoceras sp.

TRILOBITA

Phacops rana Green
Proetus cf. clarus

It will be seen from the above list of species that the Boyle fauna is quite distinctly that of the Hamilton.

THE CASEY FAUNA

Along the south and southeast side of the Blue Grass region the writer has distinguished a cherty limestone resting in apparent unconformity on the Beechwood limestone or its equivalent in that region, to which the name Casey limestone was applied. The fauna of this upper-middle Devonian limestone in this region is not large, nor is it distinctly different from that of the Boyle limestone in the same region as may be seen from the following list of fossils from this limestone: *Favosites eximius, F. goodwini, F. cf. epidermatus, Ambocoelia umbonata, Pentamerella pavilionensis, Productella spinulicosta, Reticularia fimbriata, Rhipidomella vanuxemi, Spirifer segmentum, S. varicosus, Stropheodonta concava, Platyostoma lineatum.*

The fossils of the Casey indicate that the sedimentary break at the base of this limestone was a relatively short one.

THE DUFFIN FAUNA

In the Devonian area lying south and southeast of the Bluegrass region, on the east side of the Cincinnati anticline, Foerste has distinguished as the Duffin layer or bed a more or

less dolomitic limestone lying immediately below the New Albany shale, and unconformable on the middle Devonian limestone. In Estill and Powell counties this Duffin bed furnished a Tully fauna, which was also present in lenses or bands of similar limestone that was interbedded with the black New Albany shale for a distance of several feet above the base of that formation. This fauna contained the species *Ambocoelia umbonata, Camarotoechia cf sappho, Camarotoechia sp., Chonetes cf. mucronatus, Coelospira sp., Gypidula cf. comis, Hypothyris cuboides?, Leiorhynchus quadricostatus, Leiorhynchus sp., Martinia subumbona, Spirifer tullius, Spirifer sp.,* and *Strophalosia sp.*

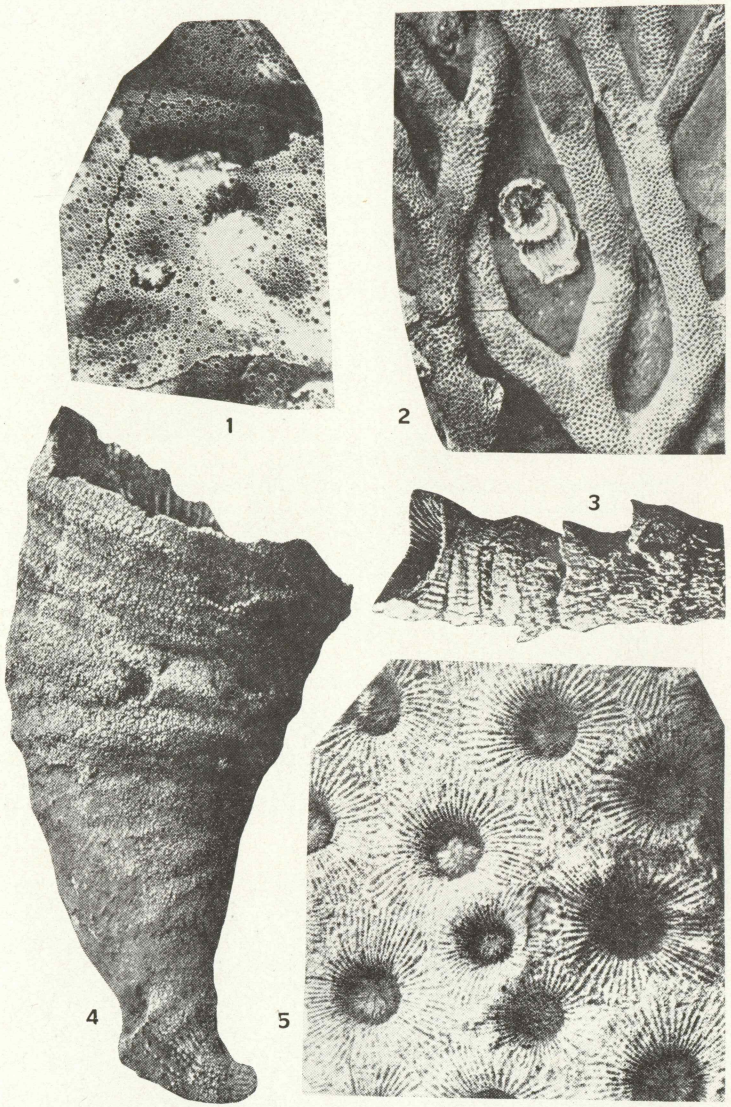
THE NEW ALBANY FAUNA

The New Albany fauna in Kentucky is mostly of Genesee age. It is most abundant in the lower part of the black shale, but in places several of the species continue a number of feet above the base, and may be found in some places near the top of this formation. The number of species in this fauna is not large, but in places the individual shells are very abundant. The following are the more common species in the New Albany shale: *Polygnathus cf. dubius, Prioniodus armatus, P. cf. radiatus, Leiorhynchus quadricostatus, Lingula ligea, L. spatulata, L. (Lingulipora) williamsana, Lingula sp., Orbiculoidea cf. minuta, Meristella cf. haskinsi, Roemerella cf. grandis, Schizobolus concentricus, Plethospira socialis, Stroparollus sp.,* and *Styliola fissurella.*

Explanation of Plate XXVII

Figure

1. *Favosites canadensis* Billings. From the Jeffersonville limestone after Rominger.
2. *Cladopora bifurca* Davis. From the Jeffersonville limestone. After Davis.
3. *Blothrophyllum cinctutum* Davis. From the Jeffersonville limestone. After Davis.
4. *Zaphrentis prolifica* Billings. From the Jeffersonville limestone. After Davis.
5. *Phillipsastrea gigas* Billings. From the Jeffersonville limestone. After Davis.



Fossils of the Jeffersonville Limestone—Devonian

Explanation of Plate XXVIII

Figure

1 & 8. *Elaeacrinus* (*Nucleocrinus*) *verneuili* Troost. Jeffersonville limestone. After Grabau and Shimer.

2- 3. *Pentamerella pavilionensis* Hall. Jeffersonville limestone. After Nettelroth.

4. *Chonetes mucronatus* Hall. Jeffersonville and Sellersburg limestones. After Hall.

5- 6. *Camarotoechia tethys* Billings. Jeffersonville limestone. After Nettelroth.

7. *Atrypa reticularis* Linnaeus. Jeffersonville and Sellersburg limestones. After Nettelroth.

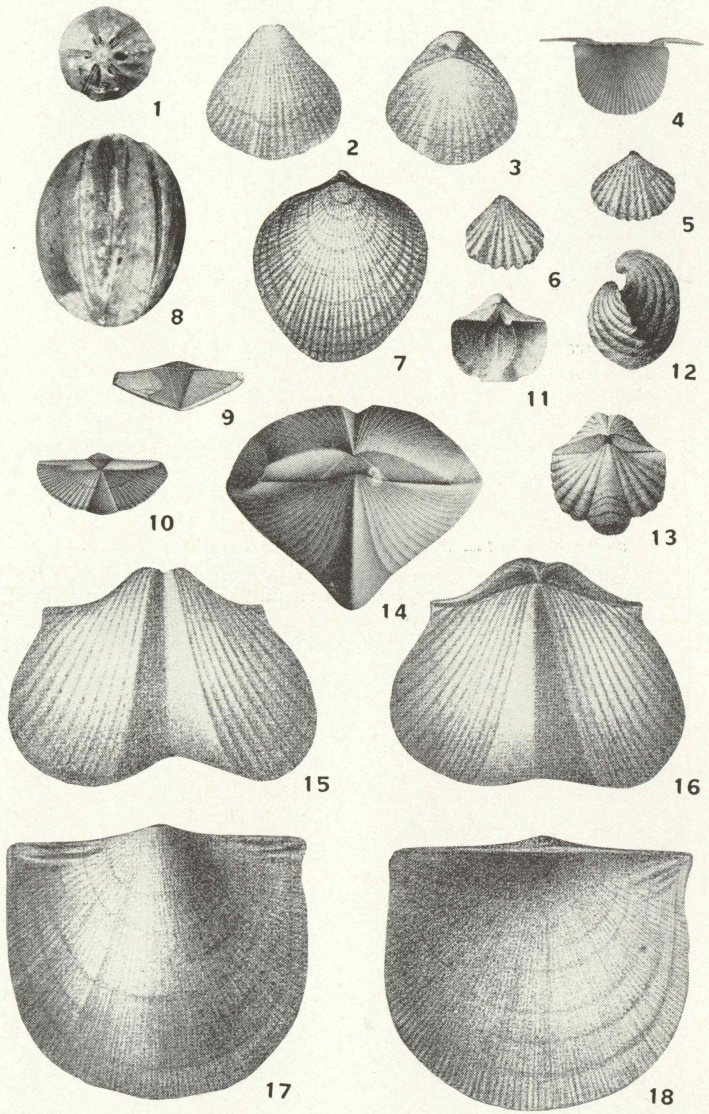
9-10. *Spirifer segmentum* Hall. Jeffersonville and Sellersburg limestones. After Hall.

11-13. *Spirifer gregarius* Clapp. Jeffersonville limestone. After Hall.

14-16. *Spirifer acuminatus* Conrad. Jeffersonville limestone. 14 after Hall. 15 and 16 after Nettelroth.

17-18. *Stropheodonta hemispherica* Hall. Jeffersonville limestone. After Nettelroth.

PLATE XXVIII



Fossils of the Jeffersonville Limestone—Devonian

Explanation of Plate XXIX

Figure

1- 2. *Conocardium cuneus* Conrad. Jeffersonville limestone. After Nettelroth.

3. *Modiomorpha mytiloides* Conrad. Jeffersonville and Sellersburg limestones. After Hall.

4- 5. *Nucula niotica* Hall and Whitfield. Sellersburg limestone. After Nettelroth.

6. *Platyostoma lineata* var. callosa Hall. Sellersburg limestone. After Nettelroth.

7. *Nucula neda* Hall and Whitfield. Sellersburg limestone. After Nettelroth.

8 & 12. *Pleurotomaria sulcomarginata* Conrad. Jeffersonville limestone. After Nettelroth.

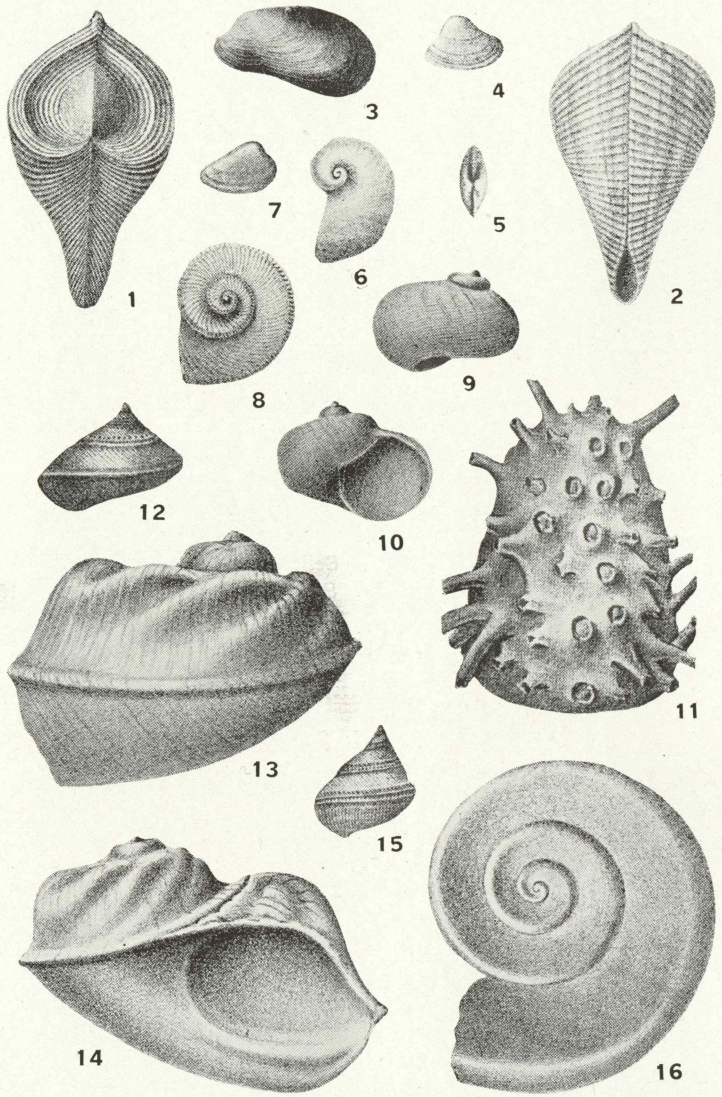
9-10. *Platyostoma lineata* Conrad. Sellersburg limestone. After Nettelroth.

11. *Platyceras dumosum* Conrad. Jeffersonville and Sellersburg limestones. After Nettelroth.

13-14. *Turbo shumardi* Verneuil. Jeffersonville limsetone. After Nettelroth.

15. *Pleurotomaria procteri* Nettelroth. Jeffersonville limestone. After Nettelroth.

16. *Pleuronotus decewi* Billings. Jeffersonville limestone. After Nettelroth.



Fossils of the Sellersburg and Jeffersonville Limestone—Devonian

Explanation of Plate XXX

Figure

1- 2. *Spirifer hobbsi* Nettelroth. Sellersburg limestone. After Nettelroth.

3. *Trematospira hirsuta* Conrad. Sellersburg (Hamilton) limestone. After Hall.

4- 5. *Athyris vittata* Hall. Sellersburg limestone. After Nettelroth.

6- 7. *Camarotoechia sappho* Hall. Sellersburg limestone. After Hall.

8- 9. *Chonetes coronatus* Hall. Sellersburg limestone. After Hall.

10. *Tropidoleptus carinatus* Conrad. Sellersburg limestone.

11. *Reticularia fimbriata* Conrad. Sellersburg limestone. After Hall.

12-13. *Rhipidomella vanuxemi* Hall. Sellersburg limestone. After Nettelroth.

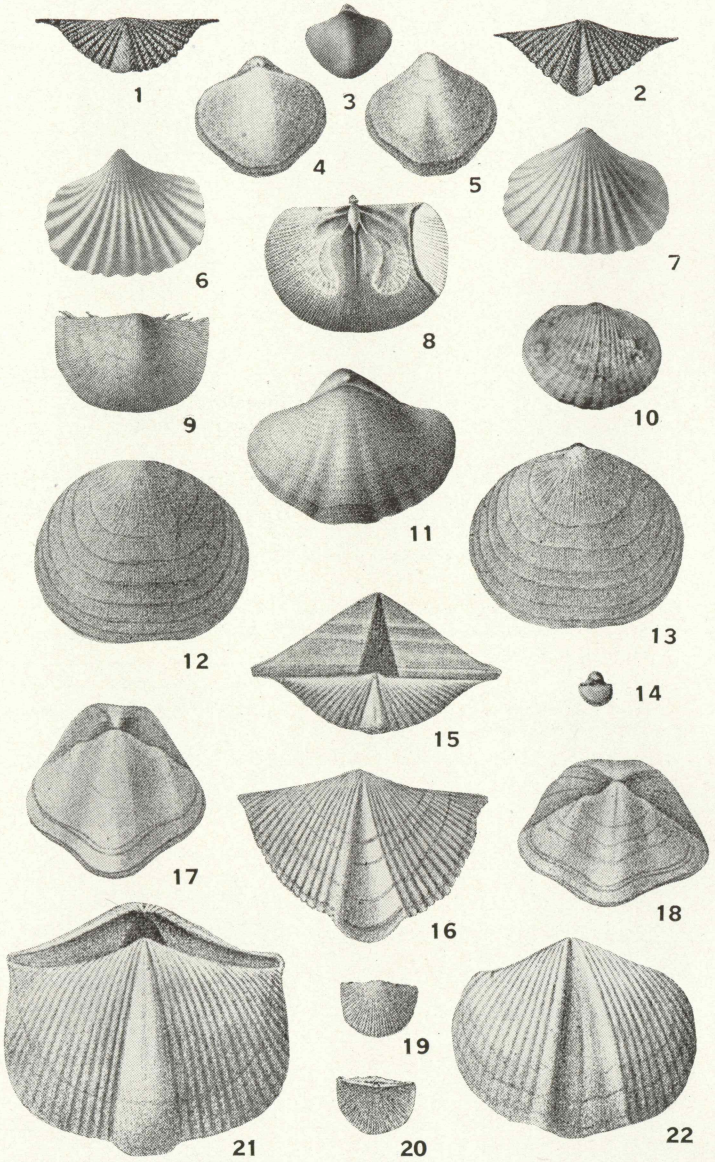
14. *Ambocoelia umbonata* Conrad. Sellersburg limestone. After Nettelroth.

15-16. *Spirifer fornacula* Hall. Sellersburg and Jeffersonville limestones. After Nettelroth.

17-18. *Pentagonia unisulcata* Conrad. Sellersburg limestone. After Nettelroth.

19-20. *Chonetes yandellanus* Hall. Sellersburg limestone. After Nettelroth.

21-22. *Spirifer granulosus* Hall. Sellersburg limestone. After Nettelroth.

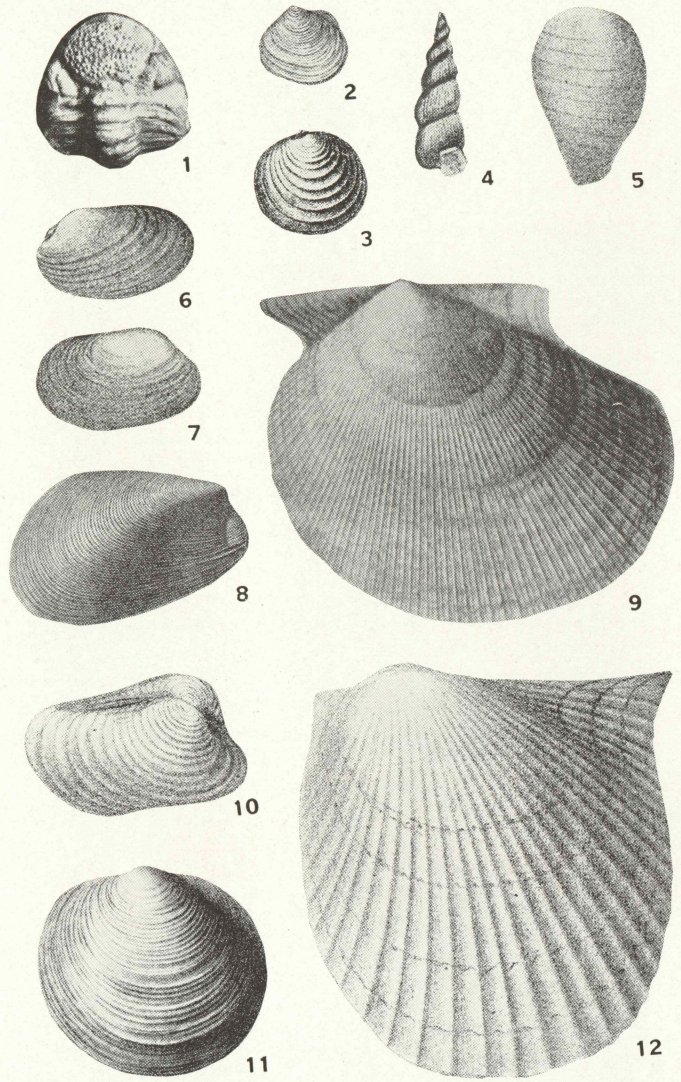


Fossils of the Sellersburg Limestone—Devonian

Explanation of Plate XXXI

Figure

1. *Phacops rana* Green. Sellersburg limestone.
2. *Paracylas ohioensis* Meek. Sellersburg limestone. After Nettelroth.
3. *Paracyclas lirata* Conrad. Sellersburg limestone. After Hall.
4. *Loxonema hydraulicum* Hall and Whitfield. Sellersburg limestone. After Nettelroth.
5. *Gomphoceras turbiniforme* Meek and Worthen. Sellersburg limestone. After Nettelroth.
6- 7. *Clinopistha antiqua* Meek. Sellersburg limestone. After Nettelroth.
8. *Modiomorpha concentrica.* Conrad. Sellersburg limestone. After Hall.
9. *Aviculopecten princeps* Hall. Sellersburg limestone. After Hall.
10. *Grammysia gibbosa* Hall and Whitfield. Sellersburg limestone. After Nettelroth.
11. *Paracyclas elliptica* Hall. Sellersburg and Jeffersonville limestones After Hall.
12. *Glyptodesma cancellata* Nettelroth. Jeffersonville limestone. After Nettelroth.



Fossils of the Sellersburg and Jeffersonville Limestone—Devonian

Explanation of Plate XXXII

Figure

1- 3 *Lingula* (*Lingulipora*) *williamsana* Girty. New Albany shale. After Girty.

4- 5. *Lingula spatulata* Vanuxem. New Albany shale. After Hall.

6. *Lingula ligea* Hall. New Albany shale After Hall.

7 *Roemerella grandis* Vanuxem. New Albany shale. After Hall.

8-10. *Schizobolus concentricus* Vanuxem. New Albany shale. After Grabau and Shimer.

11-13. *Chonetes mucronatus* Hall. Duffin bed. After Hall.

14-17. *Spirifer subumbona* Hall. Duffin bed. After Hall.

18. *Leiorhynchus quadricostatus* Vanuxem. Duffin bed. After Girty.

19-20. *Hypothyris cuboides* (Sowerby). Duffin bed. After Hall.

21-22. *Ambocoelia umbonata* Conrad. Duffin bed. After Md. Surv.

23. *Gypidula* cf. *comis* Owen. Duffin bed. After Hall.

24. *Styliola fissurella* Hall. New Albany shale. After Kindle.

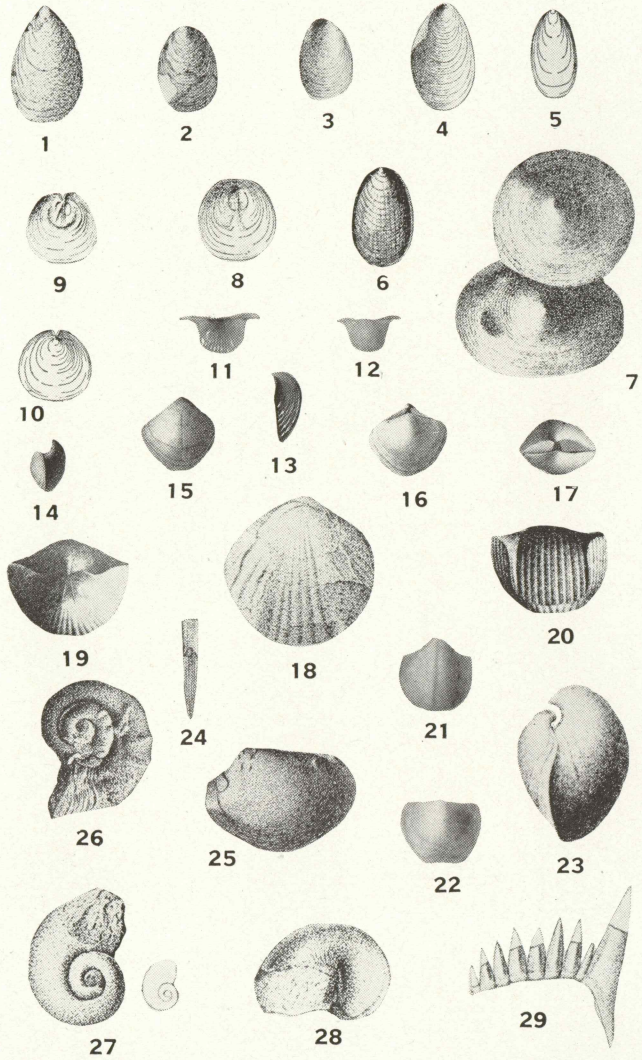
25. *Paleoneilo* sp. New Albany shale. After Kindle.

26. *Straparollus* sp. New Albany shale. After Kindle.

27-28. *Plethospira socialis* Girty. New Albany shale. After Girty.

29. *Prioniodus* Sp.

PLATE XXXII



Fossils of the Duffin Limestone and New Albany Shale—Devonian

V

MISSISSIPPIAN FAUNA

By

JAMES MARVIN WELLER

CALIFORNIA STATE DIVISION MINES
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THE MISSISSIPPIAN FAUNA OF KENTUCKY

By

JAMES MARVIN WELLER

INTRODUCTION

The Mississippian System was named for the Mississippi Valley where it was first studied and the stratigraphic succession worked out, mainly in Illinois, Iowa, and Missouri. The standard section is as follows:

CHESTER SERIES	UPPER CHESTER GROUP	Kinkaid limestone Degonia sandstone Clore limestone Palestine sandstone Menard limestone Waltersburg sandstone Vienna limestone Tar Springs sandstone
	MIDDLE CHESTER GROUP	Glen Dean limestone Hardinsburg sandstone Golconda limestone Cypress sandstone
	LOWER CHESTER GROUP	Paint Creek limestone Yankeetown chert Renault limestone Aux Vases sandstone
IOWA SERIES	MERAMEC GROUP	Ste. Genevieve limestone St. Louis limestone Salem limestone Warsaw limestone
	OSAGE GROUP	Keokuk limestone Burlington limestone Fern Glen limestone
	KINDERHOOK GROUP	Sunbury shale Berea sandstone Bedford sandstone and shale

In Kentucky all of the strata between the New Albany shale below and the Coal Measures or Pennsylvania above belong to the Mississippian System.

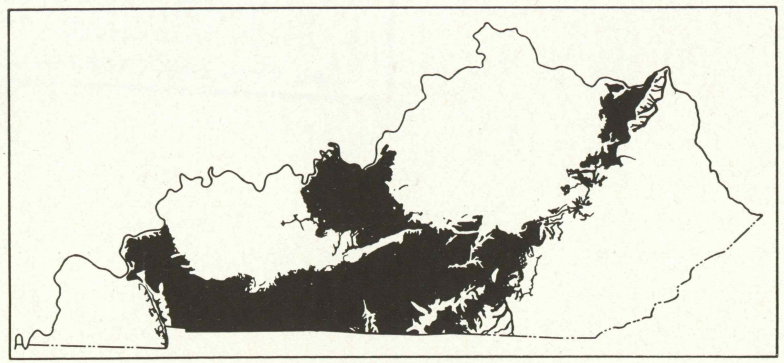


Fig. 28. Map of Kentucky showing outcrop of Mississippian rocks.

The seas which occupied the interior of North America, including the area which is now Kentucky, during the Mississippian period were transgressions from the Gulf of Mexico and except for those of the Kinderhook were broadly extensive. The clastic materials which were contributed during the first half of the period were largely derived from a land area lying to the east. On the other hand, the sands of the Chester series which are in part of continental and not margin origin, were brought in from the Ozark region and land to the north of the Chester embayment.

STRATA OF KINDERHOOK AGE

In northeastern Kentucky the New Albany shale is succeeded in ascending order by the Bedford shale, Berea sandstone, and Sunbury shale. The lower part of the Bedford shale is fossiliferous at some localities in Kentucky and has yielded a fauna with strong Devonian affinities. The Berea sandstone is unfossiliferous in Kentucky but many well characterized Mississippian species have been obtained from it in Ohio. The Sunbury is black and fissile and closely resembles the New Albany shale in character. A species of *Lingula*, another of *Orbiculoidea*, and a large variety of conodonts are the only fossils known from it.

These formations become thinner southward from the Ohio River and are not known beyond Irvine in Estill County. At this locality the Sunbury is separated from the New Albany

by only a few inches of strata representing the Bedford-Berea interval and south of here the two black shales come in contact and are indistinguishable. It is not known whether or not the Sunbury is represented in the upper part of the New Albany in other parts of Kentucky.

STRATA OF OSAGE AGE

New Providence Shale. Outcrops of the New Providence shale completely encircle the Bluegrass region and form the Knobs and the escarpment known as Muldraugh's Hill and also extend southward along the crest of the Cincinnati anticline. Near Lebanon a sandstone appears in the middle of this formation and to the eastward and northward it thickens until it has replaced the upper half of the formation. The two-fold division of the New Providence in eastern Kentucky corresponds to the Cuyahoga formation below and the Logan formation above both of which are typically represented in Ohio.

At some localities where thin limestone layers are present in the New Providence shale a large number of fossils may be collected. One of the most famous collecting localities is Buttonmould Knob, 12 miles south of Louisville. Collections from this and other localities have yielded a very large fauna. Most of the species range throughout the formation as they are present in collections made at various horizons from top to bottom. The New Providence fauna is rich in bryozoans and corals and at some localities many species of crinoids are represented. Brachiopods are present in considerable numbers although the variety of forms present is not so great while the molluscs generally are a rather inconspicuous and unimportant part of the fauna as a whole. The brachiopods are the most important species for correlation purposes and clearly show that the New Providence is of Fern Glen age. A few species are present whose range is restricted in other regions to beds either somewhat higher or somewhat lower than the Fern Glen and it is possible that a portion of the Kinderhook and lower Burlington may be represented in the New Providence. Among such species are *Schuchertella lens* (Pl. XXXIII figs. 8a, b) and *Athyris hannibalensis* (Pl. XXXIII, fig. 10) which are

restricted to the Kinderhook in the Mississippi Valley and *Brachythyris suborbicularis* (Pl. XXXIII, fig 1) and *Pustula alternata* (Pl. XXXIII, fig 11) which are not known from below the lower Burlington of this same region. Some of the more important species indicating the contemporaneity of the New Providence and Fern Glen are *Ptychospira sexplicata* (Pl. XXXIII, figs. 3a-c), *Spirifer vernonensis* (Pl. XXXIII, fig. 4) and *S. fernglenensis* (Pl. XXXIII, fig. 6). Certain other species which characterize the New Providence have not been obtained in other areas. Among these are *Rhipidomella oweni* (Pl. XXXIII, figs. 2a, b), *Strophalosia cymbula* (Pl. XXXIII, figs 5a, b), *Chonetes shumardanus* (Pl. XXXIII, figs, 7a, b) and *Spiriferina subelliptica* (Pl. XXXIII, fig. 9). The fauna of the New Providence gives no indication that this formation includes any beds of upper Burlington age.

Beds of Keokuk Age. The New Providence shale is succeeded by a series of sandy and shaly beds on the western and southern borders of the Bluegrass region which in the vicinity of Louisville have been divided into the Kenwood sandstone below, the Rosewood shale in the middle, and the Holtsclaw sandstone above. To the south and west of the Bluegrass this series of beds becomes more calcareous and passes into a cherty limestone that has been correlated with the Ft. Payne chert of Alabama. No beds of Keokuk age are known in eastern Kentucky north of Mt. Vernon. At some localities an uncomformity is believed to separate these beds from the underlying New Providence. The absence of upper Burlington faunas from Kentucky is an indication that there may be a hiatus in the midst of the Osage Group.

While the Keokuk beds have not produced as great a variety of fossils as the New Providence still the faunas are quite similar in general aspect. The brachiopods play a relatively more important part in these later Osage beds, and the bryozoans and corals are less well represented and crinoids are of much rarer occurrence. Many of the species are identical with those found in the New Providence but others which continue up into higher horizons make their first appearance here. Among these are *Productus wortheni* (Pl. XXXIV, fig. 1), *Syringothyris textus* (Pl. XXXIV, fig 2), *Spirifer keokuk* (Pl. XXXIV, fig. 4), *S. rostellatus* (Pl. XXXIV fig. 7) and *Orthotetes keokuk* (Pl. XXXIV, fig. 9). Other species which are confined exclusively to the Keokuk beds and therefore are of greater significance are *Rhynchopora beecheri* (Pl. XXXIV, figs. 5a, b) and *Spirifer crawfordsvillensis* (Pl. XXXIV, fig. 3).

In the western Kentucky counties where the Osage beds again make their appearance from beneath the younger formations they constitute a thick series of very cherty limestones. Fossils are not abundant in these strata and collections are difficult to obtain so that in this region it is not practicable to subdivide the Osage Group.

MERAMEC GROUP

Warsaw-Salem Limestones. In the Mississippi Valley two formations are recognized, the Warsaw and the Salem, between the Keokuk and the St. Louis. They are distinguished not so much by their fossils as by their lithologic character. The Salem does carry a distinctive fauna but it is made up of forms which are seldom found in any except oolitic limestone and is of little value in the recognition of the Salem where it is not oolitic and therefore capable of being separated by its lithologic features. While it is thought that the Salem has been recognized at several places in Kentucky it is best in a general discussion to consider these two formations as a single unit.

The Warsaw-Salem formation overlies beds of Keokuk age and it is possible that they are separated by a slight unconformity. It outcrops along the western side of the Bluegrass region and occupies considerable areas in south-central Kentucky. East of the Bluegrass it extends as far north as Berea but has not been recognized beyond. It also comes to the surface in limited areas in the western counties of the State.

The Warsaw-Salem contains coarsely crystalline crinoidal beds, earthy yellowish argilaceous limestone, more or less shale and, particularly in eastern Kentucky, some locally conspicuous sandstone members. Geodes are present at many places.

The fauna of the Warsaw-Salem is rather distinct from that of the Keokuk and a fairly sharp transition takes place particularly in southern Kentucky. The large spiriferoids of types found in the underlying beds are not abundant, corals are not as common as at some Keokuk localities and crinoids are seldom to be obtained. Among the characteristic fossils of the Warsaw-Salem are the brachiopods *Spirifer washingtonensis* (Pl. XXXV, fig. 4), *S. lateralis* (Pl. XXXV, fig 3) and *S. keokuk* (Pl. XXXIV, fig. 4). The last species occurs also in the Keokuk but is not as abundant as in these higher beds. Two species which are an unfailing guide to this formation and occur at no other horizon are the crinoid *Talarocrinus simplex* (Pl. XXXV, figs. 9a, b) and the blastoid *Metablastus wortheni* (Pl. XXXV, fig. 8). The bryozoan genus *Archimedes* (Pl. XLI, figs. 1a-6, Pl. XLIII, fig. 7) occurs for the first time in Kentucky, in the Warsaw-Salem. However it is not nearly so abundant as in the later Chester faunas. One of the species which is locally very common in these strata is the brachiopod *Productus magnus* (Pl. XXXV, fig. 1). It is unknown in the typical Warsaw but occurs in great numbers in beds of similar age in southeastern Missouri and on the whole the Kentucky fauna rather closely resembles that of this region to the west.

The typical Salem fauna is not known in Kentucky although a few of its members occur locally. This fauna is a peculiar one in which small gastropods and pelecypods play a most conspicuous part. It usually occurs in oolitic limestone associated with large numbers of the foraminifera *Endothyra baileyi* (Pl. XXXV, fig 7). Many of the species of this fauna are reminiscent of Devonian ancestors and it recurs with only slight modification at several later horizons notably the Ste. Genevieve, lower Chester and even well up in the Pennsylvanian.

St. Louis Limestone. In western Kentucky the St. Louis outcrops extend from Hardin County southward to Green River and thence southwestward to the Tennessee line. Farther west they enter the State again in Trigg County and extends northwestward toward the Ohio River. In eastern Kentucky they extend northward from the Tennessee line to the vicinity of Frenchburg beyond which they are absent. The St. Louis everywhere overlies beds of Warsaw-Salem age except in eastern Kentucky north of Berea where it overlaps onto older strata.

The St. Louis is usually rather sharply distinct lithologically from its adjacent formations. Its massive, dense, or fine grained limestone beds aid in distinguishing it from the crinoidal, more coarsely crystalline and argilaceous beds of the Warsaw-Salem and the oolitic beds of the Ste. Genevieve.

The most important guide fossil to the St. Louis is the massive colonial coral *Lithostrotion canadense* (Pl. XXXVI, figs. 1a, b). It is known in Kentucky only in this formation although in southeastern Missouri it occurs in the upper part of the Salem limestone. Another species *L. proliferum* (Pl. XXXVII, figs. 1a, b) is also rather common in the St. Louis although it does range upward into the lower Ste. Genevieve. Good collections are difficult to obtain from the St. Louis limestone both on account of its dense and massive character and the fact that it is usually covered by deep residual soil. Its fossils however are often to be obtained as casts in the chert which strews the surface of its zone of outcrop. In most places however the St. Louis may be readily recognized by the corals mentioned above and its lithologic character. A large number of the characteristic Warsaw-Salem species have never been observed in the St. Louis.

Ste. Genevieve Limestone. The Ste. Genevieve limestone everywhere overlies the St. Louis. In western Kentucky it occupies a more or less wide belt about the western coal field. In eastern Kentucky it outcrops in a much narrower zone completely across the State. In western Kentucky the Ste. Genevieve succeeds the St. Louis conformably but along its eastern outcrop an unconformity is at least locally present and north of Frenchburg where the St. Louis is absent the Ste. Genevieve lies unconformibly upon older beds.

Throughout much of its extent the Ste. Genevieve is more or less oolitic and this character is an important one in differentiating it from the St. Louis. Some beds of the Ste. Genevieve are notably sandy this being particularly true of its

northern outcrops in eastern Kentucky. In the western counties of the State a thin but persistent sandstone member, the Rosiclare, is present in the upper part of the formation.

Fossils are usually difficult to obtain from this massive limestone formation and its fauna has never been thoroughly studied. The coral *Lithostrotion proliferum* (Pl. XXXVII, figs. 1a, b) which occurs abundantly in some parts of the St. Louis persists into the lower beds of the Ste. Genevieve. On the other hand the crinoid *Platycrinus penicillus* (Pl. XXXVIII, figs. 2a-c) which is commonly present almost everywhere in the Ste. Genevieve and is the most reliable means of differentiating it from the overlying Chester, also occurs in the upper St. Louis. Another important guide fossil which is known from no other formation is the brachiopod *Pugnoides ottumwa* (Pl. XXXVIII, figs. 5a, b). In the middle part of the Ste. Genevieve occur a number of corals which seem to be entirely restricted to this horizon. Among these are *Michelinia subramosa* (Pl. XXXVIII, fig. 6) and *Lithostrotion harmodites* (Pl. XXXVIII, figs. 8a-c). This latter species is a colonial form which usually occurs in large heads sometimes as big as a bushel basket. A number of long range forms which are common in some of the lower formations did not survive the Ste. Genevieve. One of the most characteristic of these is *Rhipidomella dubia* (Pl. XXXVIII, figs. 3a-c). In some of the oolitic beds there is a recurrence of the peculiar Salem fauna characterized by many small gastropods and pelecypods.

CHESTER SERIES

Everywhere within the upper Mississippi and Ohio Valleys the Chester series unconformably overlies the Iowa series. This is the most important break within the Mississippian System and marks a change in conditions followed by shallower, less extensive and oscillating seas. The Chester outcrops completely encircle the western coal field of Kentucky to the east and south, and occur along a narrow belt beneath the Pennsylvanian strata upon the east side of the Cincinnati anticline.

The Chester faunas possess an aspect entirely different from those of the lower Mississippian formations. Their most conspicuous character generally consists in the abundant presence of bryozoans belonging to the genus *Archimedes* (Pl. XLI, figs. 1a-6, Pl. XLIII, fig. 7) and blastoids of the genus *Pentremites* (Pl. XXXV, figs. 10a, b, Pl. XXXVII, figs. 5a, b, Pl. XXXVIII, figs. 9a-c, Pl. XL, figs. 5a, b 9a-11b, Pl. XLI, figs. 8a, b 12a-13, Pl. XLII, figs. 8-9b, Pl. XLIII, figs. 2a, b, Pl. XLIV, figs. 2, 3 5a, b). Although they do occur in lower beds, wherever, in Kentucky, species belonging to either of these genera are common it is fairly certain that the strata are of Chester age. The peculiar Salem fauna recurs with only slight modifications at several horizons in the Chester particularly in the lower part where the beds are notably oolitic at some localities and also in the Middle Chester where oolites however are seldom present.

LOWER CHESTER GROUP

Aux Vases Sandstone. This formation which occurs at the base of the Chester series in the typical section of southwestern Illinois, is absent in Kentucky.

Renault Limestone. The Renault is the basal formation of the Chester series throughout Kentucky and everywhere directly overlies the Ste. Genevieve limestone and the typical Chester fauna appears in it for the first time. It has yielded its most extensive fauna in western Kentucky where its lower part is notably shaly. Farther eastward however where the formation is composed of massive limestone extensive collections are much more difficult to obtain.

The Renault is equivalent to the upper and greater portion of Ulrich's Ohara member of the Ste. Genevieve and to the lower half of Butts' Gasper limestone as described in Meade and Breckenridge counties.

The Renault is easily distinguished from the underlying Ste. Genevieve limestone by the presence of the bilobed bases of the several species of the crinoid *Talarocrinus* (Pl. XL, figs. 3, 6-7b) and the absence of the stem segments and cups of *Platycrinus penicillus* (Pl. XXXVIII, figs 2a-c). These fossils are fairly common and are almost always to be found when a careful search is made.

The fauna of the Renault and that of the Paint Creek limestone have much in common but there are four species which so far as known are restricted to the lower shaly phase of the Renault in western Kentucky. These are the coral *Amplexus geniculatus* (Pl. XL, figs. 1a-c), the brachiopod *Spiriferina subspinosa* (Pl. XL, figs. 2a, b) and the crinoids *Talarocrinus buttsi* and *Globocrinus unionensis* (Pl. XL, figs. 8a, b). Of these *T. buttsi* only has been collected from the Renault farther east where this formation has lost its shaly character. The base of this crinoid is subconical and narrowly bowl-shaped and thus differs from the other species of this genus which have disk-shaped bases with a deeply impressed suture separating the two plates. These other species occur in the upper part of the Renault and are also widely distributed in this formation geographically. *Pentremites* with the "pyriformis" type of elongated bases (Pl. XL, figs 5a, b) make their first appearance in the Renault and at many places bases of the bryozoan *Lyropora* (Pl. XLI, fig. 10) are abundant. One strange feature of the Renault fauna is the rarity of bryozoans of the genus *Archimedes* (Pl. XLI, figs. 1a-6, Pl. XLIII, fig 7) which are so conspicuous in most of the higher Chester limestones.

Bethel Sandstone. In Kentucky the formation which occupies the position of the Yankeetown chert in the typical Mississippi Valley section is known as the Bethel sandstone. This formation thins out to the eastward from the western Kentucky counties and upon the south side of the coal field has not been recognized beyond Todd County. It appears however at its proper position on the northeast side of the coal field where it has been called the Sample sandstone. Along the south side of the western Kentucky coal field and also in eastern Kentucky where the Bethel sandstone is absent, the Paint Creek limestone rests directly upon the Renault. Where this situation prevails it is usually impracticable to separate these limestones which may here be appropriately combined to form the Renault-Paint Creek formation.

Paint Creek Limestone. The Paint Creek limestone everywhere overlies the Bethel sandstone and where this is absent overlaps and directly succeeded the Renault. It is equivalent to the whole of the Gasper in the western Kentucky counties but represents only the upper portion of this formation as it is interpreted by Butts in Meade and Breckinridge counties.

The Paint Creek fauna has much in common with that of the Renault. Species of *Talarocrinus* (Pl. XL, figs. 3, 6-7b) with bilobed bases are also present in this formation although they are generally not as numerous. The bryozoans *Cystodictya labiosa* (Pl. XLI, figs. 7a, b), *Glyptopora punctipora* and *Lyropora* (Pl. XLI, fig. 10) are common to both formations. The *Pentremites* show a very great expansion in the Paint Creek and are present in both greater numbers and variety. Additions to the fauna which are not present or are rare in the Renault include several species of the crinoid genus *Pterotocrinus* which are usually represented by the wing plates (Pl. XLII, figs. 2b-d, Pl. XLIII, figs. 3-4b, Pl. XLIV, fig. 7) and a great variety of the bryozoan genus *Archimedes* (Pl. XLI, figs. 1a-6, Pl. XLIII, fig. 7). One species, *A compactus* (Pl. XLI, fig. 4) is rather characteristic of this fauna although it does occur rarely at higher horizons. *Chonetes chesterensis* (Pl. XLI. figs. 11a, b) is the most important of the brachiopods as this species is unknown in any other formation except the Glen Dean in which it occurs rarely. Another noteworthy feature is the much greater abundance of *Spiriferina spinosa* (Pl. XXXIX, figs. 3a-c) over *S. transversa* (Pl. XXXIX, figs. 2a-c). *Camarotoechia purduei* is a rare brachiopod which is known in Kentucky only from the Paint Creek limestone.

MIDDLE CHESTER GROUP

Cypress Sandstone. The Cypress sandstone is one of the most persistent sandstones of the Chester series. It completely encircles the western coal field upon the south and east and everywhere directly overlies the Paint Creek limestone in western Kentucky. It has not been definitely identified however in eastern Kentucky east of the Cincinnati anticline although it may be represented by a 10-foot sandstone which occurs at about the proper horizon 12 miles southeast of Monticello.

Golconda Limestone. The Golconda limestone overlies the Cypress sandstone and its outcrops extend around the

southern and eastern sides of the western coal field. It has not been certainly recognized east of the Cincinnati anticline but it may be represented by a thin marly shale bed which overlies the Renault-Paint Creek formation and is in turn succeeded by a limestone with the typical Glen Dean fauna.

Most of the species of the Golconda fauna are common long ranging Chester forms but certain new ones are introduced here for the first time and a consideration of these together with certain previously mentioned species which did not survive after the Paint Creek make the recognition of this formation easy. The most important new species is *Camarophoria explanata* (Pl. XLII, figs. 7a-d), a common and widely distributed brachiopod which is a certain index to beds younger than the Paint Creek. A number of other species are restricted to this formation so far as is known. These include the crinoid *Pterotocrinus capitalis* (Pl. XLII, figs. 2a-d), the blastoids *Pentremites obesus* (Pl. XLII, fig. 1) and *P. platybasis* (Pl. XLII, figs 9a, b), the brachiopod *Rhynchopora perryensis* and the bryozoan *Archimedes lativolvis*. The wing plates of *Pterotocrinus capitalis* (Pl. XLII, figs. 2b-d) are common at many localities in the western counties of Kentucky although they are unknown farther east. *Pentremites obesus* (Pl. XLII, fig. 1) while usually not abundant is a very conspicuous form as it is one of the largest known species of this genus. Species of *Archimedes* (Pl. XLI, figs. 1a-6, Pl. XLIII, fig. 7) are very abundant and the crinoid *Agassizocrinus* whose peculiar base (Pl. XLI, figs 9a, b) is easily recognized becomes common for the first time.

An interesting feature of the Golconda fauna is the occurrence of a considerable variety of molluscan species. While this aspect of the fauna is reminiscent of the Salem practically all of the species are new and the great majority of them have never been described.

Hardinsburg Sandstone. The Hardinsburg like the Cypress is a very persistent sandstone formation. It is everywhere present at its proper horizon around the borders of the western coal field but apparently is not developed in eastern Kentucky.

Glen Dean Limestone. The Glen Dean limestone everywhere overlies the Hardinsburg sandstone. East of the Cincinnati anticline it is recognized by its characteristic fauna from the Tennessee line northward to Carter County.

The most important fossil of the Glen Dean limestone is the bryozoan *Prismopora serrulata* (Pl. XLIII, fig. 1). While this species is not restricted to this formation it is usually much more abundant in it than in any other. It also occurs in the Golconda and Vienna limestones and a few specimens have been observed in the Menard but during Glen Dean time this species flourished in great luxurience and some shaly partings in the limestone are crowded with specimens. *Archimedes laxus* (Pl. XLIII, fig. 7) is another bryozoan which while also present in the Golconda is much more abundant in the Glen Dean. On the whole the abundance of these two species is a much better guide to the Glen Dean in the western Kentucky counties than farther eastward about the extremity of the western coal field. The blastoid *Pentremites spicatus* (Pl. XLIV, fig. 3) is rather characteristic of the Glen Dean and the crinoids *Pterotocrinus bifurcatus* (Pl. XLIII, fig. 3) and *P. acutus* (Pl. XLIII, figs. 4a, b) are so far as known confined to this formation but they are ordinarily not abundant and in some areas are rare or entirely absent. In addition to the forms previously mentioned the Glen Dean has yielded a very large fauna which is particularly rich in bryozoans and of course many of the species are the common widely ranging Chester forms.

UPPER CHESTER GROUP

The upper Chester group is well developed in all its members in the western Kentucky counties but to the eastward the several formations lose their individuality and grade laterally into a series of strata largely composed of shale. This shale is known in western Kentucky as the Leitchfield formation while east of the Cincinnati anticline it has been referred to the Pennington shale which receives its name from a locality in Virginia.

Limestone layers occuring at various horizons in the Leitchfield shale are more or less fossiliferous but the upper

Chester faunas as a whole are so similar that it has not as yet proved practicable to correlate them with any of the several formations which are known farther to the west.

Tar Springs Sandstone. This sandstone overlies the Glen Dean limestone throughout its whole extent. It pinches out to the eastward however and is not known as a continuous formation beyond Bowling Green on the south side of the western coal basin although it also occurs in the vicinity of Cloverport in Breckenridge County. East of these limits it is patchy, very shaly or entirely absent.

Vienna Limestone. The Vienna limestone succeeds the Tar Springs sandstone. In the western Kentucky counties the limestone which constitutes its lower portion carries a great deal of chert in thin layers by which character it may be recognized. But where to the east this cherty limestone is replaced by shale and the overlying Waltersburg sandstone is absent, this formation can not be separated from the Menard.

Paleontologically the Vienna limestone is known to have little that is diagnostic. As stated above *Prismopora serrulata* (Pl. XLIII, fig. 1), the bryozoan that is so abundant in the Glen Dean, also occurs in this formation. On the other hand the pelecypod *Sulcatopinna missouriensis* (Pl. XLIV, fig. 1) which is one of the most striking members of the Menard fauna appears for the first time in the Vienna but is rare. On the whole the Vienna has not yielded a very large fauna due principally no doubt to its poor exposures and limited extent.

Waltersburg Sandstone. The Waltersburg sandstone overlies the Vienna. This sandstone however is not recognized beyond the western Kentucky counties and when it is absent the Vienna and Menard limestones cannot be satisfactorily separated.

Menard Limestone. The Menard limestone directly overlies the Waltersburg in that part of western Kentucky where it is recognizable. Beyond, it rests upon strata of Vienna age and farther on loses its identity in the Leitchfield shale.

The Menard carries a considerable fauna and where it is advantageously exposed many fossils may be secured. Among these the blastoid *Pentremites fohsi* (Pl. XLIV, fig. 2) which

is nearly as large as the Golconda species *P. obesus* (Pl. XLII, fig. 1) and the crinoid *Pterotocrinus menardensis* (Pl. XLIV, fig. 7) have never been found at any other horizon. The partial or complete substitution of *Composita subquadrata* (Pl. XLIV, figs. 4a-c) and *Eumetria costata* (Pl. XXXIX, figs. 8a, b) in place of the common Lower and Middle Chester species *C. trinuclea* (Pi. XLIII, figs. 5a, b) and *E. vera* (Pl. XXXIX, figs. 7a, b) and the introduction of the typical *Spirifer increbescens* (Pl. XLIV, fig. 6) are particularly characteristic of this limestone of the upper Chester group. These three species which appear here for the first time are large and the *Eumetria* and *Spirifer* are more coarsely ribbed than their closely related predecessors. The presence of the pelecypod *Sulcatopinna missouriensis* (Pl. XLIV, fig. 1) sometimes in considerable numbers is another character of this fauna which may serve in its identification.

Palestine Sandstone. The Palestine sandstone overlies the Menard limestone and is well developed in the western Kentucky counties but to the eastward it pinches out or becomes an indistinguishable member of the Leitchfield shale.

Clore Limestone. The Clore limestone which succeeds the Palestine is characteristically developed in the western Kentucky counties but loses its identity to the eastward.

The Clore limestone has nowhere yielded large collections of fossils. Most of the species that have been collected are common Chester forms but the presence of *Spirifer increbescens* (Pl. XLIV, fig. 6) and *Composita subquadrata* (Pl. XLIV, figs. 4a-c) are clearly indicative of its Upper Chester position. The only species of any particular significance however is the slender branching byrozoan *Batostomella nitidula* (Pl. XLIV, fig. 8). While this species may occur at other horizons it is very common upon the surfaces of some of the Clore limestone layers and prolific colonies must have existed in the sea when these beds were being formed.

Degonia Sandstone. The Degonia sandstone which overlies the Clore has not been recognized beyond the western counties of Kentucky.

KINKAID LIMESTONE. This formation succeeds the Degonia sandstone and is the uppermost member of the Chester series. It is recognized as a distinct formation only in the western Kentucky counties.

The Kinkaid limestone has in general not yielded faunas of any great diversity and the species which have been obtained are not distinctive. It is not known to possess any paleontological characters which would serve to certainly distinguish it from the other upper Chester limestones.

PRE-PENNSYLVANIAN UNCONFORMITY

A very important unconformity separates the Mississippian and Pennsylvanian systems. Channels were cut in the Mississippian rocks and locally a considerable thickness of strata was removed. In western Kentucky the lowest formation upon which the Pennsylvanian beds have been observed to rest is the Cypress sandstone. In eastern Kentucky the Pennsylvanian in a general way overlaps successively older beds in a northerly direction. The lowest formation with which it is known to come in contact is the Logan (upper New Providence).

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For a fuller description of the stratigraphy of the Mississippian system in Kentucky the reader is referred to the following reports by Charles Butts;

Descriptions and Correlations of the Mississippian Formations of Western Kentucky: Kentucky Geol. Survey, 1917.

The Mississippian Series of Eastern Kentucky: Kentucky Geol. Survey, series 6 vol. 7, 1922.

In consulting these reports however the reader should remember that they are the result of reconnaissance and not detailed studies and certain of the author's correlations particularly of the lower Chester formations have been somewhat invalidated by more detailed surveys of later date.

For accurate descriptions of the Mississippian stratigraphy of certain smaller areas that have been studied in detail and extended faunal lists for the various formations the following reports by Stuart Weller may be consulted;

The Geology of Hardin County: Illinois State Geological Survey, Bulletin 41, 1920.

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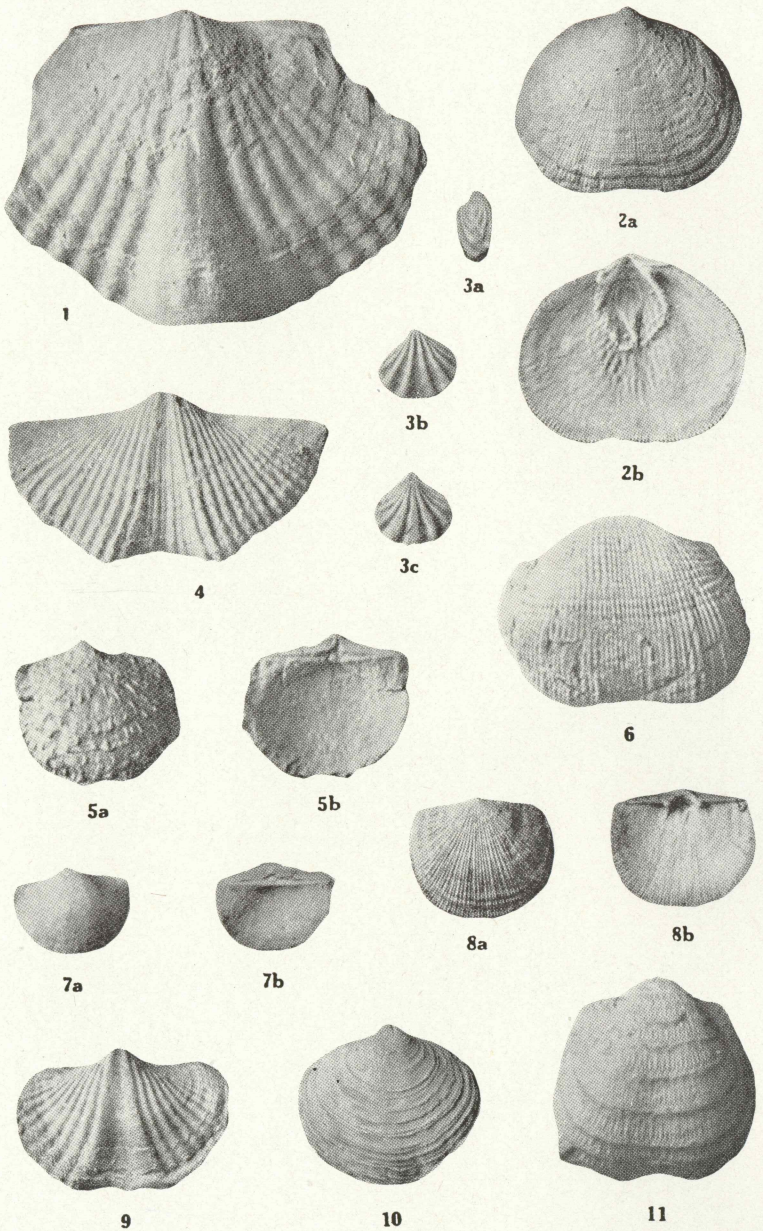
Explanation of Plate XXXIII

FOSSILS OF THE NEW PROVIDENCE SHALE.

Figure

1. *Brachythyris suborbicularis* (Hall). Lower Burlington to Keokuk.
2a, b. *Rhipidomella oweni* Hall and Clarke. Confined to the New Providence.
3a-c *Ptychospira sexiplicata* (White and Whitefield). Fern Glen.
4. *Spirifer vernonensis* Swallow. Fern Glen and Lower Burlington.
5a, b. *Strophalosia cymbula* Hall and Clarke. Confined to the New Providence.
6. *Productus fernglenensis* Weller. Fern Glen and Lower Burlington.
7a, b. *Chonetes shumardanus* De Koninck. Confined to the New Providence.
8a, b. *Schuchertella lens* (White). Kinderhook.
9 *Spiriferina subelliptica* (McChesney). Confined to the New Providence.
10. *Athyris hannibalensis* (Swallow) Kinderhook.
11. *Pustula alternata* (Norwood and Pratten). Burlington, Keokuk and Warsaw.

All figures after Stuart Weller.



Fossils of the New Providence—Mississippian.

Explanation of Plate XXXIV

FOSSILS FROM FORMATIONS OF KEOKUK AGE.

Figure

1. *Productus wortheni* Hall. Keokuk and Warsaw.
2. *Syringothyris textus* (Hall). Keokuk and Warsaw.
3. *Spirifer crawfordsvillensis* Weller. Keokuk.
4. *Spirifer keokuk* Hall. Keokuk and Warsaw.

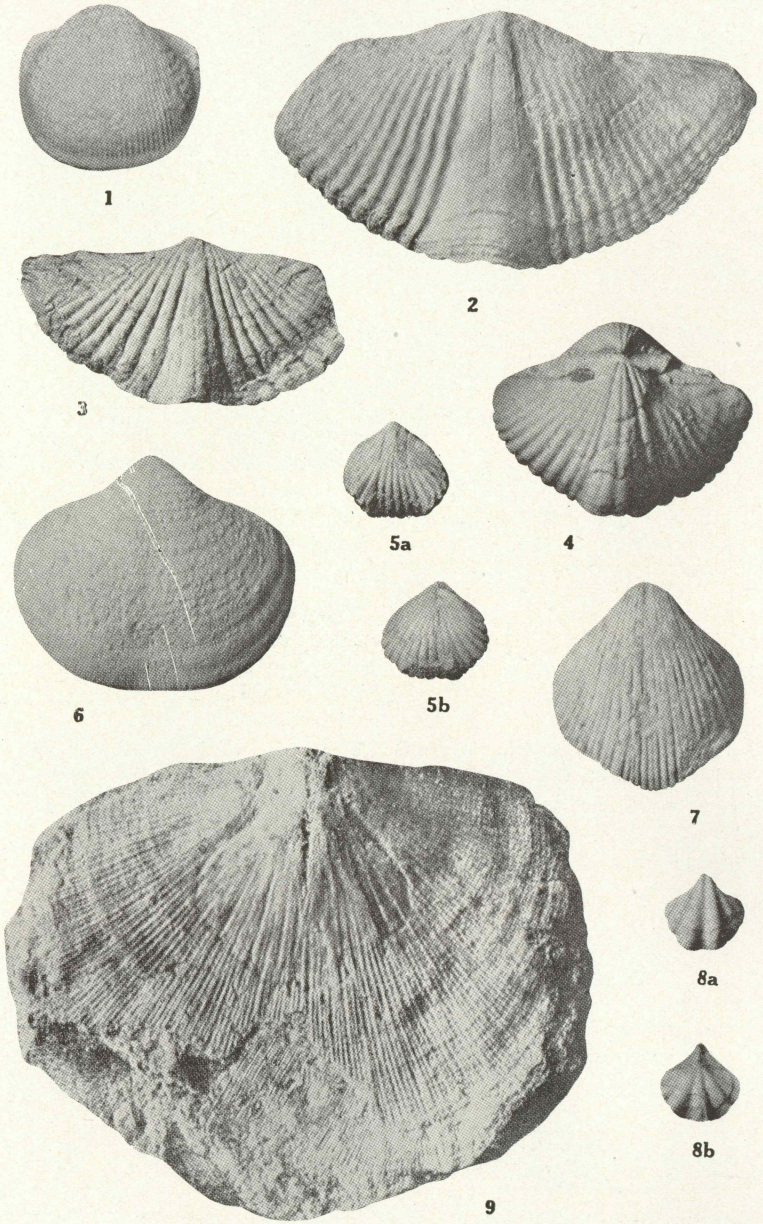
5a, b. *Rhynchopora beecheri* Greger. Keokuk.

6. *Reticularia pseudolineata* (Hall). Burlington, Keokuk and Warsaw.
7. *Spirifer rostellatus* Hall. Keokuk and Warsaw.

8a, b. *Cyrtina burlingtonensis* Rowley. Fern Glen, Burlington and Keokuk.

9. *Orthotetes keokuk* (Hall). Keokuk and Warsaw.

All figures after Stuart Weller.



Fossils of Keokuk Age—Mississippian

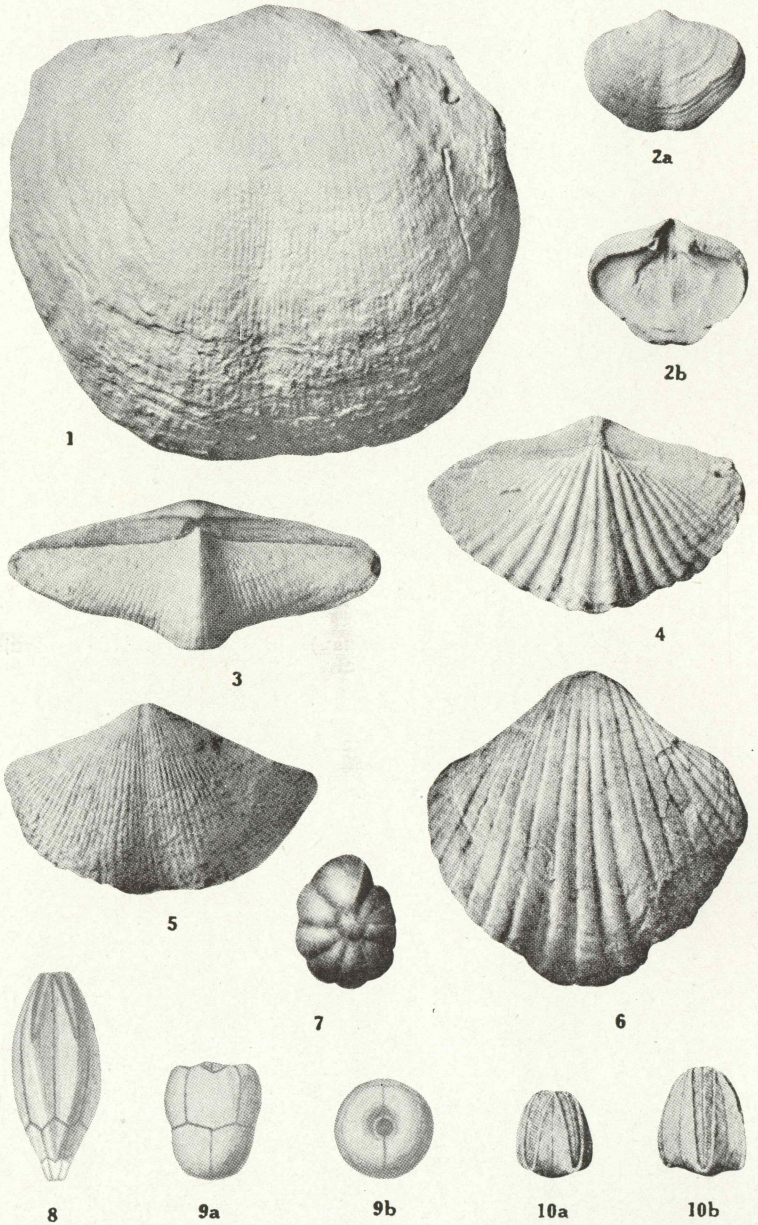
Explanation of Plate XXXV

FOSSILS FROM THE WARSAW-SALEM LIMESTONE

Figure

1. *Productus magnus* Meek and Worthen. Upper Keokuk and Warsaw.
2a, b. *Athyris densa* Hall. Salem.
3. *Spirifer lateralis* Hall. Warsaw and Salem.
4. *Spirifer washingtonensis* Weller. Upper Keokuk and Warsaw.
5. *Spirifer tenuicostatus* Hall. Keokuk, Warsaw and Salem.
6. *Brachythyris subcardiformis* (Hall). Warsaw and Salem.
7. *Endothyra baileyi* (Hall). Salem to Pennsylvanian. Greatly enlarged.
8. *Metablastus wortheni* (Hall). Warsaw.
9a, b. *Talarocrinus simplex* (Shumard). Warsaw.
10a, b. *Pentremites conoideus* Hall. Warsaw and Salem.

Fig. 7 after Whitfield, 8 after Worthen, 9 after Wachsmuth and Springer, 10 after Ulrich, all others after Stuart Weller.



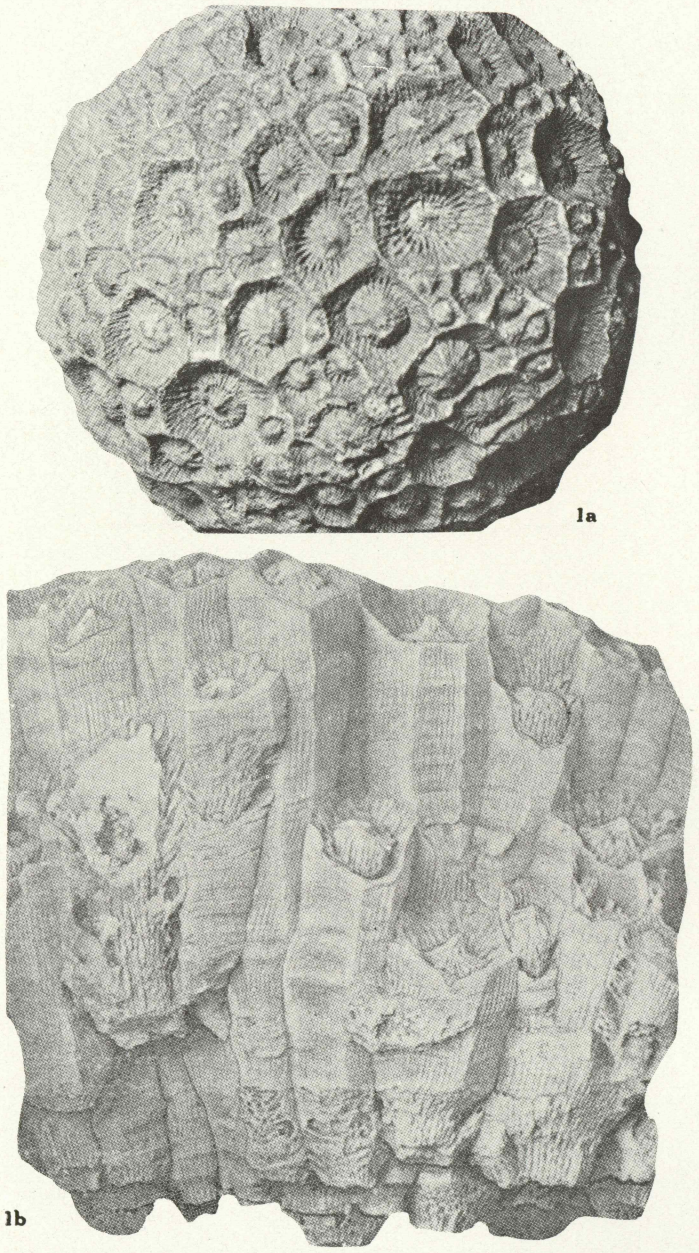
Fossils of the Warsaw-Salem—Mississippian

Explanation of Plate XXXVI

FOSSILS FROM THE ST. LOUIS LIMESTONE.

Figure

1a, b. *Lithostrotion canadense* (Castelnau). Upper Salem and St. Louis. 1a, photograph by Savage, 1b, after Ulrich.



Fossils of the St. Louis—Mississippian

Explanation of Plate XXXVII

FOSSILS FROM THE ST. LOUIS LIMESTONE

Figure

1a, b. *Lithostrotion proliferum* Hall. St. Louis and lower Ste. Genevieve.

2a, b. *Productus marginicinctus* Prout. St. Louis.

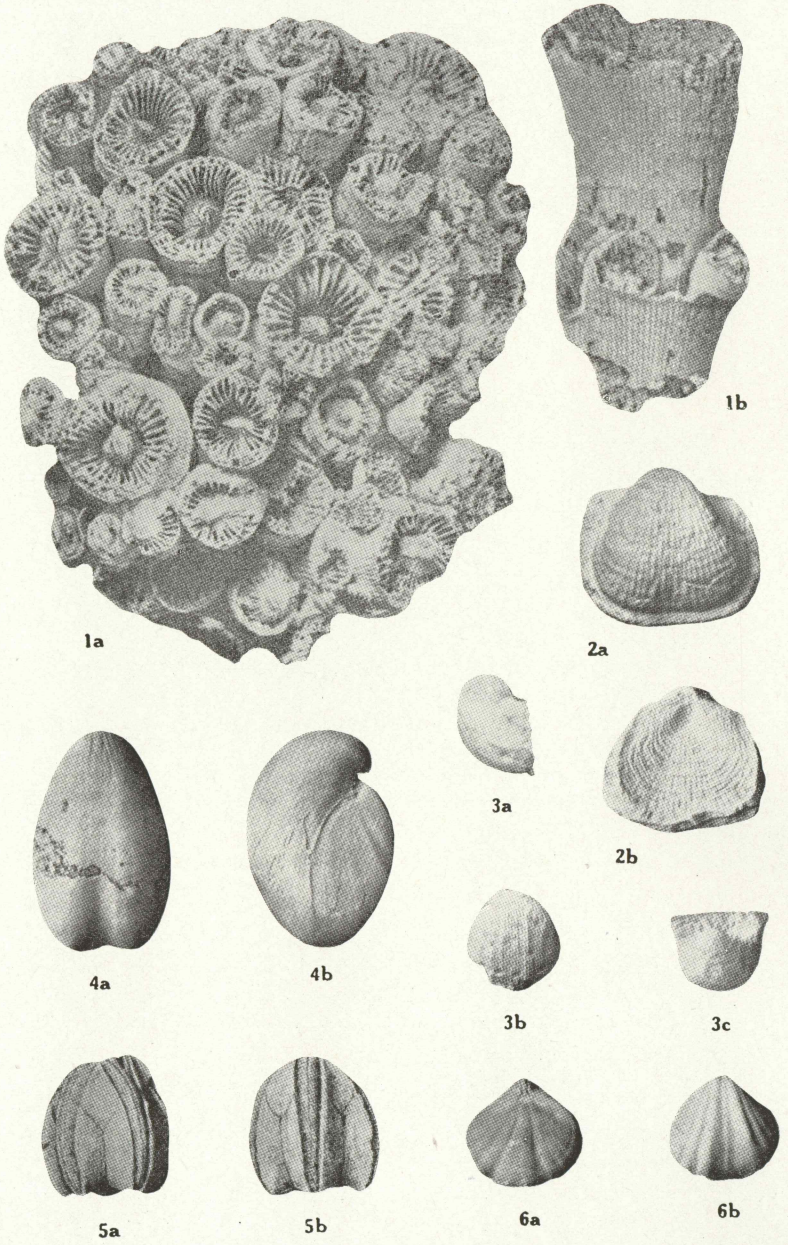
3a-c. *Productus scitulus* Meek and Worthen. St. Louis.

4a, b. *Dielasma sinuata* Weller. Keokuk to St. Louis.

5a, b. *Pentremites cavus* Ulrich. Described from lower St. Louis but should probably be referred to Salem.

6a, b. *Brachythyris altonensis* Weller. St. Louis.

Figures 1 and 5 after Ulrich, all others after Stuart Weller.



Fossils of the St. Louis—Mississippian

Explanation of Plate XXXVIII

FOSSILS FROM THE STE. GENEVIEVE LIMESTONE.

Figure

1a, b. *Spirifer pellaensis* Weller. Ste. Genevieve.

2a-c. *Platycrinus penicillus* Meek and Worthen. Upper St. Louis and Ste. Genevieve. 2a view of basal plates, 2b, c stem segments.

3a-c. *Rhipidomella dubia* (Hall). Keokuk to Ste. Genevieve.

4a, b. *Menophyllum princetonensis* Ulrich. Ste. Genevieve.

5a, b. *Pugnoides ottumwa* (White). Ste. Genevieve.

6. *Michelinia subramosa* Ulrich. Ste. Genevieve.

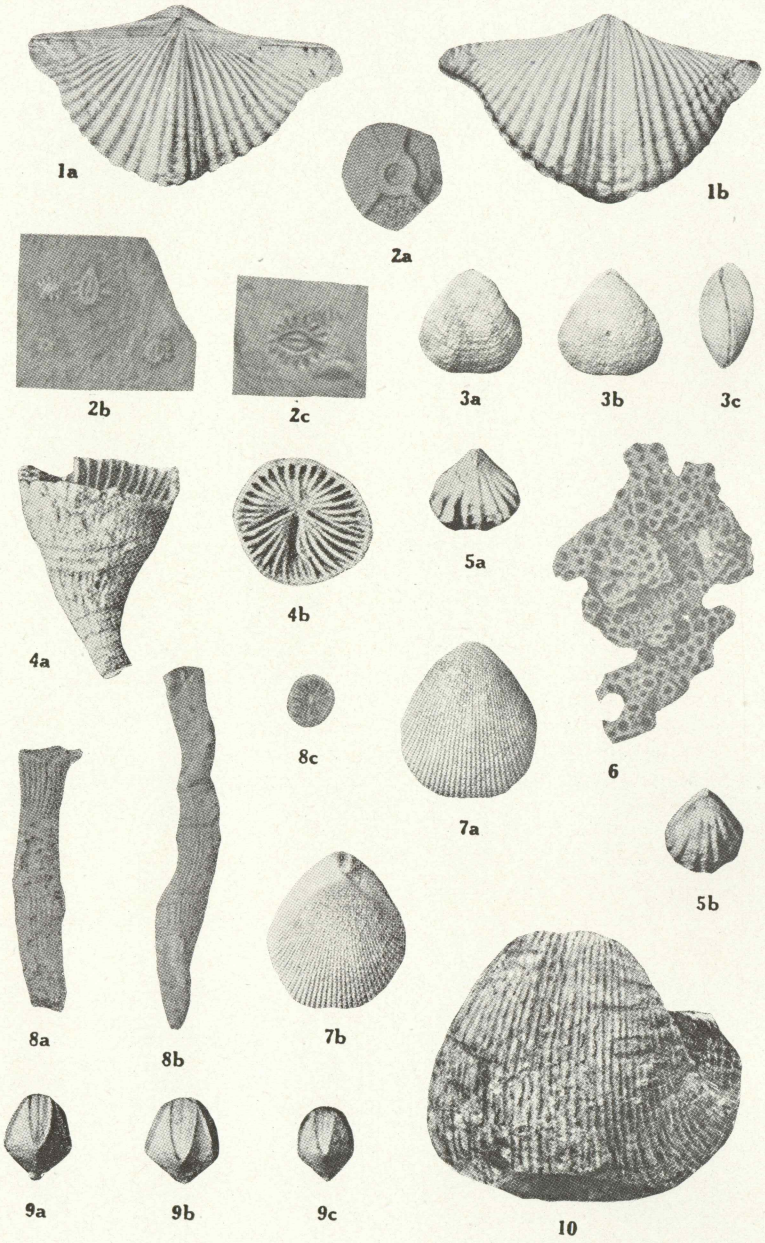
7a, b. *Eumetria verneuiliana* (Hall). Salem to Lower Chester.

8a-c. *Lithostrotion harmodites* Milne-Edwards and Haime. Ste. Genevieve. Occurs in large colonies.

9a-c. *Pentremites princetonensis* Ulrich. St. Louis to Renault.

10. *Productus arkansanus* Girty: Chester, reported by Ulrich from Ste. Genevieve.

Figures 2, 4, 6, 8, and 10 after Ulrich, all others after Stuart Weller.



Fossils of the Ste. Genevieve—Mississippian

Explanation of Plate XXXIX

FOSSILS FROM THE CHESTER SERIES.

Figure

1a, b. *Spirifer leidyi* Norwood and Pratten. Ste. Genevieve and Chester.

2a-c. *Spiriferina transversa* (McChesney). Ste. Genevieve and Chester.

3a-c. *Spiriferina spinosa* (Norwood and Pratten). Ste. Genevieve and Chester.

4a-c. *Girtyella brevilobata* (Swallow). Ste. Genevieve and Chester.

5a-c. *Girtyella indianensis* (Girty). Ste. Genevieve and Chester.

6a-c. *Dielasma illinoisensis* Weller. Chester.

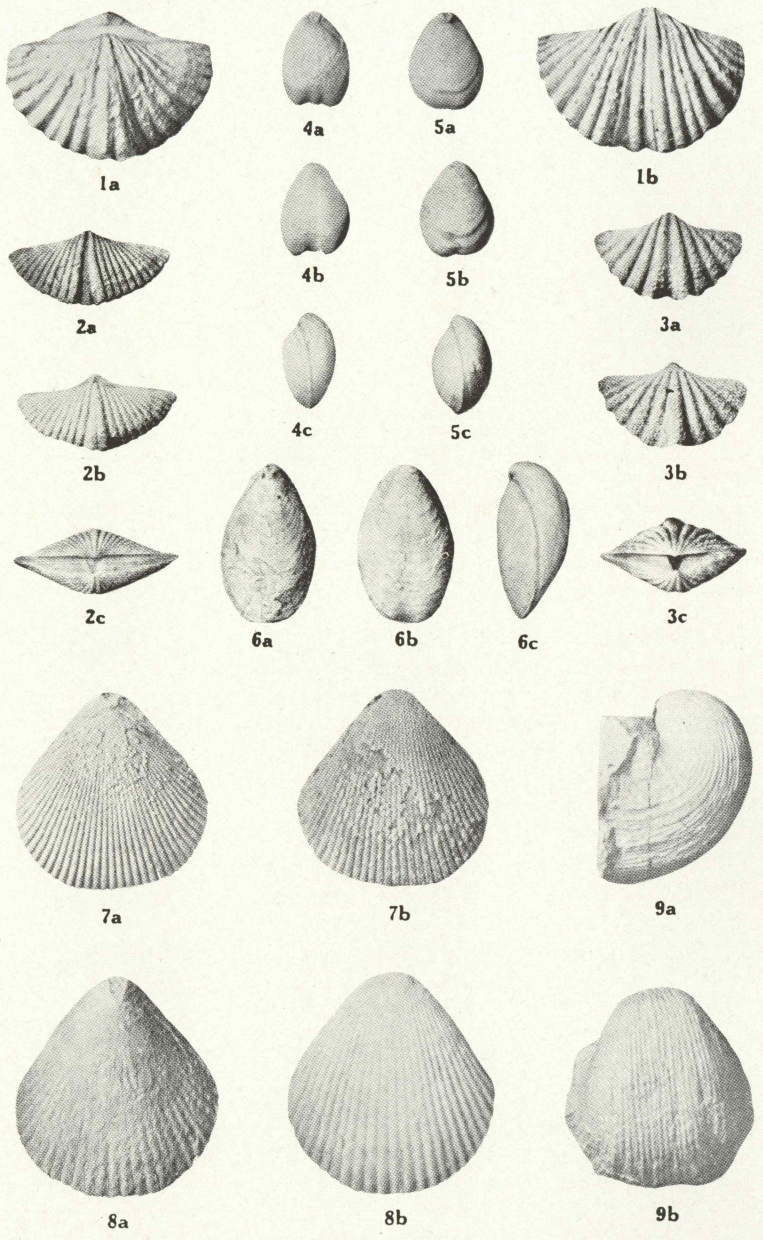
7a, b. *Eumetria* vera (Hall). Chester.

8a, b. *Eumetria costata* (Hall), Chester.

9a, b. *Diaphragmus elegans* (Norwood and Pratten). Ste. Genevieve and Chester.

All figures after Stuart Weller.

PLATE XXXIX



Fossils of the Chester—Mississippian

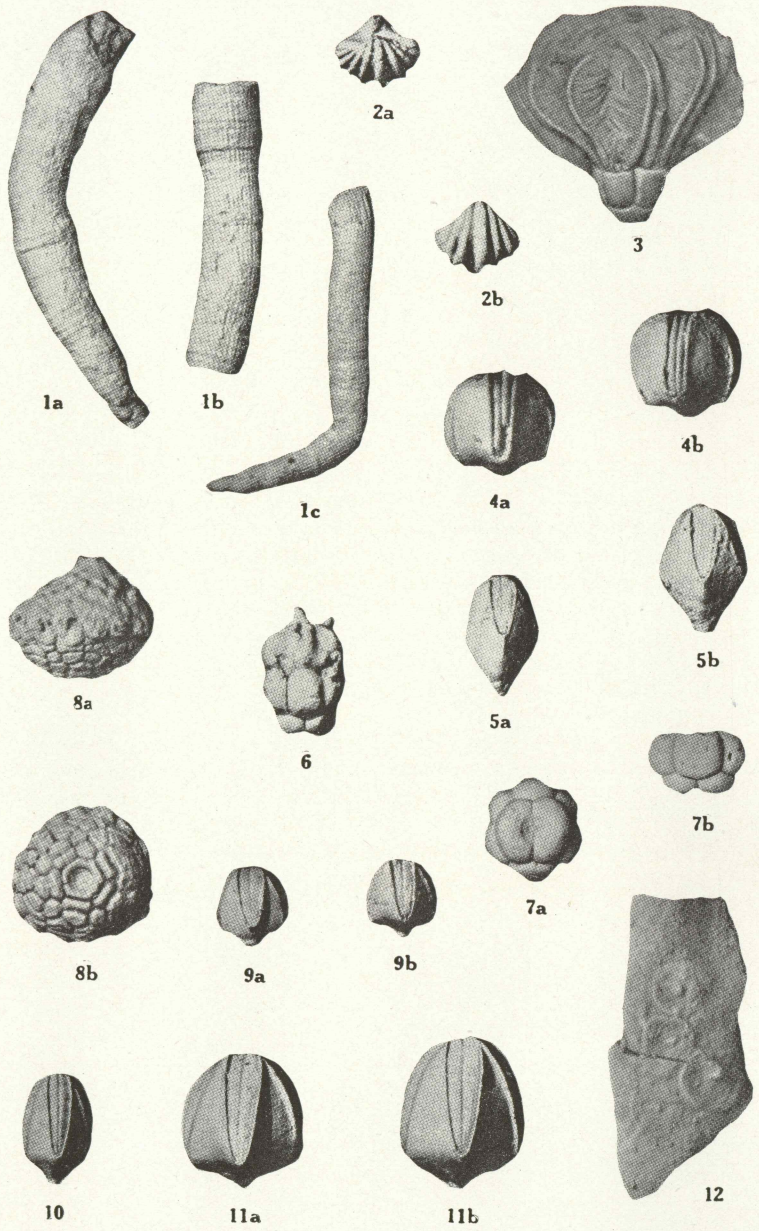
Explanation of Plate XL

FOSSILS FROM THE RENAULT LIMESTONE.

Figure

1a-c. *Amplexus geniculatus* Worthen. Renault.
2a, b. *Spiriferina subspinosa* Weller. Renault.
3. *Talarocrinus patei.* Miller and Gurley. Renault.
4a, b. *Mesoblastus glaber* (Meek and Worthen). Ste. Genevieve and Renault.
5a, b. *Pentremites buttsi* Ulrich. Renault.
6. *Talarocrinus ovatus* Worthen. Renault.
7a, b. *Talarocrinus inflatus* Ulrich. Renault.
8a, b. *Globocrinus unionensis* (Worthen). Renault.
9a, b. *Pentremites pinguis* Ulrich. Renault.
10. *Pentremites pulchellus* Ulrich. Ste. Genevieve and Renault.
11a, b. *Pentremites godoni* (DeFrance). Renault and Paint Creek.
12. *Crania chesterensis* Miller and Gurley. Chester.

Figure 3 after Springer, all others after Stuart Weller.



Fossils of the Renault—Mississippian

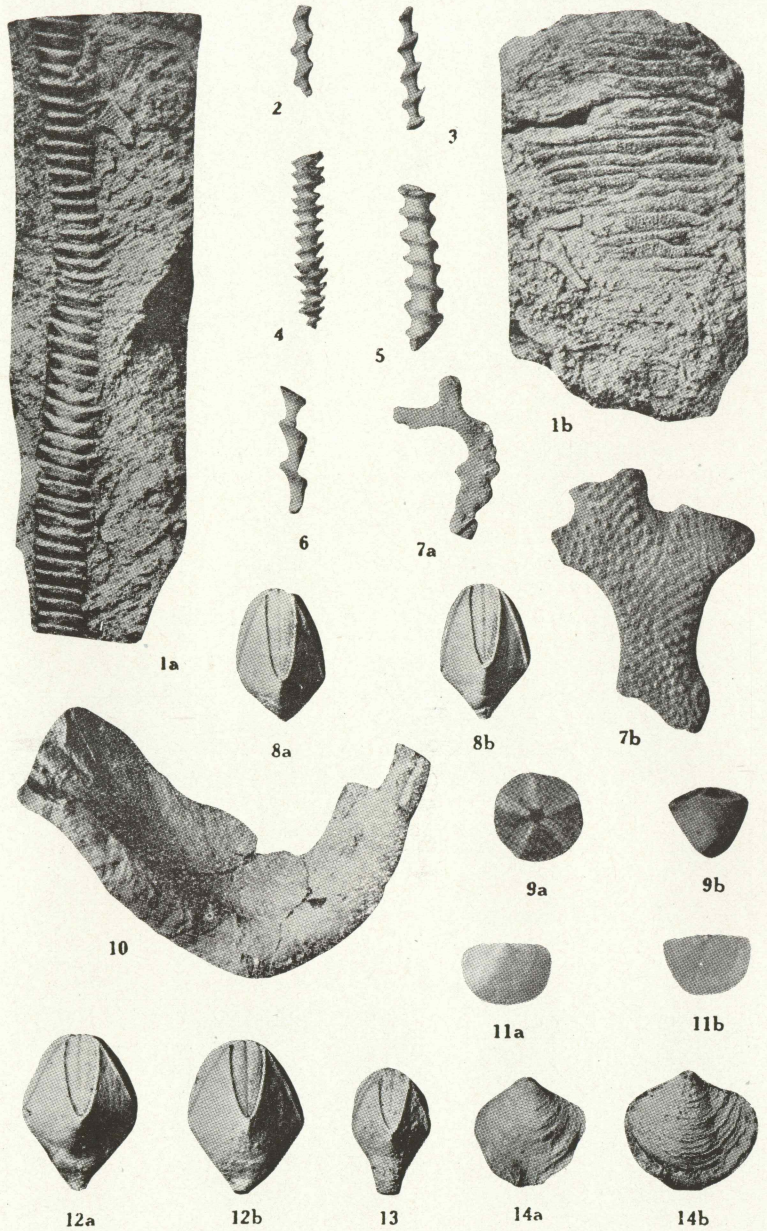
Explanation of Plate XLI

FOSSILS FROM THE PAINT CREEK LIMESTONE.

Figure

1a, b. *Archimedes confertus* Ulrich. Paint Creek and Golconda.
2. *Archimedes meekanus* Hall. Paint Creek to Menard.
3. *Archimedes proutanus* Ulrich. Paint Creek to Glen Dean.
4. *Archimedes compactus* Ulrich. Paint Creek and Golconda.
5. *Archimedes swallovanus* Hall. Paint Creek to Menard.
6. *Archimedes distans* Ulrich. Paint Creek to Kinkaid.
7a, b. *Cystodictya labiosa* Weller. Renault and Paint Creek. 7b magnified 3½ diameters.
8a, b. *Pentremites symmetricus* Hall. Paint Creek.
9a, b. *Agassizocrinus* sp. Chester.
10. *Lyropora quincuncialis* Hall. Renault to Golconda.
11a, b. *Chonetes chesterensis* Weller. Paint Creek, rarely in Glen Dean.
12a, b. *Pentremites pyramidatus* Ulrich. Paint Creek to Glen Dean.
13. *Pentremites gemmiformis* Hambach. Paint Creek.
14a, b. *Cleiothyridina sublamellosa* (Hall). Ste. Genevieve and Chester.

Figures 1 and 9, after Ulrich, all others after Stuart Weller.



Fossils of the Paint Creek—Mississippian

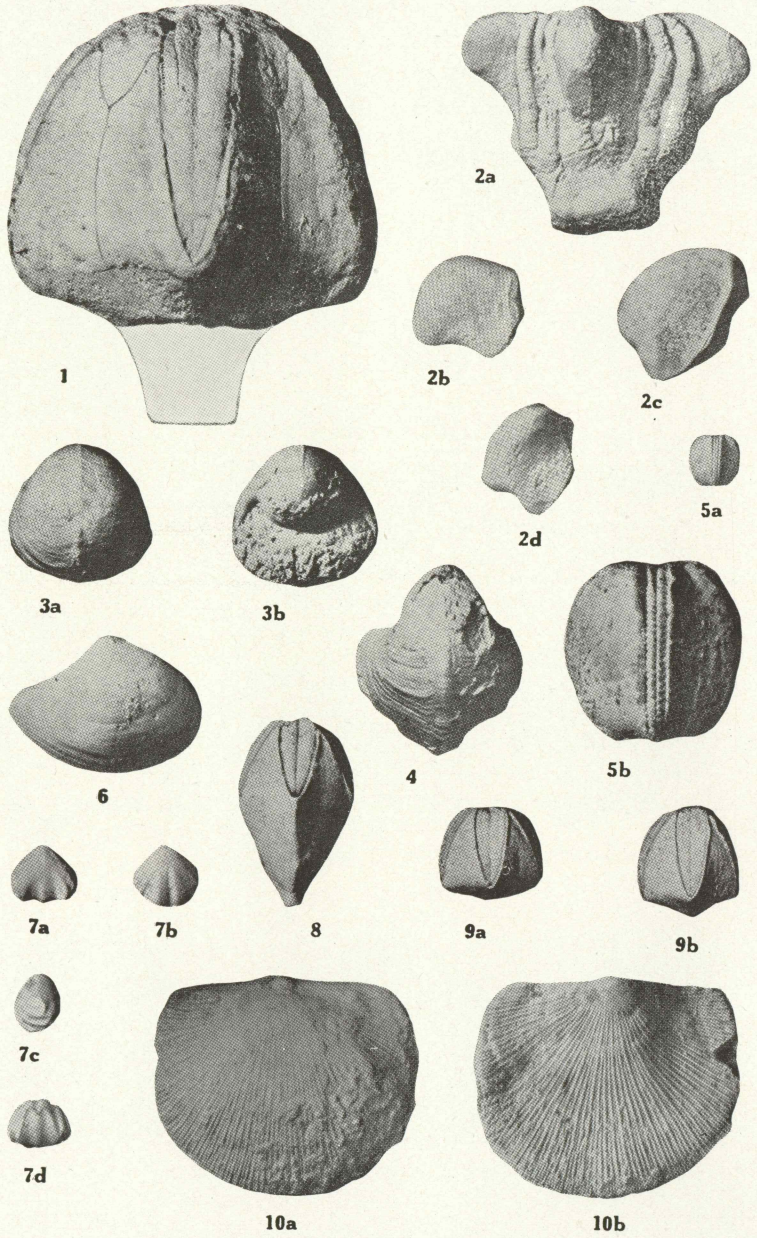
Explanation of Plate XLII

FOSSILS FROM THE GOLCONDA LIMESTONE.

Figure

1. *Pentremites obesus* Lyon. Golconda.
2a-d. *Pterotocrinus capitalis* (Lyon). Golconda.
3a, b. *Bellerophon chesterensis* Weller. Paint Creek and Golconda.
4. *Bucanopsis ornatus* Weller. Golconda.
5a, b. *Mesoblastus incurvatus* Weller. Paint Creek and Golconda. 5b magnified 3½ diameters.
6. *Leda chesterensis* Weller. Paint Creek and Golconda.
7a-d. *Camarophoria explanata* (McChesney). Golconda to Kinkaid.
8. *Pentremites okawensis* Weller. Golconda and Glen Dean.
9a, b. *Pentremites platybasis* Weller. Golconda.
10a, b. *Orthotetes kaskaskiensis* (McChesney). Ste. Genevieve and Chester.

All figures after Stuart Weller.



Fossils of the Golconda—Mississippian

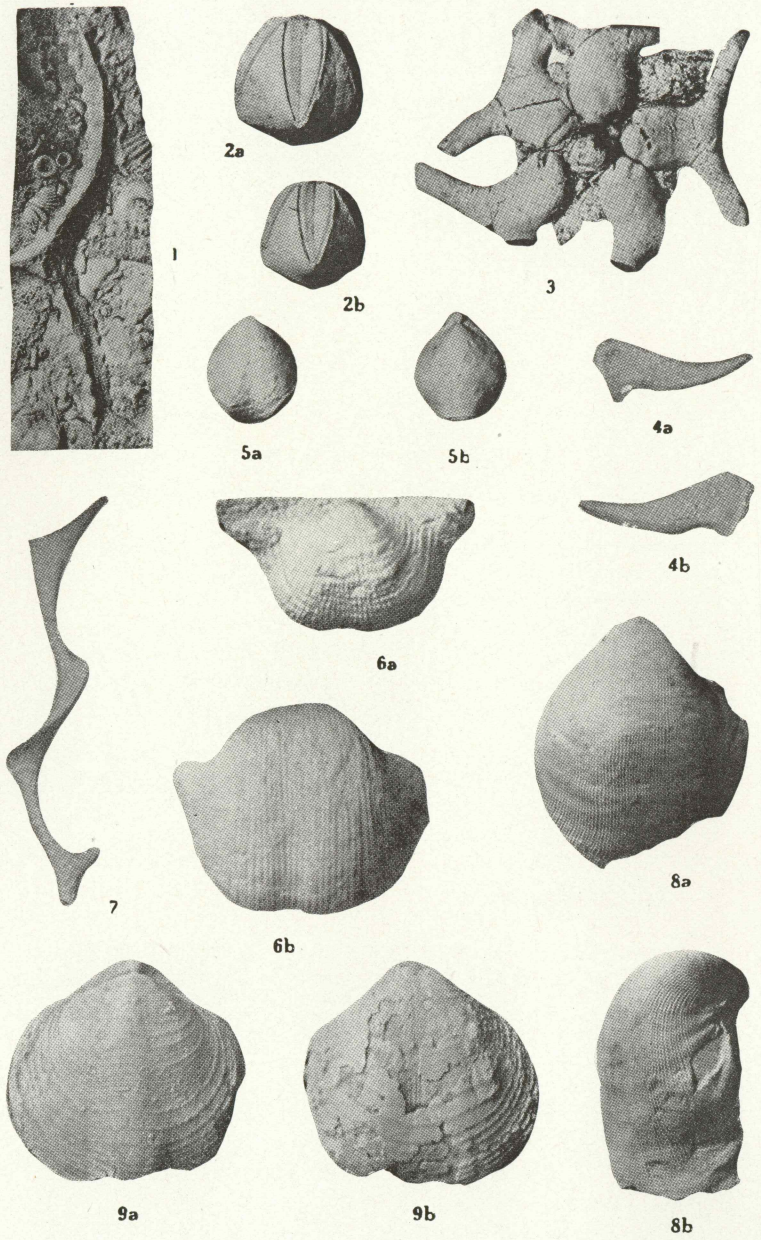
Explanation of Plate XLIII

FOSSILS FROM THE GLEN DEAN LIMESTONE.

Figure

1. *Prismopora serrulata* Ulrich. Golconda to Vienna, particularly Glen Dean.
2a, b. *Pentremites brevis* Ulrich. Glen Dean.
3. *Pterotocrinus bifurcatus* Wetherby. Glen Dean.
4a, b. *Pterotocrinus acutus* Wetherby. Glen Dean.
5a, b. *Composita trinuclea* (Hall). Salem to Chester.
6a, b. *Productus inflatus* McChesney. Chester.
7. *Archimedes laxus* Hall. Golconda and Glen Dean.
8a, b. *Productus ovatus* Hall. Kinderhook to Chester.
9a, b. *Reticularia setigera* (Hall). Ste. Genevieve and Chester.

Figures 4 and 7 after Ulrich, all others after Stuart Weller.



Fossils of the Glen Dean—Mississippian

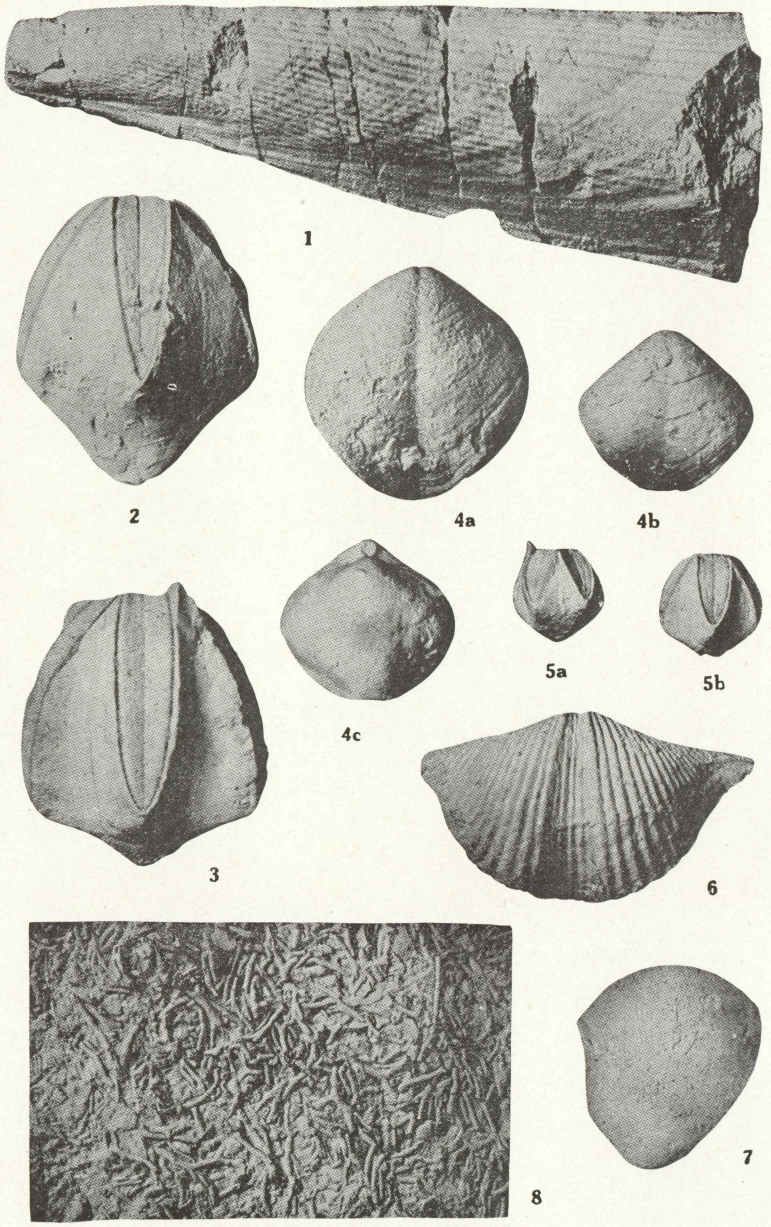
Explanation of Plate XLIV

FOSSILS FROM THE UPPER CHESTER GROUP.

Figure

1. *Sulcatopinna missouriensis* (Swallow). Vienna to Kinkaid, particularly Menard.
2. *Pentremites fohsi* Ulrich. Menard.
3. *Pentremites spicatus* Ulrich. Glen Dean to Menard.
4a-c. *Composita subquadrata* (Hall). Vienna to Kinkaid.
5a, b. *Pentremites cherokeeus* Hall. Vienna and Menard.
6. *Spirifer increbescens* Hall. Upper Chester. A related form occurs in Lower and Middle Chester.
7. *Pterotocrinus menardensis* Weller. Menard.
8. *Batostomella nitidula* Ulrich. Chester. Particularly abundant in Clore.

All figures after Stuart Weller.



Fossils of the Upper Chester—Mississippian

VI

PENNSYLVANIAN INVERTEBRATE FAUNA

By

William Clifford Morse

THE PENNSYLVANIAN INVERTEBRATE FAUNA OF KENTUCKY

By

WILLIAM CLIFFORD MORSE

INTRODUCTION

Among the Pennsylvanian shales, sandstones, and coals in eastern Kentucky are a number of fossiliferous beds, containing invertebrate faunas, beautifully preserved and wonderfully interesting, though rather puzzling in their vertical and especially in their horizontal distribution. During 1919, when the months of July and August were spent in the field, these beds yielded 36 collections, 3 being from unknown beds and 33 forming the basis of the present report.

In the attempt to trace and correlate these fossiliferous beds, of which, with a single exception, not more than one is present in any one section, the region, stretching from Tug Fork of Big Sandy River at Borderland on the east to North Fork of Kentucky River at Copeland on the west, was traversed. Inasmuch as this region includes parts of 7 counties, Martin, Pike, Johnson, Floyd, Magoffin, Knott, and Breathitt, or of 8 quadrangles, Williamson, Harold, Paintsville, Prestonsburg, Hindman, Salyersville, Troublesome, and Buckhorn, the work was, of necessity, largely reconnoissance. Moreover, as the region lies within the border limits of the Pennsylvanian basin, and streams do not anywhere completely penetrate the system, it is obviously not possible either to start at the base of the system or to begin at the margin of known beds. The region has, therefore, to be treated as an isolated area, and the beds given local names.

PENNSYLVANIAN FORMATIONS

The names, positions, and relations of these beds are shown in the following table, and brief descriptions of them are given in the subsequent pages.

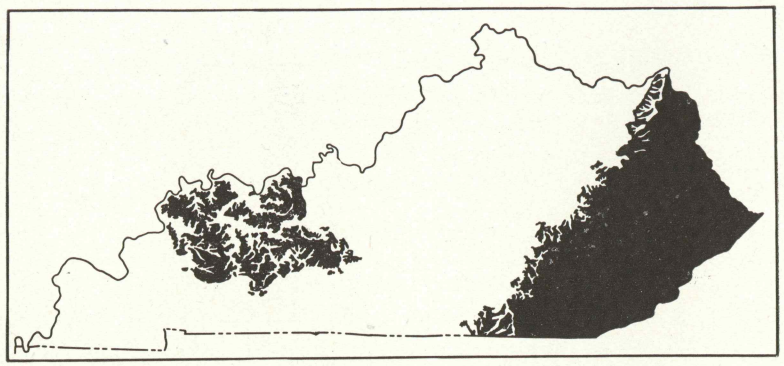


Fig. 29. Distribution of Pennsylvanian sediments.

	Feet
Flint Ridge flint	3
Interval	370
Lost Creek limestone	3
Interval	127
Saltlick beds	7
Interval	35
Magoffin beds	6
Middle coal, "Taylor", or Copeland coal	4
Interval	221
Kendrick shales—(Copland shales)	20
Lower coal, "Thacker", or Bevins coal	5
Interval	45
Elkins Fork shales	10
Interval	45
Dwale shales	—
Prestonsburg No. 1 coal	3
Interval	49
Total	953

DWALE SHALES

The lowest and oldest fossiliferous bed which was studied may be designated the Dwale shales, from the town of Dwale, where they are associated with the Prestonsburg coal. The fossil specimens (Coll. 4) came from the dump of the abandoned mine of the Dwale Coal Company, one-half mile northwest of Dwale in Floyd County (Prestonsburg quadrangle). They belong to *Lingula carbonaria*, and hence their shales may represent brackish water deposits rather than marine.

ELKINS FORK SHALES

The name Elkins Fork is proposed for the shales which are exposed opposite the school of that name in northern Pike County (Williamson Quadrangle). The known fossiliferous portion of the shales is only 8½ feet thick, is blue and argillaceous, and lies only three feet above the creek level. The fauna, although containing other forms, is represented almost exclusively by species of the single genus, Productus. By barometer, the shales lie 50 feet below the Kendrick shales. Nothing further is known concerning the geographic distribution of these lower shales.

The collecton (No. 28) of fossils from the Elkins Fork shales at the type locality consists of the following forms:

BRACHIOPODA

Productus cora d'Orbigny
P. (Marginifera) missouriensis Girty
P. (Pustula) nebraskensis Owen
P. nodosus Newberry
P. (Pustula) symmetricus McChesney
P. (Marginifera) wabashensis (?) Norwood and Pratten

PELECYPODA

Aviculopecten herzeri Meek
Myalina swallovi McChesney

GASTROPODA

Worthenia tabulata Conrad

CEPHALOPODA

Orthoceras spc.

BEVINS COAL

In accordance with his custom to call coals of unknown stratigraphic position by the name of the farm on which they were opened, Crandall referred to such a coal in eastern Pike County as the Bevins coal, inasmuch as it was opened on Mr. J. Bevins farm on Big Creek.[1] His section of the coal and associated beds is as follows:

	Thickness Inches	Total Inches
Pennsylvanian, undifferentiated		
Sandstone		
Shale	10	

[1] Crandall, A. R. The coals of Big Sandy Valley; Kentucky Geological Survey, Bull. 4, pp. 54-58, 1905.

	Thickness Inches	Total Inches
Bevins coal		57
Coal	11	
Clay	1	
Coal	32	
Shale	1	
Coal	12	
Pennsylvanian, undifferentiated		
Under clay		

Because the overlying Kendrick shales have not been found to contain characteristic fossils, or any for that matter, east of the Bevins locality, it becomes necessary to refer repeatedly to the underlying coal. The term Bevins has been revived, therefore, but in order that the name may conform to the standards of geologic nomenclature and be a geographic one, the type locality has been shifted slightly from Couder Post Office on Fraley Branch to Bevins Branch where the coal is opened on the farm of Mrs. G. M. D. Bevins. At this place the coal is five feet thick, is 755 feet above sea level, and is overlain by a black carbonaceous shale filled with typical Kendrick fossils.

KENDRICK SHALES

The Kendrick shales were so named by State Geologist Jillson[2] from exposures at the Dr. Kendrick homestead near the headwaters of Cow Creek in Floyd County, Kentucky. They are also well developed on Sugarloaf Branch the next creek to the north of Cow Creek where they are present in both the fossiliferous and nonfossiliferous phases in the upper and lower stretches of the branch.

The Kendrick shales are largely bluish and black carbonaceous shales which contain considerable calcareous material. They vary considerably in lithology from place to place as well as in invertebrate fossil content, being very fossiliferous in places and barren in others. Contemporaneous erosin or local unconformity erosion has removed part or all of them in places, so that their position in such places is occupied by younger beds, the unconformable relation thus represented not always being apparent in many of the poor exposures, unless the younger unconformable beds should be of marked lithologic

[2] Jillson, W. R. The Kendrick shale—A new calcareous fossil horizon in the Coal Measures of eastern Kentucky—The Mineral and Forest Resources of Kentucky, Ser. V, Vol. I, No. 2, pp. 96-104, 1919.

difference, as sandstones for example. At the type locality they have the composition shown in the next section. Their variation is shown in subsequent sections.

Section (No. 7) of Cow Creek at the Second House below the Kendrick Homestead.

	Thickness Feet	Total Feet
Pennsylvanian, undifferentiated		12.0
Sandstone, coarse, gray, rather massive and irregular. Contains *Sigillaria*	12.0	
Kendrick shales		19.5
Shales, soft, clayey, dove-colored or brown	1.5	
Shales, bluish-black, carbonaceous	2.5	
Siderite nodules, cone-in-cone	0.5	
Shales, dark bluish-black and black, carbonaceous. They are slightly fossiliferous at the top; more so in the middle; and slightly so at the base, the basal part containing Orbiculoidea, Productus, etc.	12.5	
Sandstone, bluish-black, micaceous. Contains Productus	1.0	
Shales, soft, clayey, or fire clay, dark bluish	1.5	
Pennsylvanian, undifferentiated		5.5
Coal, bituminous	0.5	
Covered (said to be bluish fire clay)	1.0	
Clay, shaly, dark bluish-black, or fire clay	1.0	
Sandstone, cross-bedded	3.0	

The complete list of fossils from the Kendrick shales at and near the type locality (Collections 1, 2, 8, 20, 21, 22, and 23) is as follows:

ANTHOZOA

Lophophyllum profundum Milne-Edwards and Haime

CRINOIDEA

Basal plates and stems
Hydreionocrinus kansasensis Weller

BRYOZOA

Bryozoa undetermined

BRACHIOPODA

Ambocoelia planoconvexa Shumard
Chonetes glaber Geinitz
Cleiothyridina orbicularis McChesney
Lingula umbonata Cox
Lingulipora kentuckyensis Morse
L. nebraskensis Meek
Orbiculoidea (Roemerella) patula Girty
Orbiculoidea sp.
Productus cora d'Orbigny
P. (Marginifera) missouriensis Girty
P. nebraskensis Owen
P. nodosus Newberry
P. sp.
Reticularia perplexa McChesney
Spirifer rockymontanus Marcou

PELECYPODA
Anthraconeilo taffiana Girty
Astartella arcuata Morse
A. compacta Girty
A. concentrica Conrad
A. kentuckyensis Morse
Avicula acosta Cox
Aviculopinna sp.
A. americana Meek
Deltopecten texanus Girty
Edmondia glabra Meek
Entolium aviculatum Swallow
Leda bellistriata Stevens
L. jillsoni Morse
Lima retifera Shumard
Modiola sp.
Monopteria sp.
Nucula sp.
N. anodontoides Meek
Nuculopsis ventricosa Hall
Pinna sp.
Pleurophorus subcostatus Meek and Worthen
Posidonomya fracta Meek
Prothyris elegans Meek
Schizodus affinis Herrick
S. alpinus Hall
Solenomya sp.
Yoldia glabra Beede and Rogers

GASTROPODA
Aclisina stevensana Meek and Worthen
Bellerophon sp. 1, sp. 2
B. crassus Meek and Worthen
B. (Patellostium) montfortanus Norwood and Pratten
B. (Bucanopsis) meekianus Swallow
Bulimorphia minuta Stevens
Meekospira peracuta Meek and Worthen
Pleurotomaria new sp.
Schizostoma catilloides Conrad
Sphaerodoma brevis White
S. primigenia Conrad
Trepospira depressa Cox
Worthenia new sp. 1
W. new sp. 2
W. tabulata Conrad
Zygopleura plebeia Herrick

SCAPHOPODA (Dentalium)
Plagioglypta annulistriata Meek and Worthen

CEPHALOPODA
Cyrtoceras sp.
Gastrioceras new sp. 1 sp. 2, and sp. 3
G. montgomeryense Miller and Gurley
G. occidentale Miller and Faber
Metacoceras scuptile Girty
Orthoceras new sp. 1 and sp. 2
O. colletti Miller
O. (Pseudorthoceras) knoxense McChesney

CRUSTACEA
Phillipsia trinucleata Herrick

The Kendrick shales lie 105 feet above the Prestonsburg coal. They form the roof shales of the lower coal (Thacker) of Tug Fork of Big Sandy River and of the tributaries of this fork, both in the vicinity of Borderland, W. Va.

The shales are exposed in the streams to the east of the type locality as far as Bevins Branch of Big Creek (Williamson quadrangle). From this point they have not been recognized, and their position was determined only by tracing the underlying coal from Bevins Branch down Big Creek and thence up Tug Fork to Hatfield and Borderland, where the coal proves to be the lower bed (Thacker). The shales are non-fossiliferous even as close to the type locality as the lower stretches of Sugarloaf Branch. Westward from this point they have not been recognized except at Copland on North Fork of Kentucky River (Buckhorn quadrangle), where they lie just above track level. A few hundred feet down stream the shales are largely or wholly replaced by sandstone, as a result of contemporaneous, or subsequent erosion and later deposition of younger beds.

MAGOFFIN BEDS

The name Magoffin is proposed for the shales and limestones so extensively developed in southern Magoffin County (Salyersville and Prestonsburg quadrangles). These beds are not limited to this county, but probably they have their most typical development here.

The beds consist of two thin layers of limestone, separated by a thin bed of shales, and all three underlain and overlain by thin beds of shales. In places the upper shales are fossiliferous; in other places the lower shales; and in still others, neither one is fossiliferous. In spite of the fact that the two layers of limestone and included shales are fossiliferous, the variation in the fossil content of the underlying and overlying shales makes the drawing of the lower and upper lines of contact an arbitrary matter. The total thickness assigned to the beds is

likewise an arbitrary matter, but that shown in the following section is perhaps an average. The position of the beds above the thin coal is significant.

Section (No. 31) at the head of Sycamore Branch of Oakley Creek at the home of Mrs. Sarah Salyers (Salyersville quadrangle)

	Thickness Feet	Total Feet
Pennsylvanian, undifferentiated		18.0
Sandstone, massive, some iron ore nodules	18.0	
Magoffin beds		9.4
Shales, blue and black, clayey and carbonaceous. Basal part fossiliferous	3.5	
Limestone, layer, dove-colored; fossiliferous	1.0	
Shales, upper part calcareous and very fossiliferous	1.5	
Limestone, layer, impure and sandy; fossiliferous	0.4	
Shales, soft, blue, clayey, filled with plant fossils	3.0	
Copland coal and fire clay		1.2
Coal, bituminous	0.2	
Fire clay, shaly	1.0	
Pennsylvanian, undifferentiated		7.0
Sandstone above and shales below	7.0	

The collection (No. 31) of fossils from the Magoffin beds at the type locality contains the following forms:

CRINOIDEA
- Crinoid stems and plates

BRACHIOPODA
- Chonetes granulifer Owen
- Composita subtilita Hall
- Derbya crassa Meek and Hayden
- D. robusta (?) Hall
- Orbiculoidea spc.
- Productus (Marginifera) missouriensis Girty
- P. semireticulatus Martin
- Reticularia perplexa McChesney
- Spirifer opimus Hall
- S. rockymontanus Marcou

PELECYPODA
- Astartella concentrica (?) Conrad
- Edmondia ovata Meek and Worthen
- Leda sp.
- Nuculopsis ventricosa Hall

GASTROPODA
- Bellerophon (Euphemus) carbonarius Cox

The Magoffin beds lose their identity as limestone bearers east of the headwaters of Licking River. Their position is, therefore, difficult to determine, but they are computed to lie approximately 330 feet above the coal mined at Boscoe. This coal is said to be opened just above the railroad track at short

intervals down Beaver Creek and Levisa Fork to Prestonsburg, where it is correlated with the Prestonsburg No. 1 coal. The coal was not traced from Boscoe to Dwale, but the above universal correlation by the coal men is accepted as correct or as essentially so. The Magoffin beds, accordingly, lie about 220 or 230 feet above the Kendrick shales, and are, therefore, the representatives of the roof shales of the middle, Taylor, coal, so extremely fossiliferous in the Kentucky mines opposite Borderland, West Virginia. Southward and westward from the type locality, the Magoffin shales and limestones can be traced through Knott and Breathitt counties to North Fork of Kentucky River at Copland (Buckhorn quadrangle), where they form the roof of the coal mined at Copland. The middle, Taylor, coal at Borderland is, therefore, the same bed of coal as the one mined at Copland.

SALTLICK BEDS

Just south of the gap between Grassy Creek and Raccoon Branch (Prestonsburg quadrangle) and just northeast of the one between Saltlick Creek and Quicksand Creek (Hindman quadrangle) are impure limestones, which might be mistaken easily for the Magoffin beds, because of their stratigraphic position so near the Magoffin beds and also because of their structure at the Saltlick-Quicksand gap, where the beds consist of two thin layers of limestone separated by a thin interval of shales. Careful measurements at this gap showed, however, that the beds under discussion lie 35 feet above the Magoffin beds, and careful study revealed that they are lithologically different from those beds. As the following section indicates, the beds are best exposed at the head of Saltlick Creek, after which stream it is proposed to name them.

Section (No. 36) in the highway at the head of Saltlick Creek.

	Thickness Feet	Total Feet
Pennsylvanian, undifferentiated		7.5
Shales, sandy	7.5	
Saltlick beds		7.3
Limestone, blue, impure, shaly at the top; fossiliferous	1.3	
Shales, blue, carbonaceous, and sandy; fossiliferous	5.5	
Limestone, impure, sandy and blue	0.5	

The complete list of fossils from the Saltlick beds at the type locality (Collection 35) consists of the following:

BRACHIOPODA
Ambocoelia planoconvexa Shumard
Chonetes granulifer Owen
Derbya crassa Meek and Hayden
Productus cora d'Orbigny
P. (Marginifera) missouriensis Girty
Spirifer opimus Hall
GASTROPODA
Schizostoma catilloides Conrad

The extent of the Saltlick beds is unknown. The loose blocks of limestone (Collection 19) in the gap between Mare Creek and Buffalo Creek (Harold quadrangle) may be Saltlick in age, because of their position and fossil content. Outside of the three gaps mentioned the Saltlick beds have not been recognized as such.

LOST CREEK LIMESTONE

On the divide between Lost Creek and Big Branch of North Fork of Kentucky River (Buckhorn quadrangle), just north of the gap through which passes the road connecting these two streams, is a thin limestone which differs markedly from all the others of eastern Kentucky. Where exposed along the crest of the ridge, the limestone is rather badly broken, but large blocks show it to be at least three and one-half feet thick. The lower two-thirds is a fossiliferous dolomitic limestone, and the upper third is a blue shelly limestone. The limestone is very fossiliferous, Bryozoa being especially abundant. It lies, by barometric measurement, about 175 feet above the Magoffin beds and nearly 130 feet above the Saltlick beds. For more reasons than one, this dolomitic limestone is very appropriately named the Lost Creek limestone from the stream of that name.

The list of fossils (Collection 37) from the Lost Creek limestone at the type locality is as follows:

BRYOZOA
Fenestelloid specimen
BRACHIOPODA
Chonetes granulifer Owen
Composita subtilita Hall
Derbya crassa Meek and Hayden
Productus sp.
Spirifer sp.
Spiriferina kentuckyensis Shumard

FLINT RIDGE FLINT

On Flint Ridge at the head of Leatherwood Branch of South Quicksand Creek (Troublesome quadrangle), 30 feet from the top of the ridge and near the 1,500-foot contour line, and also 550 feet, by barometer, above the Magoffin beds, is a three-foot bed of flint, which is yellow in color and contains no fossils. Loose dolomitic or leached limestone blocks associated with the flint are very fossiliferous, however. The Flint Ridge flint which lies so near the top of the high ridge has not been recognized outside of this area.

The collection (No. 14) of fossils from the Flint Ridge flint at the type locality contains the following forms:

CRINOIDEA
Crinoid stems
BRYOZOA
Fenestelloid specimen
BRACHIOPODA
Orbiculoidea convexa Shumard
Productus nebraskensis Owen
Spirifer rockymontanus Marcou
PELECYPODA
Allerisma terminale Hall
Lima retifera (?) Shumard
Pseudomonotis kansasensis (?) Beede
GASTROPODA
Bellerophon (Bucanopsis) meekianus ? Swallow

DESCRIPTION OF SPECIES

Phylum COELENTERATA

Class ANTHOZOA

LOPHOPHYLLUM PROFUNDUM Milne-Edwards and Haime

Plate XLV, figs. 1-3a

1851. *Cyathaxonia profunda.* Milne-Edwards and Haime, Mon. des Polyp. Foss, p. 323.
Carboniferous: Flint Ridge, Ohio.

The coralla are typical rather abruptly expanding cones which are but slightly curved. The surface is marked by rather prominent longitudinal ridges and a few transverse wrinkles and depressions. One of the two specimens has the characteristic columella or pseudocolumella as the case may be.

Distribution. Kendrick shales: Collections 3, 8, 21, 22, 18, 15.

PHYLUM MOLLUSCOIDEA

CLASS BRACHIOPODA

LINGULA CARBONARIA SHUMARD

Plate XLV, figs. 4-7

1858. *Lingula carbonaria.* Shumard, Trans. St. Louis Acad. Sci., Vol. 1, p. 215.
Coal Measures: Clark County, Missouri.

1922. *Lingula carbonaria.* Morningstar, Geol. Surv. Ohio, Bull. 25, p. 166, pl. 7, figs. 1-3.
Pottsville formation: Ohio.

Most of the shells of this species are of medium size, measuring 6 by 11 millimeters. In outline, they are distinctly subrectangular. The umbonal and middle portions of the valves are moderately convex; the sides and front, flattened. The surfaces of both valves are marked by fine concentric striae, which are decidedly grouped along the lateral and anterior margins, and by less distinct radiating striae.

The shells agree rather closely with those figured by Dr. Hellen Morningstar, being, perhaps, a trifle more rectangular. They differ from *L. kanawhensis* Price in their smaller size and espcially in their rectangular rather than more transverse outline

Distribution. Dwale shales: Collection 4.

LINGULIPORA KENTUCKYENSIS N. SP.

Plate XLVI, figs. 1-4a

The shells are large, being twice the length of *L. nebraskensis.* Like that species they are subtrigonal in outline and almost as wide as long, the greatest breadth being near the anterior margin. The front and anterolateral margins are, perhaps, more uniformly rounded; the sides are nearly straight, converging toward the beak at an angle of about ninety-two degrees.

The surface is lustrous and is ornamented by minute prominent sharp abrupt concentric ridges, which are separated from one to another by flat interspaces but two to three times as wide as the ridges. Accordingly the concentric ridges are approximately twice as numerous as on *L. nebraskensis.*

Length 28 millimeters.

The species resembles *L. nebraskensis* in its lingulate shape and sharp concentric ridges and differs from that species in having twelve ridges instead of only seven or eight to five millimeters of space. The difference in number cannot be attributed to the difference in size of the shells of the two species, for the larger species has the more closely spaced ridges

Distribution. Kendrick shales: Collections 1, 8, 21, 22, 7.

LINGULIPORA NEBRASKENSIS MEEK

Plate XLVI, figs. 5-6a

1872. *Lingula scotica* var. *nebrascensis.* Meek, U. S. Geol. Survey, Nebraska Final Rept., p. 158, pl. 8, figs. 3a, 3b.
Upper Coal Measures, Nebraska City, Neb.

The shells range from small to medium in size. They are subtrigonal in outline and about as wide as long, the greatest breadth being near the anterior margin. The front is broadly rounded; the antero-lateral margins abruptly so; the sides are nearly straight, converging toward the beak at an angle of eighty to ninety degrees.

The surface is brilliant and is marked by minute but prominent, sharp, abrupt concentric ridges, which are separated from one another by flat interspaces four or five times as wide as the ridges.

Length 12 to 14 millimeters.

The species is characterized by its lingulate shape and sharp concentric ridges.

Distribution. Kendrick shales: Collections 8, 22.

ORBICULOIDEA (ROEMERELLA) PATULA GIRTY

Plate XLVII, figs. 1-4

1911. *Roemerella patula.* Girty, New York Acad. Sci. Annals, Vol. 21, p. 125.
Wewoka formation: Wewoka and Coalgate quadrangles, Okla.

The shells are of medium size, ranging from sixteen to eighteen millimeters in diameter.

The brachial valves are low and regularly convex. The apex or beak is small, eccentric, being about two-thirds of the distance from the posterior margin to the center.

The pedicle valve is not represented.

The surface is marked by fine, abruptly raised concentric ridges, which are separated by broader flattened interspaces. As in Girty's type, the exfoliated portion of the shell is marked most conspicuously by very fine radiating plications and striae, the plications being slightly more prominent.

The specimens seem to agree exactly with the species *patula*, which Girty referred to the subgenus *Roemerella* of Hall and Clarke, largely on the internal markings of the brachial (dorsal) valve, which markings those authors neither mention nor illustrate, though they do both with the subgenus *Lindstroemella*. In the absence of the pedicle valve, the concavity of which constitutes the subgeneric value of *Roemerella*, it is impossible to definitely refer the present forms to a subgenus of the genus *Orbiculoidea*, again illustrating the fact that it is often easier to identify a species than it is to identify a refined subgenus or genus, and illustrating the futility of such refinement in either practical paleontology or stratigraphy.

Distribution. Kendrick shales: Collections 2, 20, 1, 8, 21, 22, 23, 9, 18, 7, 29, 30, 15.

DERBYA CRASSA Meek and Hayden

Plate XLVII, figs. 5, 5a

1858. *Orthisina crassa.* Meek and Hayden, Proc. Acad. Nat. Sci. Phil., p. 261.
Coal Measures: Leavenworth, Kans.

Though largely or exclusively fragmental the specimens of this species can readily be identified by their Strophomenoid outline and crenulated growth lines, produced by the concentric lines crossing two or more series of radiating costae, separated by wider interspace. The shells are doubly convex and subcircular, the hinge line being, therefore, much shorter than the width of the shell. In addition to the ornamentation mentioned, both valves are somewhat contorted and undulating, the concentric wrinkles being rather prominent in some specimens.

Distribution. Kendrick shales: Collections 9, 7, 24, 15; Magoffin beds: Collections 27, 26, 25, 31, 12, 32, 33, 16; Saltlick beds: Collection 35; Lost Creek limestone: Collection 37.

CHONETES GLABER Geinitz

Plate XLVIII, figs. 1-10

1866. *Chonetes glabra.* Geinitz, Carb. und Dyas in Nebr., p. 60, Tab. 4, figs. 15-18. (Not *C. glaber* Hall, 1857).
Dyas, Nebraska City, Nebr.

The shells are small, thin, concavo-convex, and sub-semicircular in outline.

The pedicle valve is but moderately convex. Its most distinctive features are two broad undefined prominences which diverge from the beak toward the antero-lateral margins, thus forming a triangular sinus between them. The hinge line bears six diverging prominent spines on each side of the beak.

The concave brachial valve conforms rather closely to the convex pedicle valve.

Scarcely less distinctive than the converging prominences of the pedicle valve is the smooth surface of both valves, save for a few indistinct concentric lines of growth.

Distribution. Kendrick shales: Collections 3, 2, 20, 1, 8, 21, 22, 23, 9, 18, 6, 7, 24, 30, 15.

CHONETES GRANULIFER Owen

Plate XLVIII, figs. 11-16a

1852. *Chonetes granulifera.* Owen, Rept. Geol. Survey Wisconsin, Iowa and Minnesota, p. 583, pl. 5, fig. 12.
Carboniferous limestone: Near mouth of Keg Creek, Mo.

For *Chonetes* the shells are rather large, though not nearly so much so as some of the Mississippian species. In outline they are roughly semi-circular. As presented the shells are nearly plano-convex or but slightly concavo-convex. The pedicle valves are moderately and rather uniformly convex. The brachial valves are almost flat. Both valves are covered by fairly uniform, beautiful fine radiating costae, which are crossed by concentric growth lines, more conspicuous on the brachial valve.

Chonetes granulifer is distinguished from other Pennsylvanian species by the uniform convexity of the pedicle valve and the radiating costae.

Distribution. Magoffin beds: Collections 27, 25, 31, 12, 32, 33, 36, 16; Saltlick beds: Collections 19, 35; Lost Creek limestone: Collection 37.

PRODUCTUS (MARGINIFERA) MISSOURIENSIS Girty

Plate XLVII, figs. 6-11

1915. *Marginifera muricata var. missouriensis.* Girty, Missouri Bureau Geol. and Mines, Vol. 13, p. 350, pl. 30, figs. 2-5a.
Cherokee shale: Mo.

The shells are small in size and typical productoid in form.

The pedicle valves are almost uniformly curved from the beak to the anterior edge and are approximately as broad as long. They are covered by small uniform ribs, which bear spine bases, especially in the umbonal region, and which in that region are crossed by a few less distant concentric wrinkles. Some of the specimens have a fairly well defined sinus.

The brachial valves are slightly concave. The interior surface of this valve has less regular ribs or costae than those of the pedicle valve, and in the visceral area these are crossed by more pronounced concentric wrinkles.

Although some of the specimens have a sinus on the pedicle valve, their shape otherwise and their fine regular costae agree very closely with the variety *missouriensis* of the species *muricata* which Girty doubtfully referred to the subgenus *Marginifera*. None of the present specimens show the internal ridge characteristic of *Marginifera*. It may be possible, therefore, to recognize this subgenus after the species has been definitely determined.

Distribution. Elkins Fork shales: Collection 28; Kendrick shales: Collections 3, 2, 20, 1, 8, 21, 22, 23, 9, 18, 7, 24, 29, 30, 15; Magoffin beds: Collections 27, 26, 25, 31, 12; Saltlick beds: Collections 19, 35.

PRODUCTUS NEBRASKENSIS Owen

Plate XLVII, figs. 12-16

1852. *Productus nebrascensis.* Owen, Rept. Geol. Survey Wisconsin, Iowa, and Minnesota, p. 584, Pl. 5, fig. 3.
Carboniferous limestone: Bellevue, Missouri River, Nebr.

This species is represented by a brachial valve which is medium in size and slightly concave in the visceral area, though the remainder of the valve conforms to the contour of the pedicle valve. Both the interior of the valve (brachial) and the impression of the exterior reveal the short discontinuous ribs and the concentric undulations or wrinkles so characteristic of

the species when the shell and the numerous spines are exfoliated.

Distribution. Elkins Fork shales: Collection 28; Kendrick shales: Collections 22, 24, 15; Magoffin beds: Collection 12; Flint Ridge flint: Collection 14.

PRODUCTUS NODOSUS Newberry

Plate XLIX, figs. 1-4

1861. *Productus nodosus.* Newberry, Ives, Colorada Expl. Exped., p. 124, Pl. 1, figs. 7-7b.
Carboniferous limestone: Santa Fe, New Mex.

The shells are of medium size and typically productoid in form, though all of them have been more or less compressed or crushed in the compacting of the shales.

The pedicle valve is, of course, the more gibbous of the two. Like *P. cora* it is covered by fine closely arranged costae, some of which, along the median line, on converging toward the anterior end unite to form, or at least to support, the few large spine bases.

The brachial valves are slightly concave in the visceral area. They are covered by the same kind of costae, some of which converge and unite to form a median row of a few large spine bases, as on the pedicle valve. In the visceral area the costae are crossed by rather numerous concentric wrinkles.

P. nodosus is easily recognized by its productoid form, *P. cora* type of costae, and particularly by the converging and uniting of some of the costae to form the median line of a few large spine bases.

Distribution. Elkins Fork shales: Collection 28; Kendrick shales: Collections 3, 8, 21, 22, 23, 15.

PRODUCTUS SEMIRETICULATUS Martin

Plate XLIX, figs. 5-8

1847. *Productus semireticulatus.* De Koninck, Mon. du Gen. Prod. et Chon., p. 83, Pl. 8, figs. 1a-h; Pl. 9, figs. 1a-m; Pl. 10, figs. 1a-d.
Carboniferous: Ohio, Mo., Ind., Ill., Ky., South America.

The shells are of medium size and wider than long. All the specimens are more or less crushed. The pedicle valve is convex, and, in most forms, it has a more or less definite sinus, which the crushing of the shells commonly accentuates. Though the surfaces of most specimens are covered with rather regular

medium costae, still the costae vary somewhat in size on some of the forms. In the posterior part, the radiating costae are crossed by concentric striae in such a manner as to develop distinct concentric costae, hence, the reticulate ornamentation so characteristic of this half or part of the shell. The brachial valve is flattened in the visceral region, but in the remaining portion conforms to the pedicle valve into which it fits. Its ornamentation is virtually the same as that of the pedicle.

Perchance some of these specimens are *P. costatus*-like forms similar to the ones Meek submitted long ago (before 1872) to Mr. Davidson, the English authority on Brachiopoda, who considered them small *P. semireticulatus* (U. S. G. S. of Nebraska, p. 160.)

Distribution. Kendrick shales: Collection 15; Magoffin beds: Collections 31, 12, 32, 33, 16.

SPIRIFER CAMERATUS Morton

Plate XLIX, figs. 9-10

1836. *Spirifer cameratus.* Morton, Am. Jour. Sci., Vol. 29, pp. 32, 150, Pl. 2, fig. 3.
Coal Measures: Putnam Hill, Zanesville, Ohio.

The shells are large and transverse, incomplete pedicle valves measuring fifty-four millimeters in breadth at the hinge line and thirty-four millimeters in length. The pedicle valve is moderately convex. Its medium sinus is conspicuous, being an abrupt groove at the beak and broader and less abrupt at the anterior end. The cardinal area is arched and is bounded by two nearly parallel margins. The beak is small and incurved. The surface of the sides and of the sinus is covered with medium rounded costae separated from each other by grooves of smaller size. The costae are typically arranged in bundles so characteristic of the species. The brachial valve was not secured.

Distribution. Kendrick shales: Collection 18.

SPIRIFER ROCKYMONTANUS Marcou

Plate L, figs. 1-3

1858. *Spirifer rocky-montana.* Marcou, Geol. North America, p. 50, pl. 7, figs. 4-4e.
Mountain limestone: Tigerus, New Mex.

The shells are small, slightly wider than long. Both valves are strongly and almost equally convex.

The pedicle valve is strongly convex and has an elevated pointed beak. The mesial sinus is well defined at the beak and gradually increases in depth and width toward the anterior. It contains distinct ribs which are not so stout as those on the sides of the valve which are about eight in number.

The brachial valve is slightly less convex. It is marked by a prominent mesial fold which originates as a sharp plication, the two branches of which anterior to the point of bifurcation are not so curved as the ribs on the side of the valve.

The surfaces of both valves are further ornamented by fine radiating striae and concentric growth lines of which the striae are the more prominent.

Distribution. Kendrick shales: Collections 8, 21, 22, 18; Magoffin beds: Collections 27, 31, 12, 32; Saltlick beds: Collection 19; Flint Ridge flint: Collection 14.

RETICULARIA (SQUAMULARIA) PERPLEXA McChesney

Plate L, fig. 4

1860. *Spirifer perplexa.* McChesney, Desc. New Pal. Foss., p. 43. Upper Coal Measures: Almost every part of the country where rocks of that age occur.

1899. *Reticularia perplexa.* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., Pt. 3, p. 577, Pl. 72, fig. 1a.
Upper Coal Measures: McAlester quadrangle, Ind. Ter.

This species is represented by a brachial valve which is convex and has a slightly elevated beak. The surface bears evidence of the concentric rows of fine spines, which form the reticulate ornamentation so characteristic of the genus.

This species was long referred to the genus *Spirifer* and then in 1899 to *Reticularia* (McCoy 1844) by Girty. *Reticularia* has become a well established genus for a number of Mississippian species by virtue of its easily recognized reticulate surface. Though not considered distinctive by its creator, Gemmellaro, in 1899, the genus *Squamularia*, according to Girty in 1903 is a non-septate form of the reticulate type to which *perplexa* should be referred. Weller showed in 1914 that even in some of the specimens of true *Reticularia* the median septum of the brachial valve has berome almost obsolete, though they are septate forms. As early as 1903 Girty found, "in practice", difficulty in distinguishing poorly preserved or imperfect forms of *Squamularia perplexa* from *Seminula sub-*

tilita and *Ambocoelia planoconvexa*. Now in 1927 it is possible to refer doubtfully to the genus *Squamularia* those specimens not preserving or showing the obsolescent median septum provided the paleonlotogist has determined them to belong to the species *perplexa* or the stratigrapher has shown them to come from Pennsylvanian or Permian beds, another striking example of the futulity of basing generic differentiation on minor concealed features or of establishing subgeneric differentiation on scarcely specific values.

Distribution. Kendrick shales: Collection 22; Magoffin beds: Collections 27, 31.

AMBOCOELIA PLANOCONVEXA SHUMARD

Plate L, fig. 5

1855. *Spirifer planoconvexa.* Shumard, Missouri Geol. Survey, Second Ann. Rept., p. 202.
Upper Coal Measures: On Missouri River, near mouth of Platte River.

The shells are small and plano-convex.

The convex pedicle valve has the stout beak projecting beyond the shoulders of the valve in typical *Ambocoelia* fashion. A small but distinct mesial sinus extends from the beak to the anterior end.

The brachial valve is nearly flat and decidedly transverse. In some specimens it is marked by an indistinct sinus.

The surface is practically smooth.

Distribution. Kendrick shales: Collections 3, 2, 1, 8, 22, 9, 18, 6, 24, 15; Magoffin beds: Collection 27; Saltlick beds: Collection 35.

COMPOSITA SUBTILITA HALL

Plate L, fig. 6

1852. *Terebratula subtilita.* Hall, Stansbury's Exped. Great Salt Lake of Utah, p. 409, Pl. 4, figs. 1, 2.
Carboniferous: Missouri River, near Weston.

The shells are medium in size and subovoid in shape. Both valves are nearly equal and convex. The pedicle valve is rather uniformly convex, save for the mesial sinus which begins as an indistinct line and gradually increases in depth and breadth to the anterior margin. The beak is small, incurved, and obliquely truncated to form the foramen. The brachial valve is slightly more convex along a median line, but it has no distinct mesial

fold, a curved notch in the margin accommodating the sinus of the pedicle valve. Both valves have their surface marked by distinct growth lines.

Distribution. Kendrick shales: Collection 15; Magoffin beds: Collections 27, 31, 12, 32, 16; Lost Creek limestone: Collection 37.

CLEIOTHYRIDINA ORBICULARIS MCCHESNEY

Plate L, fig. 7

1860. *Athyrus orbicularis.* McChesney, Desc. New Spec. Foss., p. 47.
Coal Measures: Western States.

The shells are medium to large in size. Although the specimens are crushed, they seem to agree with the usual descriptions. They are subcircular in outline; approximately as wide as long; their pedicle valve is convex and has but an indistinct mesial sinus; their brachial valve is less convex and may have a less distinct sinus. In those specimens having the numerous spines broken away, the shell is decidedly lamellose in appearance.

Distribution. Kendrick shales: Collections 8, 22; Magoffin beds: Collection 12.

PHYLUM MOLLUSCA

CLASS PELECYPODA

LEDA BELLISTRIATA STEVENS

Plate L, figs. 8-15

1858. *Leda bellistriata.* Stevens, Am. Jour. Sci., Vol. 25, p. 261.
Coal Measures: Danville, Ill.; Summit, Ohio.

For members of this species, the shells are rather large, ranging from eighteen to twenty-eight millimeters in length. The ventral margin can, perhaps, be likened to a slightly concave sled runner, a considerable portion of which bends upward in a graceful curve at the anterior end. Here the cardinal margin is a continuation in about the same curvature backward toward the beak, posterior of which it is a somewhat smaller replica of the ventral margin. The lunule is an extremely narrow arrow-like triangular area, bordered by umbonal ridge margins which diverge slightly toward the anterior and gradually fade away in this direction. The escutcheon is more distinct and lanceolate in outline.

The surface of this prim little shell, as the name suggested, is ornamented with beautiful concentric striae, which alternate with fine sharp concentric ridges.

The sculpture of the internal impression, the so-called cast, is distinctive. Two or more broad shallow grooves extend obliquely from the umbonal region toward the ventral margin. The dentition is represented by a zigzag line, not unlike the suture lines of the brain.

Specimens of this beautiful and characteristic Pennsylvanian Pelecyod form a perfect series, ranging from typical normal-sized *Leda bellistriata* without a beak to typical L. *bellistriata* var *attenuata* Meek, approximately twice the normal size.

Distribution. Kendrick shales: Collections 1, 8, 22, 18, 6; Magoffin beds: Collections 27, 12.

LEDA JILLSONI N. Sp.

Plate L, figs. 16, 16a

Externally this beautiful little shell differs from the more attenuate *L. bellistriata*, elsewhere described in this report, only by its smaller size and the greater coarseness of its configuration. The specimen is small, attaining, perhaps, in its unbroken condition a length of fifteen millimeters. The surface is marked by narrow sharp abruptly raised concentric ridges separated by flat interspaces six to eight times as broad as the ridges. The ridges are 0.5 millimeter apart and total approximately fifteen on each valve, a number surpassed on the beak itself of *L. bellistriata*. In outline and sharpness of concentric ridges *L. jillsoni* resembles *L. arata* Hall, but Hall's form must have been almost twice as large and must have had less sharp and more numerous concentric ridges.

This species is named after the Director and State Geologist of Kentucky, Dr. Willard Rouse Jillson, who has shown a keen interest in these fossiliferous beds. The species can be distinguished at a glance by its ornamentation.

Distribution. Kendrick shales: Collections 1, 8, 22, 23, 6, 7, 30.

AVICULOPINNA AMERICANA Meek

Plate L, fig. 18

1867. *Aviculopinna americana.* Meek, Am. Jour. Sci., Vol. 44, p. 282.

The shells are small, ranging from twenty-five millimeters to thirty-five millimeters in length. The dorsal and ventral

margins are nearly straight and gradually converge toward the anterior end. Although both specimens are imperfect they seem to agree further with Meek's description.

The surface is ornamented by numerous sharp regularly disposed concentric ridges which are much narrower than the nearly flat interspaces. In curvature they conform to the posterior margin of the shell.

Distribution. Kendrick shales: Collections 22, 7, 15; Magoffin beds: Collection 25.

SCHIZODUS ALPINUS Hall

Plate LII, fig. 1

1858. *Dolabra? alpina.* Hall Rept. Geol. Survey Iowa, Vol. 1, Pt. 2, p. 716, Pl. 29, fig. 2.
Lower Coal Measures: Alpine Dam, Iowa.

The shells are of medium size and are slightly higher than long. They are commonly described as having curved anterior and ventral margins and an obliquely truncated posterior margin and subcentral beaks. Once gained the conception of the outline of the shell suffices to identify it at once.

Distribution. Kendrick shales: Collections 2, 1, 8, 21, 22, 9, 18, 7, 29, 30, 15; Magoffin beds: Collection 16.

DELTOPECTEN TEXANUS Girty

Plate LI, fig. 1

1904. *Limipecten texanus.* Girty, U. S. Nat. Mus. Proc., Vol. 27, p. 722. Pl. 45, figs. 1, 2, 3; Pl. 46, figs. 4?; Pl. 47, figs. 1, 2, 3.
Pennsylvanian (Cisco): Graham, Young County, Texas.

The shell is large, being at least ninety by ninety millimeters and therefore about as long as high.

The left valve is moderately and rather uniformly convex. Both the anterior and the posterior wings are large; the anterior wing is set off from the shell proper by an abrupt change in slope. The surface is covered with rather widely spaced radiating ribs, "which are more or less regularly unequal in size" (Girty). Crossing the ribs on well preserved forms are irregular concentric scalloped lamellae.

Though imperfectly preserved the right valve is much flatter than the left. The surface has the same radial and concentric ornamentation as the left valve, but the radiating ribs are so much smaller and so much more closely spaced as to suggest another species were the valve not attached to the left one.

As observed by Girty, the shell consists of two conspicuous layers, but in the Kendrick form the outer layer is dark and earthy, whereas the inner is light and pearly.

Distribution. Kendrick shales: Collections 8, 23.

ALLERISMA TERMINALE Hall

Plate LI, fig. 2

1852. *Allorisma terminalis.* Hall, Stansbury's Exped. to Great Salt Lake, p. 413, Pl. 2, figs. 4a, b.
Carboniferous: Big Blue River.

The shells are large and elongate, from two to three times as long as high. The dorsal and ventral margins are nearly parallel, being nearly straight or respectively slightly concave and convex. The beaks are near the anterior end. The surface is marked by strong concentric rounded ridges which are separated by narrower grooves. Though commonly compressed and represented only by external and internal impressions, this splendid Pennsylvanian form can be readily recognized by its large size, subcuneate shape, and prominent concentric ridges.

Distribution. Magoffin beds: Collections 12, 16; Flint Ridge flint: Collection 14.

PROTHYRIS ELEGANS Meek

Plate LII, fig. 2

1871. *Prothyris elegans.* Meek, Am. Jour. Conch., Vol. 7, p. 8, Pl. 1, fig. 3.
Coal Measures: Nebraska City, Nebraska; Ohio; Illinois, Michigan.

The shell is subrectangular in outline and about four times as long as high. The ventral and dorsal margins are nearly straight and parallel. The beaks are not distinct and are located near the antero-dorsal angle at which is the well defined notch. The surface is marked by fine concentric growth lines or striae which are more conspicuous along the ventral and posterior portions.

Distribution. Kendrick shales: Collection 22.

ASTARTELLA ARCUATA N. Sp.

Plate LII, figs. 4-5a

Associated with other *Astartella*, particularly with *A. kentuckyensis*, are some rare specimens which, from the "swing" of the shell and the nature of the sculpture, obviously belong to a species not yet described. The shells are medium in size. In profile the dorsal concave line is parallel with the ventral

convex line in such a manner as always to suggest the Hollander's wooden shoe. Though imperfect specimens, the ventral line seems to be very convex, bending abruptly upward into the rather straight anterior line and likewise into the curved posterior margin. There is no well delimited umbonal ridge, but the greatest convexity of the shell passes downward and backward in a curve somewhat parallel with the concave dorsal and convex ventral margins thus accentuating this peculiar outline or "swing" of the shell.

The surface is covered with rather fine concentric ridges and furrows, of about equal size, which have the characteristic curvature or "swing" of the shell. The species can be thus be differentiated at a glance from the other species of the genus.

Distribution. Kendrick shale: Collections 8, 22.

ASTARTELLA CONCENTRICA Conrad

Plate LII, fig. 3

1842. *Nuculites concentricus.* Conrad, Acad. Nat. Sci. Phil. Jour. Vol. 8, Pt. 2, p. 248.
Coal Measures: Pennsylvania.

The shell is small in size and subquadrilateral in outline. The dorsal border is nearly straight. The ventral border is likewise nearly straight or but slightly convex, curving strongly toward the front and more so toward the rear. The rear slope makes an obtuse angle with the dorsal border.

The valves are fairly convex, being most so in the umbonal region. The umbonal ridge is broad and is not sharply differentiated.

The surface is marked by sharp angular concentric ridges and broad shallow interspaces, resembling respectively the crests and troughs of waves.

Distribution. Kendrick shales: Collections 3, 8, 22, 9; Magoffin beds: Collections 31?, 12.

ASTARTELLA KENTUCKYENSIS N. Sp.

Plate LII, figs. 6-9a

The shells are stout and medium in size; they commonly attain a length of twenty-five millimeters. The ventral margin and the hinge line are nearly parallel, though the umbos rise above the upper line. The ventral margin is but slightly convex, except in those specimens which have been compressed with the induration of the inclosing shale. Anteriorly it bends

abruptly upward in a pronounced curve; posteriorly, in a sharp angular curve. The lunule is heart-shaped; the escutcheon, an elongated oval; both are but slightly differentiated, the escutcheon the more so by an indistinct groove parallel to the posterior margin of the umbonal ridge.

In most specimens the umbonal ridge as such is not conspicious, being so embracing. It includes the whole triangular area between the antero-ventral and the postero-ventral angles and the beak, thus constituting almost the whole of each valve. Longitudinally the triangle is nearly a plane surface, but vertically it is a gently curved surface, becoming progressively more curved towards the beaks. Few specimens show even a trace of sinus.

The internal structure has not been observed.

The whole surface is marked by pronounced concentric ridges and grooves, which are approximately the reverse complements of each other. Near the line extending from the beak to the antero-ventral angle, the concentric ridges increase by division or implantation, thus giving a saucy tilt to the sculpture, perhaps the most distinctive feature of the shell.

This species seems to be confiined to the Kendrick shales, and it is, therefore, one of the most diagnostic in the Pennsylvanian system of Kentucky.

Distribution. Kendrick shales: Collections 3, 2, 20, 1, 8, 21, 22, 23, 9, 18, 6, 7, 24, 29, 30.

Class SCAPHOPODA

PLAGIOGLYPTA ANNULISTRIATA. Meek and Worthen

Plate LIII, fig. 1

1870. *Dentalium annulostriatum.* Meek and Worthen, Acad. Nat. Sci. Philadelphia Proc., p. 45.
Coal Measures: Danville, Ill.

The collection contains one imperfect specimen which seems to belong to this species which Meek and Worthen described in the following terms: "Shell very small, rather distinctly tapering, and slightly arched; aperture and section circular; surface ornamented by regular, distinct, annular costae, which pass around a little obliquely, and are separated by rounded furrows of the same breadth as the costae themselves" (1873).

Distribution. Kendrick shales: Collection 22.

Class GASTROPODA

WORTHENIA TABULATA Conrad

Plate LIII, fig. 2

1835. *Turbo tabulatus.* Conrad, Pennsylvania Geol. Soc. Trans. Vol. 1, Pt. 2, p. 267, Pl. 12, fig. 1.

The specimens range in size from minute shells to large ones more than twenty millimeters in length. The prominent nodose carina, bounded by two lesser carinae, divides the volutions into subequal halves. The flattened sloping upper half of each whorl is conical in profile whereas the exposed portion of the lower half is cylindrical.

The surface is marked by revolving and transverse striae, which give to the shell a reticulate sculpture.

Perhaps the most characteristic feature of the shell is the resemblance of the profile of the spire to a graded series of cylinders. Into the truncated conical cap of each larger form almost the whole cylinder of the next size has been thrust.

Distribution. Elkins Fork shales: Collection 28; Kendrick shales: Collections 22, 18; Magoffin beds: Collections 27, 25.

TREPOSPIRA DEPRESSA Cox

Plate LIII, figs. 14-21

1857. *Pleurotomaria depressa.* Cox, Kentucky Geol. Survey Rept., Vol. 3, p. 569, Pl. 8, figs. 10, 10a. (Not *P. depressa* Phillips, 1836).
Coal Measures: Bonharbour, Davies County and Airdrie, Muhlenberg County, Ky.

The shells of this species range in size from small to medium, the largest shells attaining a diameter of only nineteen millimeters. They are discoidal or rather lens-shaped. Accordingly, the spire is low, and, save for the sculpture, each volution joins without a break the preceding one in such a way as to maintain the lens shape of the entire shell. The peripheral portion of the whorl consists of a sharp edge above which is a slight groove into which fits the inner portion of the succeeding whorl. The inner edge of the whorl is marked by a slightly elevated belt on which are developed the single spiral row of nodes, which, with the lens shape of the shell, form such a characteristic feature of the species. The slit band lies just above the carina. The umbilicus is broad and shallow.

The lower surface is beautifully marked by fine growth lines, each of which bends forward in a graceful curve. The upper surface is similiarly marked, but it is not so commonly preserved.

As previously stated, the characteristic features of the shell are the lens shape and spiral row of nodes.

Distribution. Kendrick shales: Collections 3, 2, 1, 8, 21, 22, 9, 18, 7, 24, 29, 30; Magoffin beds: Collections 27, 25, 12.

BELLEROPHON (EUPHEMUS) CARBONARIUS Cox

Plate LIII, fig. 3

1857. *Bellerophon carbonarius.* Cox, Kentucky Geo. Survey Rept., Vol. 3, p. 562.
Coal Measures: Kentucky.

The shells are small, the larger of them attaining a diameter of only ten millimeters. In outline they are subspherical. The whorls are embracing. There is no umbilicus. The anterior or apertural portion of the shell is smooth; the posterior portion, in the preserved forms, is marked by the characteristic revolving ridges, which are narrow and sharp and which project abruptly from the flat interspaces.

Distribution. Kendrick shales: Collections 18, 30, 15; Magoffin beds: Collections 27, 25, 31, 12.

BELLEROPHON CRASSUS Meek and Worthen

Plate LIII, figs. 4-10

1860. *Bellerophon crassus.* Meek and Worthen, Proc. Acad. Nat. Sci. Philadelphia, p. 458.
Lower Coal Measures: Pittsburg, St. Clair County, Ill.

The shells are mostly small, a few, however, attain a diameter of fifteen millimeters. In shape they are typical Bellerophons, being subspherical in outline. The outer whorl is all embracing. Transversely the aperture is almost a perfect oval. In most specimens there is but a faint suggestion of an umbilicus. The columnella is both prominent and stout. The surface is faintly marked by somewhat imbricating growth lines which bend gently forward except in the median portion where they bend abruptly backwards to cross the slit band.

The shell is characterized by its Bellerophon shape and its plainness, most specimens scarcely showing the fine lines of growth.

Distribution. Kendrick shales: Collections 3, 2, 20, 1, 8, 21, 22, 23, 9, 18, 7; Magoffin beds: Collections 27, 36.

BELLEROPHON (BUCANOPSIS) MEEKIANUS Swallow

Plate LIII, figs. 11-11a

1858. *Bellerophon Meekianus.* Swallow, St. Louis Acad. Sci. Trans., Vol. 1, p. 204.
Middle Coal Measures: Lexington, Mo.
Lower Coal Measures: Howard County, Mo.

The shell is small and subglobose. The body whorl expands gently, giving the shell a very prim appearance. The slit band is not well differentiated from the rest of the shell. In fact it does not rise above the general surface of the shell, but is set off on each side by a groove which is slightly larger than the other revolving striae.

Under the magnifying glass, the conspicuous surface features are not the longitudinal striae but the longitudinal plications which alternate in size. The transverse striae are so grouped as to give the surface a somewhat wrinkled appearance.

Besides its Bellerophon outline, the other characteristic feature of the shell is its cancellate surface by means of which alone Ulrich separated the genus *Bucanopsis* from the genus *Bellerophon*, although he was in doubt that *B. meekianus* belonged to *Buchanopsis* (Op. cit. pp. 853, 854). Obviously an exfoliated specimen could be referred either to *Bellerophon* or *Bucanopsis;* hence the writer's serious objecton to generic classification so refined as to be practically useless to the stratigrapher. Furthermore it many well be questioned whether or not the revolving striae are of generic value.

Distribution. Kendrick shales: Collections 22, 9, 18; Magoffin beds: Collection 27; Flint Ridge flint: Collection 14.

SCHIZOSTOMA CATILLOIDES Conrad

Plate LIII, figs. 12-13

1842. *Inachus catilloides.* Conrad, Acad. Nat. Sci. Philadelphia Jour., Vol. 8, Pt. 2, p. 273, Pl. 15, fig. 3.
Carboniferous: Inclined plane of the Alleghany Mountain, Pa.

The shells are small and discoidal in outline. Both sides of the disk are either flat or concave. In the concave specimens the upper side is commonly the more so. Sections of the volutions are more or less quadrate, though the concavity of the two sides of the disk causes somewhat of a departure from this feature. Inasmuch as the volutions are not indented by their contact, the internal surface of the volutions are not affected,

being practically circular in cross section. Two pairs of grooves accentuate the two carinae, one of which is situated along the top edge of the periphery and the other along the bottom edge.

The surface is crossed by fine transverse striae, the arrangement of which in some specimens produced transverse or oblique ridges and in others node-like protuberances.

The most characteristic features are the discoidal shape and the flat or concave sides.

Distribution. Kendrick shales: Collections 3, 1, 8, 21, 22, 6, 15; Magoffin beds: Collection 12; Saltlick beds: Collection 35.

ZYGOPLEURA PLEBEIA Herrick

Plate LIII, fig. 22

1887. *Loxonema sp.* Herrick, Denison Univ. Sci. Lab. Bull. Vol. 2, p. 147, Pl. 14, fig. 8. (*L. plebium* in explanation of plate).
Coal Measures: Flint Ridge, Ohio.

The shell is a small gently tapering cone. In spite of the flattened sides of the volutions, the suture is rather prominent. The ornamentation of the shell consists of small transverse plications, those of the successive whorls opposing each other in such a manner as to form a series of nearly straight but broken ridges extending from the apex to the base of the shell.

The shell is readily recognized by its gently tapering cone and the prominent plications already described.

Distribution. Kendrick shales: Collection 22.

SPHAERODOMA BREVIS White

Plate LIII, fig. 23

1881. *Soleniscus brevis.* White, U. S. Geog. Survey, W. 100 Mer. Rept., Vol. 3, Supp., Appendix p. 28, Pl. 4, figs. 5a-c.
Carboniferous: Coyote Creek; north of Black Lake; and near Taos, N. Mex.

The shell is small and subglobose in outline. Perhaps the most distinctive feature of the species is the concave profile of the spire, due to the abrupt and unequal increase of the volutions. As a result of this manner of growth, the subglobose body whorl is surmounted by a minute sharply pointed spire.

Distribution. Kendrick shales: Collections 8, 22, 15.

SPHAERODOMA PRIMIGENIA Conrad

Plate LIII, fig. 24

1835. *Stylifer primogenia.* Conrad, Geol. Soc. Pennsylvania Trans., Vol. 1, Pt. 2, p. 267, Pl. 12, fig. 2.

The shell is subglobose in outline. Like *S. brevis*, it has a small low spire, but the well rounded volutions give to the spire an altogether different aspect. Due to the rounded volutions, the suture is, of course, well defined.

Distribution. Kendrick shales: Collections 8, 21, 22, 18.

BULIMORPHA MINUTA Stevens

Plate LIII, figs. 25-26

1858. *Loxonema minuta.* Stevens, Am. Jour. Sci., Vol. 25, p. 260.
Coal Measures: Sangamon County and Danville, Ill.

The shells are small. They are best described as subfusiform. Though incomplete they are perhaps four times as long as wide. All have a long slender tapering conical spire. The upper edge of each whorl laps over the lower edge of the preceding whorl in such a manner as to produce a nearly vertical suture. In spite of this well developed suture the whorls are so nearly flat as scarcely to break the continuity of the general conical slope.

In addition to its small size the most characteristic feature of the shell is the continuity of the conical slope of the spire.

Distribution. Kendrick shales: Collections 1, 22, 18.

Class CEPHALOPODA

ORTHOCERAS COLLETTI Miller

Plate LIV, figs. 1-2

1892. *Orthoceras colletti.* Miller, Adv. Sheets, 18th Rept. Geol. Survey Indiana, p. 67, Pl. 10, fig. 1.
Upper Coal Measures: Kansas City, Mo.

The shells are very thick and, for Pennsylvanian forms, they are very large. The septa are abruptly and deeply concave, the concavity exceeding the depth of the chamber. Though the specimens are crushed, the septa seem to agree with the original description in being circular in outline and distant from each other about one-fourth their diameter. Extending from septum to septum along one side of the shell, where completely exfoliated, is the small narrow longitudinal ridge, so characteristic of this Pennsylvanian species and the representative, perhaps, of the siphuncle.

The surface seems to lack ornamentation.

Distribution. Kendrick shales: Collections 2, 1, 8, 22, 23?, shoulders" (Smith, 1903).

ORTHOCERAS (PSEUDORTHOCERAS) KNOXENSE McCHESNEY

Plate LIV, figs. 3-6a

1860. *Orthoceras knoxensis.* McChesney, Des. New Spec. Foss, p. 69.
Coal Measures: Danville, Springfield, Peoria and Dr. E. Hall's mill, Knox County, Ill.

The shells are small and but slightly tapering. The septa are circular, regularly and moderately concave, distant from each other about one-third of their diameter. The siphuncle is small and approximately circular in cross section and central in position.

The surface is without ornamentation.

Without questioning the validity of the genus *Pseudorthoceras*, based, however, on the internal secondary deposit, the present forms are retained in the *Orthoceras* for the convenience of the stratigrapher.

Distribution. Kendrick shales: Collections 3, 2, 20, 8, 21, 22, 23, 9, 18, 30; Magoffin beds: Collections 27, 26?, 25, 12, 13, 33, 36?.

GASTRIOCERAS MONTGOMERYENSE MILLER AND GURLEY

Plate LIV, figs. 7-9a

1896. *Goniatites montgomeryensis.* Miller and Gurley, Bull. No. 11, Illinois State Mus. Nat. Hist., p. 38, Pl. 4, figs. 12-14.
Coal Measures: Montgomery County, Ill.

Though small the shell is robust in that the breadth nearly equals the greatest diameter. In spite of the fact that the whorls are deeply embracing, the shoulders of the inner whorls are exposed in the deep funnel-shaped umbilici. The angular nodose shoulders of the successive whorls form step-like descents into the umbilici, which are deep and wide, being one-half of the total diameter of the shell.

"There are six constrictions to a revolution, beginning at the umbilical border, curving abruptly forward on the sides and then backward on the abdomen in a broad, gentle series.

"Septa consisting of a pair of narrow tongue-shaped ventral lobes, separated by a short siphonal saddle, deeply

incised by a secondary notch or lobe; a broad, short, lateral lobe on the sides halfway between the siphon and the umbilical shoulders." (Smith, 1903).

Distribution. Kendrick shales: Collections 3, 2, 20, 1, 8, 22, 18, 6, 7, 29; Magoffin beds: Collection 27.

Register of Localities

DWALE SHALES
Harold quadrangle
4. Dwale

ELKINS FORK SHALES
Williamson quadrangle
28. Elkins Fork School

KENDRICK SHALES
Harold quadrangle
3. Head of Goebel Branch of Cow Creek
2. Tom Sellers Branch of Cow Creek
20. Branch of Cow Creek below School No. 23
1, 8, 21, 22, 23, Kendrick homestead at head of Cow Creek
9. Head of Sugarloaf Branch of Levisa Fork
18. Forks of Home Branch of Buffalo Creek
6. Daves Branch of Buffalo Creek
7. Head of Missouri Branch of Johns Creek
Williamson quadrangle
24. Jarad
29. Burris Mine on Rockhouse Fork one mile above Elkins Fork School
30. Bevins Mine at head of Bevins Branch
Buckhorn quadrangle
15. Shale near L. & N. Ry. track level at Copland

MAGOFFIN BEDS
Williamson quadrangle
27. Middle coal roof opposite Borderland
26.? Caney Fork of Pigeonroost Fork
25.? Fall Branch (edge of sheet) of Pigeonroost Creek
Salyersville quadrangle
31. Sycamore Branch of Oakley Creek
12. Head of Right Fork of Middle Fork of Licking River
13. Leatherwood Creek two miles above its confluence with South Quicksand Creek
Prestonsburg quadrangle
32. Long Branch one mile above its confluence with Licking River
33. Bate Lick Branch of Jake Wireman Fork of Licking River
34. Grassy Creek one mile above its confluence with Straight Fork of Licking River
Hindman quadrangle
36. Mouth of small tributary of Quicksand Creek one-half mile above Lick Branch
Buckhorn quadrangle
16. Roof shales of abandoned mine at Copland

SALTLICK BEDS

Harold quadrangle

19.? Limestone gap between Mare and Buffalo Creeks

Hindman quadrangle

35. Highway gap between Saltlick and Quicksand Creeks

LOST CREEK LIMESTONE

Buckhorn quadrangle

37. One-half mile north of byway across divide between Lost Creek and Big Branch of North Fork of Kentucky River

FLINT RIDGE FLINT

Troublesome quadrangle

14. One-fourth mile north of byway across divide between Leatherwood Branch and Fugate Fork

PENNSYLVANIAN INVERTEBRATE FOSSILS

Explanation of Plate XLV

Figures

1-3a. *Lophophyllum profundum.*

1. Side view of a nearly perfect specimen.
1a. The same specimen enlarged twice.
2. Side view of a specimen showing part of the calice.
2a. The same specimen enlarged twice.
3. View of a smaller specimen.
3a. The same specimen enlarged twice.

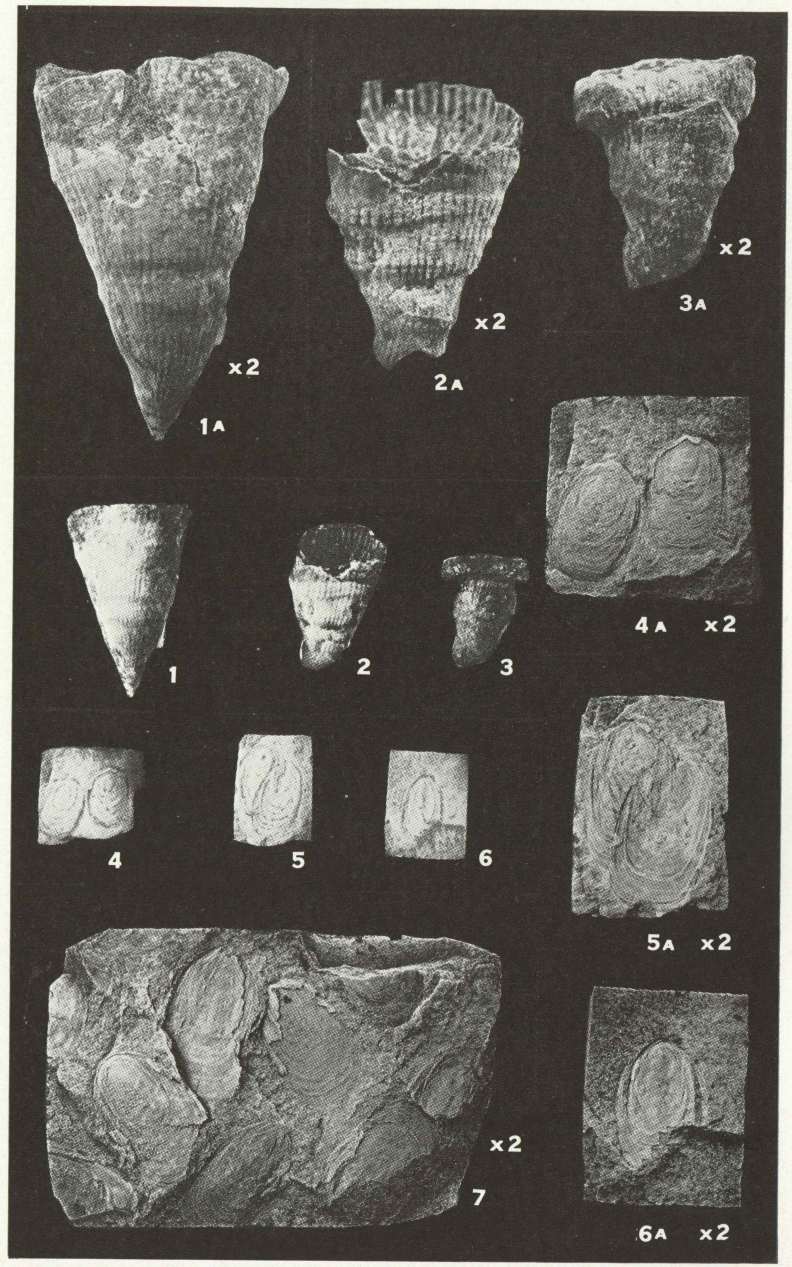
Kendrick shales: Collection 18.

4- 7. *Lingula carbonaria.*

4. A slab showing the impressions of two specimens.
4a. The slab enlarged twice.
5. A slab showing the impressions of two overlapping specimens.
5a. The slab enlarged twice.
6. A slab showing the impression of one specimen.
6a. The slab enlarged twice.
7. An excellent slab, enlarged twice, showing abundance of forms.

Dwale shales: Collection 4.

PLATE XLV



Fossils from the Kendrick and Dwale shales—Pennsylvanian

Explanation of Plate XLVI

Figures

1- 4a. *Lingulipora kentuckyensis.*

1. View of a nearly perfect specimen.
Kendrick shales: Collection 22.

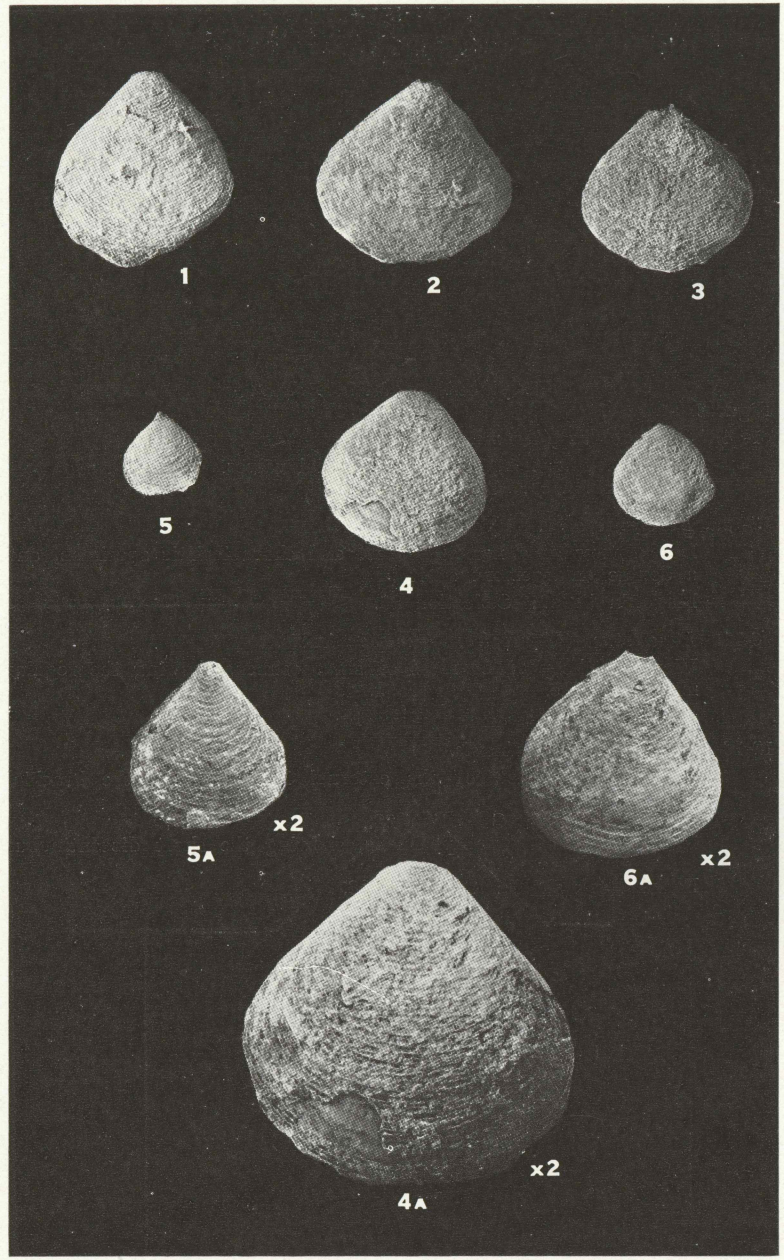
2, 3, 4. Views of three nearly perfect specimens.

4a. Specimen 4 enlarged twice to show the closely spaced concentric ridges.
Kendrick shales: Collection 8.

5- 6a. *Lingulipora nebraskensis.*

5, 5a. A nearly perfect specimen and a double enlargement of it. Note the widely spaced concentric ridges.
Kendrick shale: Collection 22.

6, 6a. A specimen having a slightly broken beak and a double enlargement of it.
Kendrick shales: Collection 8.



Fossils from the Kendrick shales—Pennsylvanian

Explanation of Plate XLVII

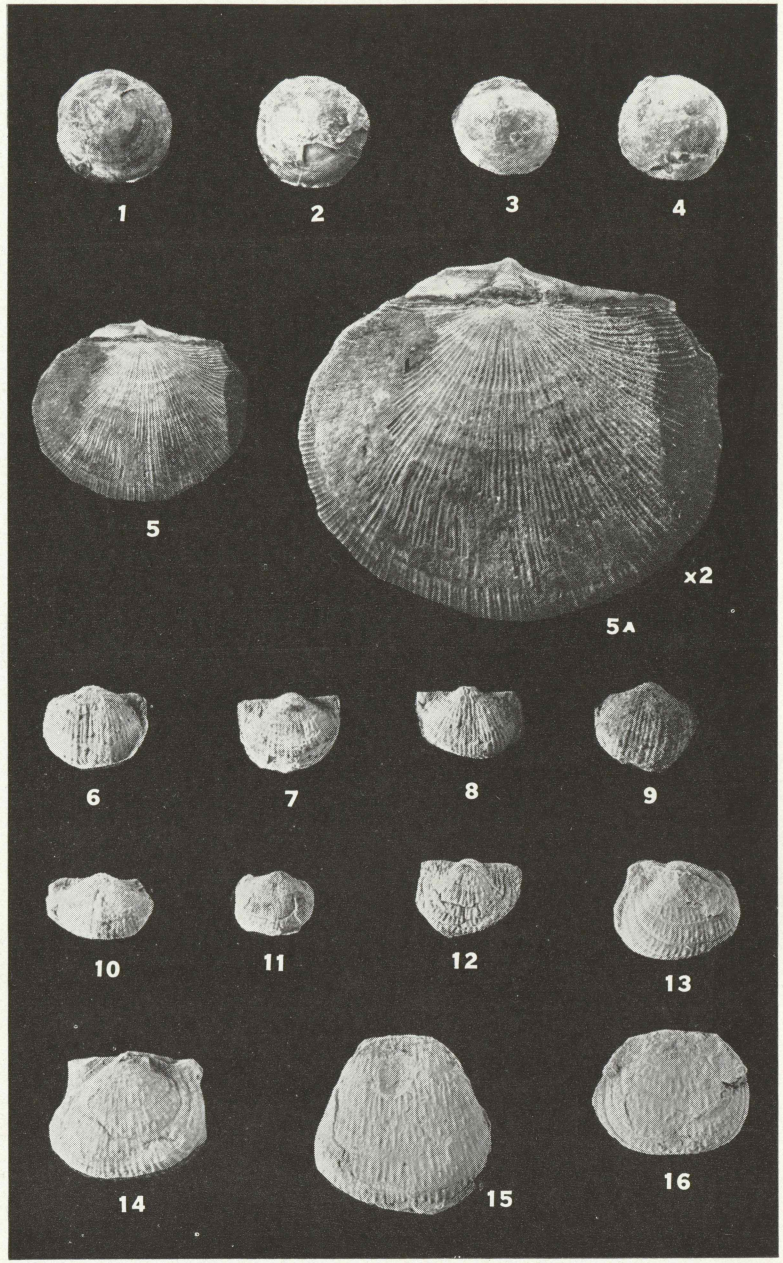
Figures

1- 4. *Orbiculoidea (Roemerella) patula.*
Views of four nearly perfect brachial valves.
Kendrick shales: Collection 22.

5- 5a. *Derbya crassa.*
Dorsal view of a nearly perfect and characteristic specimen, and a double enlargement of it.
Magoffin beds?: Collection 25.

6-11. *Productus (Marginifera) missouriensis.*
Views of the pedicle valves of six specimens showing the regular medium costae.
Kendrick shales: Collection 22.

12-16. *Productus nebraskensis.*
12. Ventral view of the external impression of the brachial valve.
Kendrick shales: Collection 22.
13-16. Views of four specimens, showing the short discontinuous radiating ribs.
Elkins Fork shales: Collection 28.



Fossils from the Kendrick shales. Magoffin beds, and Elkins Fork shales—Pennsylvanian

Explanation of Plate XLVIII

Figures

1-10. *Chonetes glaber.*

1, 1a. View of pedicle valve of a specimen and a double enlargement of it.

2, 2a. Internal view of a brachial valve of a specimen and a double enlargement of it.

3, 3a. View of a pedicle valve of a specimen and a double enlargement of it, showing the two diverging folds, and the shell free from radial ribs and striae.

4. Dorsal view of brachial valve and cardinal area of a pedicle valve of a complete specimen.

5. Pedicle valve of a specimen.

6. Dorsal view of a complete specimen.

7. Pedicle valve of a specimen.
Kendrick shales: Collection 8.

8, 9. Pedicle valves of two typical specimens.
Kendrick shales: Collection 22.

10. Pedicle valve of a small specimen.
Kendrick shales: Collection 9.

11-16a. *Chonetes granulifer.*

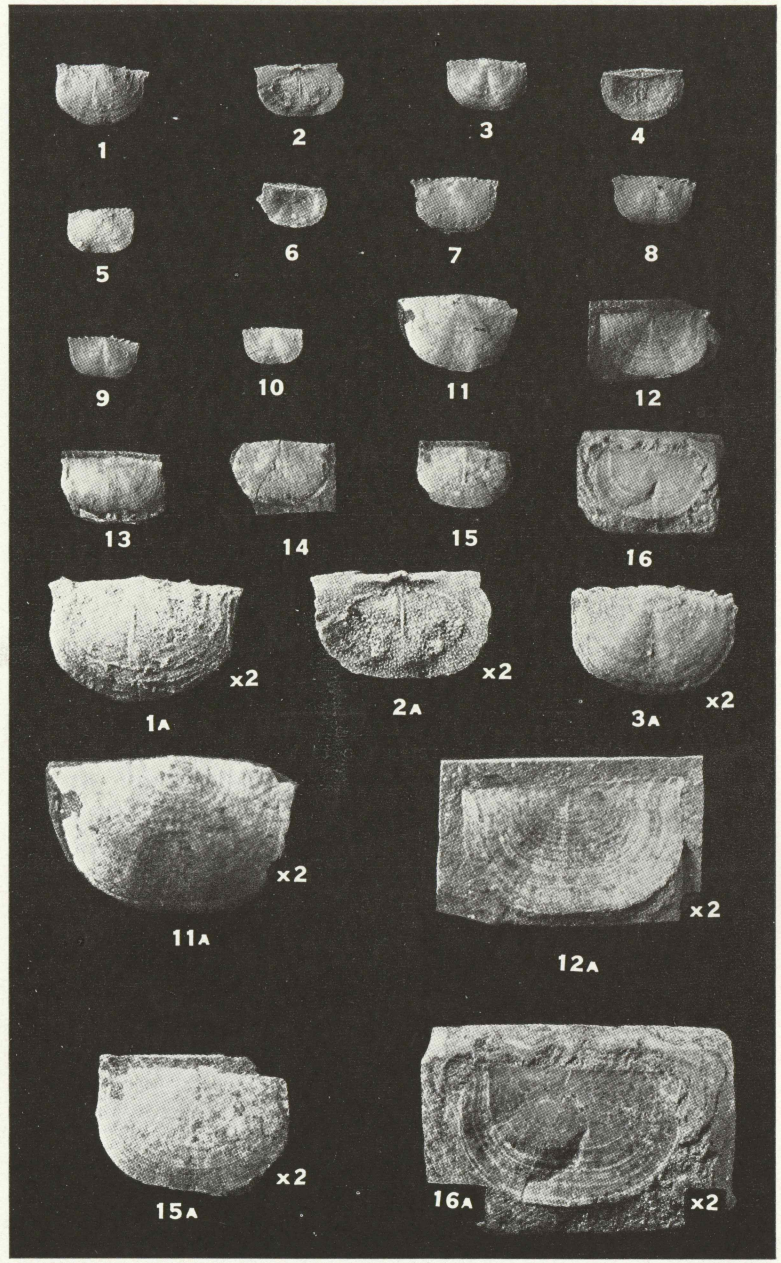
11, 11a. Pedicle valve of a typical specimen and a double enlargement of it.

12, 12a. Brachial valve of a specimen and a double enlargement of it.

13, 14. Views of the pedicle valves of two specimens.
Magoffin beds: Collection 16.

15, 15a. Pedicle valve and double enlargement of it.

16, 16a. Brachial valve and a double enlargement of it.
Magoffin beds: Collection 12.



Fossils from the Kendrick shales and Magoffin beds—Pennsylvanian

Explanation of Plate XLIX

Figures

1- 4. *Productus nodosus.*

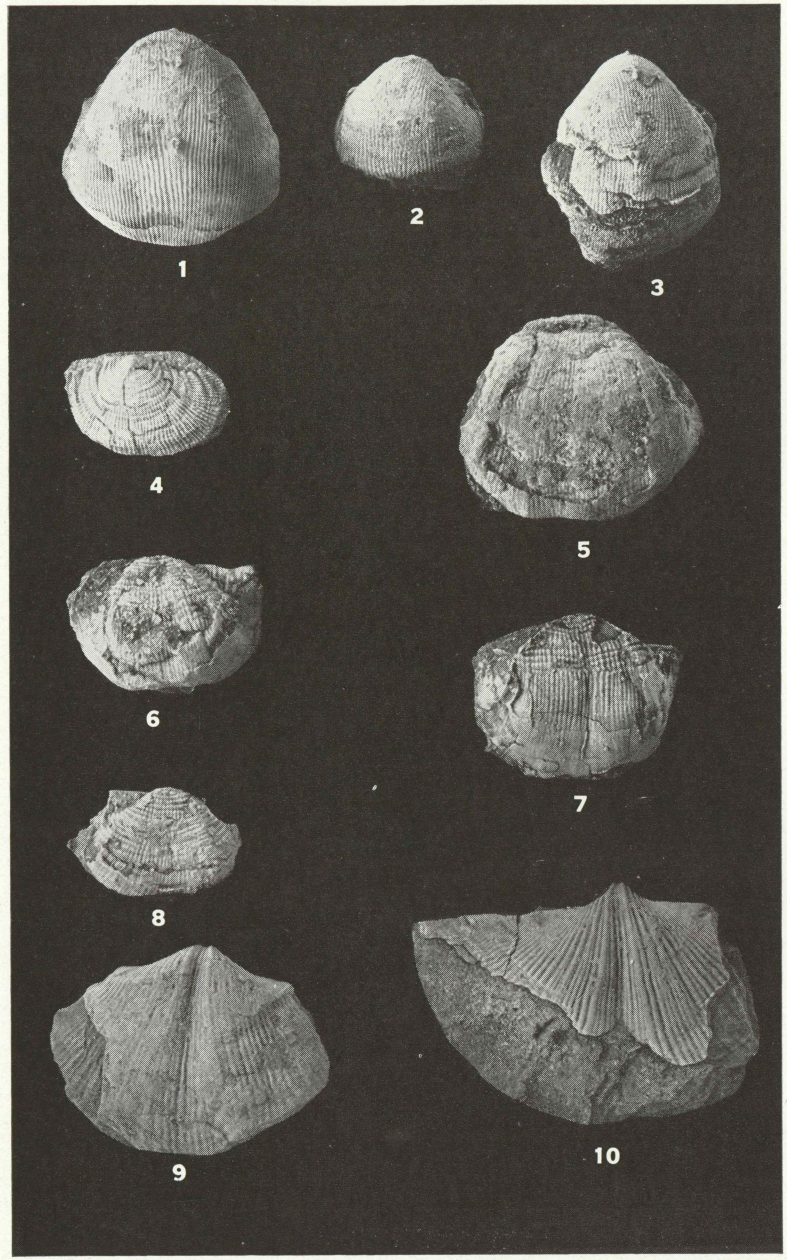
1. Pedicle valve of an excellent specimen showing the converging costae along the medium line of nodes or spine bases.
2. Pedicle valve of a smaller specimen. Kendrick shales: Collection 8.
3. Pedicle valve of a specimen showing the typical median line of nodes.
4. Ventral view of the external impression of a brachial valve. Kendrick shales: Collection 22.

5- 8. *Productus semireticulatus.*

5. Pedicle valve of a large specimen.
6. Pedicle valve of a medium specimen.
7. Pedicle valve of a medium specimen, showing the abrupt change from the reticulate to the non-reticulate parts.
8. Another specimen.
Magoffin beds: Collection 12.

9-10. *Spirifer cameratus.*

Pedicle valves of two specimens, one of which shows the extended hinge line.
Kendrick shales: Collection 18.



Fossils from the Kendrick shales and Magoffin beds—Pennsylvanian

Explanation of Plate L

Figures

1- 3. *Spirifer rockymontanus.*

1-3. Two pedicle valves and one brachial valve of three typical specimens.
Kendrick shales: Collection 22.

4. *Reticularia (Squamularia) perplexa.*

A poorly preserved specimen.
Magoffin beds: Collection 31.

5. *Ambocoelia planoconvexa.*

Dorsal view of a complete specimen.
Magoffin beds: Collection 27.

6. *Composita subtilita.*

Dorsal view of a complete specimen.
Magoffin beds: Collection 12.

7. *Cleiothyridina orbicularis.*

A rather badly crushed specimen.
Kendrick shales: Collection 22.

8-15. *Leda bellistriata.*

8-8a. Right valve of a beautiful specimen and a double enlargement of it.
9, 10. Right valves of two specimens.
11, 12. Left valves of two specimens.
13, 14. Internal impressions of left and right valves of two specimens.
15. Dorsal view of internal impressions of both valves of a specimen.
Kendrick shales: Collection 22.

16-16a. *Leda jillsoni.*

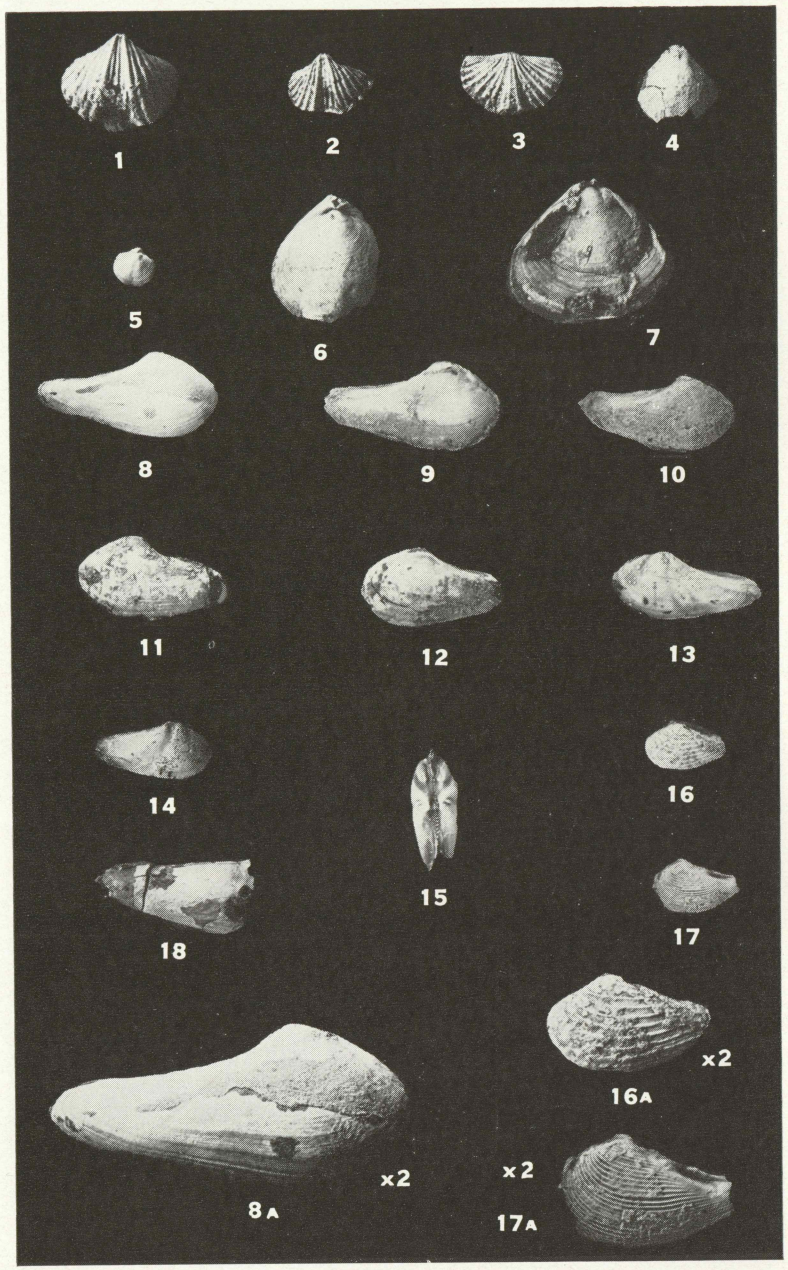
16. Left valve of type specimen.
16a. The same valve enlarged twice to show the widely spaced concentric ridges.
Kendrick shales: Collection 22.

17-17a. *Leda arata.*

17. Left valve of a specimen.
17a. The same valve enlarged twice. Introduced to show its concentric ridges intermediate between the fine ones of *L. bellistriata* and the widely spaced ones of *L. jillsoni.*
Kendrick shales: Collection 7.

18. *Aviculopinna americana.*

A left valve of an imperfect specimen.
Kendrick shales: Collection 22.



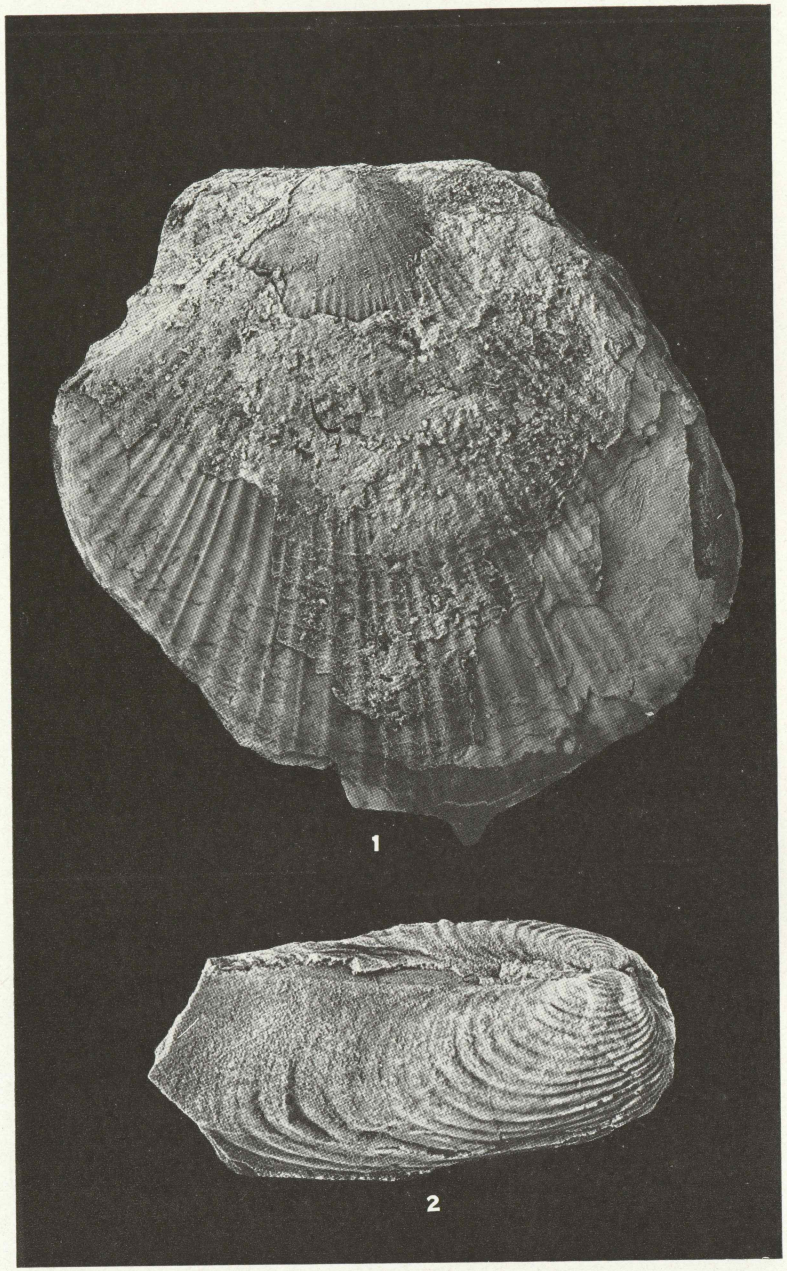
Fossils from the Kendrick shales and Magoffin beds—Pennsylvanian

Explanation of Plate LI

Figures

1. *Deltopecten texanus.*
   Left valve of a large handsome specimen.
   Kendrick shales: Collection 8.

2. *Allerisma terminale.*
   Dorsal-lateral view of a slightly distorted specimen of this excellent species.
   Flint Ridge flint: Collection 14.



Fossils from the Kendrick shales and Flint Ridge Flint—Pennsylvanian

Explanation of Plate LII

Figures

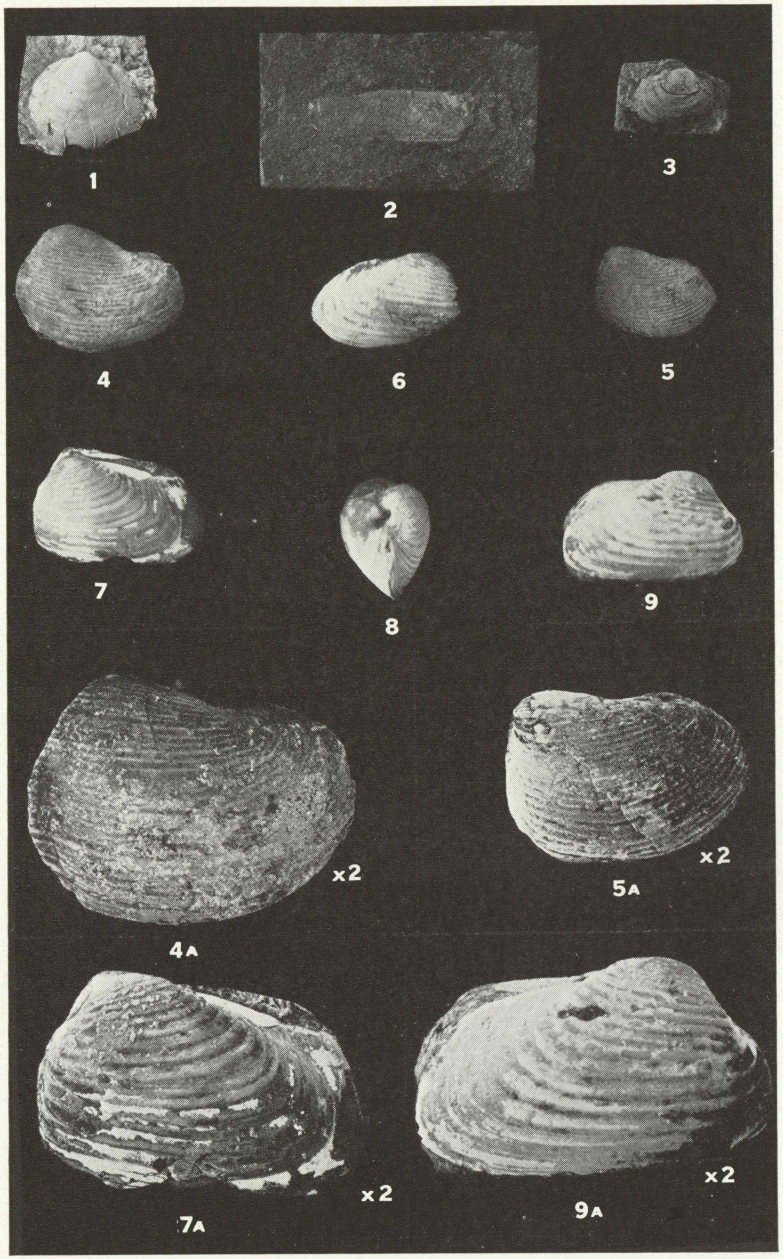
1. *Schizodus alpinus.*
   An imperfect left valve.
   Kendrick shale: Collection 22.

2. *Prothyris elegans.*
   A faintly defined valve of this delicate shell.
   Kendrick shales: Collection 22.

3. *Astartella concentrica.*
   A right valve.
   Kendrick shales: Collection 22.

4- 5a. *Astartella arcuata.*
   4, 5. Left valves of two slightly distorted specimens.
   4a, 5a. Double enlargements of specimens 4 and 5 respectively.
   Kendrick shales: Collections 22 and 8 respectively.

6- 9a. *Astartella kentuckyensis.*
   6. Right valve.
   7, 7a. Left valve and double enlargement of it.
   8. Anterior view of a distorted specimen.
   9, 9a. Right valve of a slightly distorted specimen and a double enlargement of it.
   Kendrick shales: Specimens 6 and 8 from Collection 8; Specimens 7 and 9 from Collection 22.



Fossils from the Kendrick shales—Pennsylvanian

Explanation of Plate LIII

Figures

1. *Plagioglypta annulistriata.*
An imperfect specimen referred to this species.
Kendrick shales: Collection 22.

2. *Worthenia tabulata.*
View of a broken specimen.
Kendrick shales: Collection 22.

3. *Bellerophon (Euphemus) carbonarius.*
Specimen having partly preserved sculpture.
Magoffin beds: Collection 12.

4-10. *Bellerophon crassus.*
4, 5, 6, 7. Views of four characteristic specimens.
8. Apertural view of a specimen.
9. View of still another specimen.
Kendrick shales: Collection 22.
10. View of a characteristic specimen.
Kendrick shales: Collection 7.

11-11a. *Bellerophon (Bucanopsis) meekianus.*
11. 11a. An imperfect specimen having the revolving and transverse sculpture faintly preserved and a double enlargement of it.
Kendrick shales: Collection 22.

12-13. *Schizostoma catilloides.*
Opposite views of two specimens represented largely by internal impressions ("casts").
Kendrick shales: Collection 22.

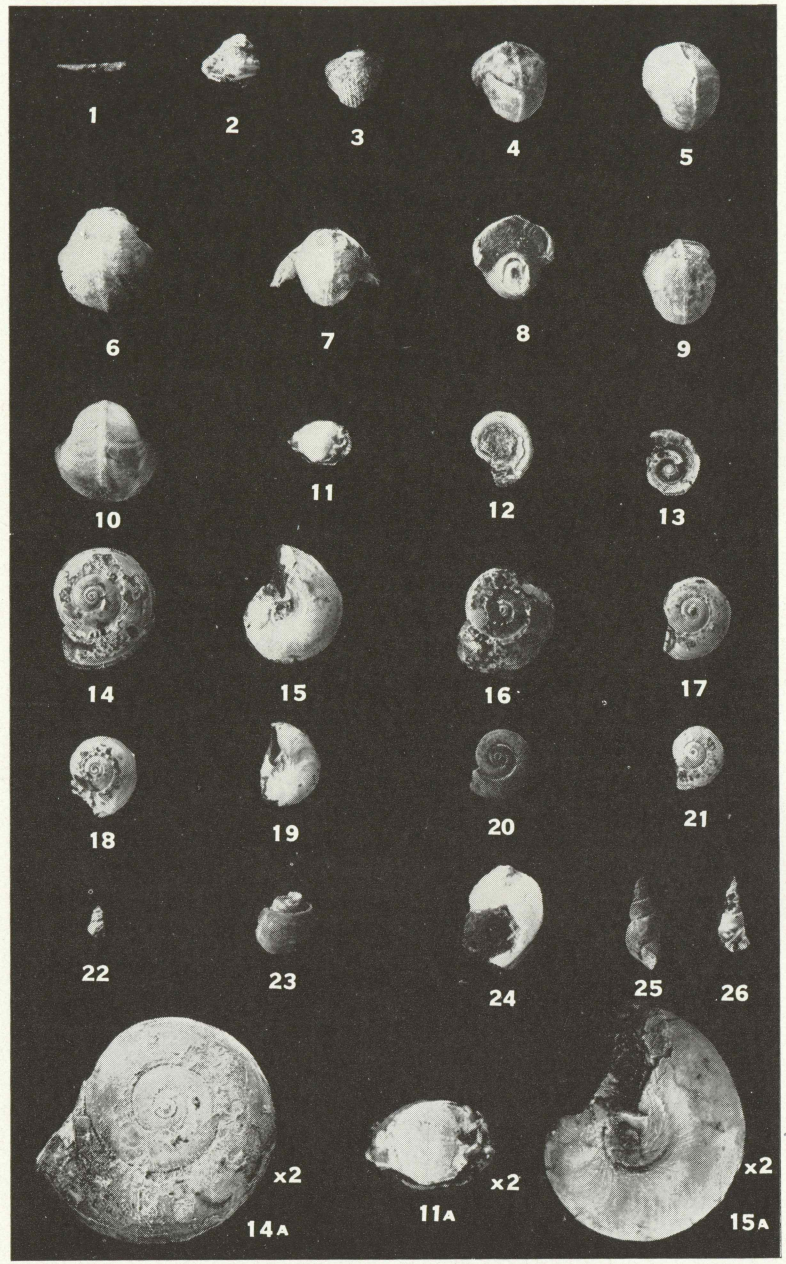
14-21. *Trepospira depressa.*
14, 14a, 15, 15a. Dorsal and ventral views of two specimens and enlargements of them. Unfortunately the revolving sutural band of nodes has been destroyed by exfoliation.
16, 17, 18. Dorsal views of three specimens having the nodose band better preserved.
19. Ventral view of a specimen.
20. Internal impression ("cast").
21. Dorsal view of a small specimen.
Fragments of the dark shaly matrix impart to all the photographs an ornamentation not inherent in these shells, which are perfectly plain except for the nodose band.
Kendrick shales: Collection 22.

22. *Zygopleura plebeia.*
An imperfect specimen having only a few of the vertical (longitudinal) ridges preserved.
Kendrick shales: Collection 22.

23. *Sphaerodoma brevis.*
An internal impression ("cast").
Kendrick shales: Collection 22.

24. *Sphaerodoma primigenia.*
A partly exfoliated chalky-white shell of this species.
Kendrick shales: Collection 22.

25-26. *Bulimorpha minuta.*
25. An internal impression ("cast").
26. A slightly exfoliated shell.
Kendrick shales: Collection 22.



Fossils from the Kendrick shales and Magoffin beds—Pennsylvanian

Explanation of Plate LIV

Figures

1- 2. *Orthoceras colletti.*

1. Fragment of a specimen.
2. Fragment of another specimen faintly showing the longitudinal ridge so characteristic of this species.

Kendrick shales: Collection 22.

3- 6a. *Orthoceras (Pseudorthoceras) knoxense.*

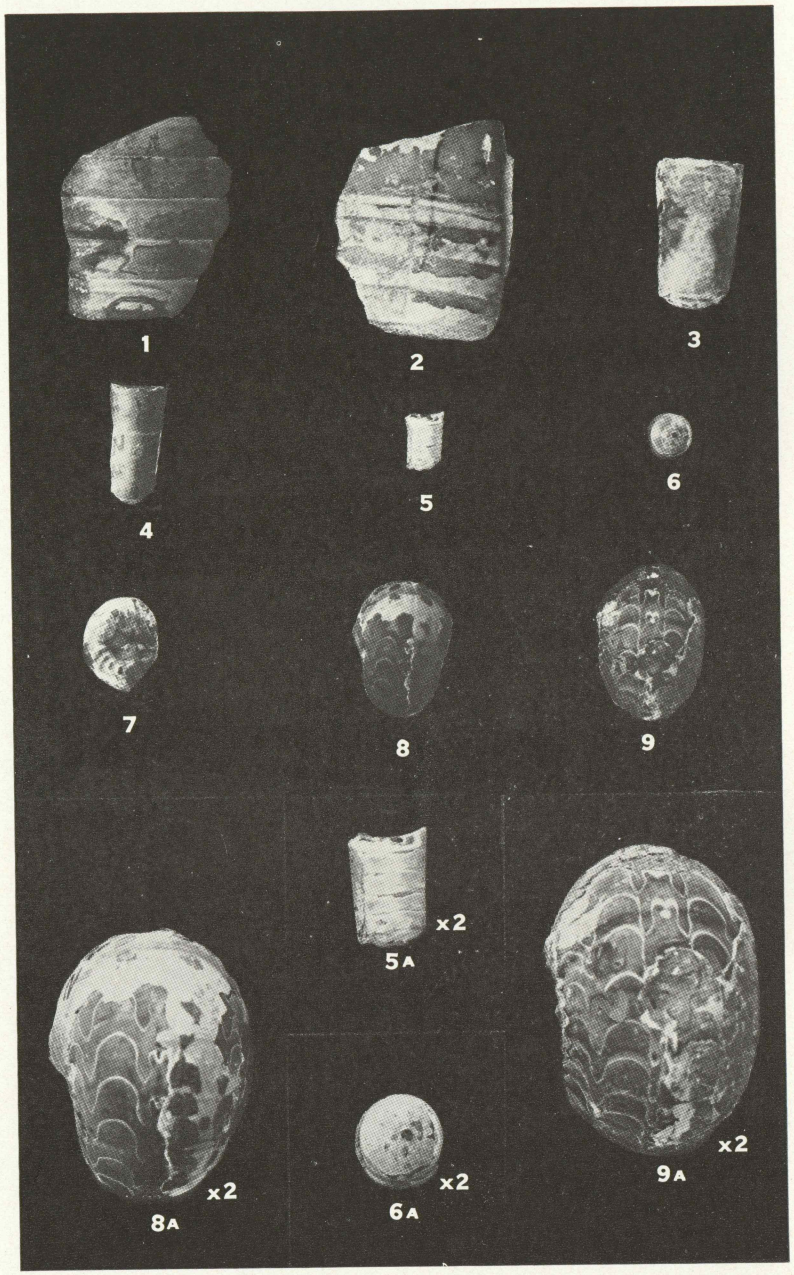
3, 4. Fragments of two specimens.
5, 5a. Segment of another specimen and a double enlargement, showing the septa.
6, 6a. End view of specimen and a double enlargement of it, showing the central position of the siphuncle.

Kendrick shales: Collection 22.

7- 9a. *Gastrioceras montgomeryense.*

7. Side view of a specimen, showing the characteristic nodose shoulder about the umbilicus.
8, 8a. Ventral view of a specimen and a double enlargement of it, showing the characteristic septal configuration.
9, 9a. The same view and an enlargement, of a larger specimen.

Kendrick shales: Collection 22.



Fossils from the Kendrick shales—Pennsylvanian

VII

PENNSYLVANIAN VERTEBRATE FAUNA

By

Roy Lee Moodie

THE PENNSYLVANIAN VERTEBRATE FAUNA OF KENTUCKY

By

ROY LEE MOODIE

INTRODUCTION

The vertebrates which one may expect to find in the Pennsylvanian of Kentucky are the various types of fishes, inclosed in nodules embedded in shale, as well as in limestone and in coal; amphibians of many types, found heretofore in nodules and in cannel coal; and probably reptiles. A single incomplete skeleton found in Ohio, described below, seems to be a true reptile. Footprints and fragmentary skeletal elements found in Pennsylvania[1], in Kansas[2], in Oklahoma[3], in Texas[4], in Illinois[5], and other regions, in rocks of late Pennsylvanian or early Permian age, and often spoken of as Permo-Carboniferous, indicate types of vertebrates, some of which may be reptiles.

No skeletal remains or other evidences of Pennsylvanian vertebrates have so far been found in Kentucky, but there is no reason why they cannot confidently be expected to occur. A single printed reference points to such vertebrate remains[6].

As shown by the map, Kentucky lies immediately adjacent to regions where Pennsylvanian vertebrates have been found. That important discoveries may still be made is indicated by Carman's recent find[7]. Ohio where important discoveries of

[1]Case, E. C. Description of vertebrate fossils from the vicinity of Pittsburgh, Pa: Annals of the Carnegie Museum, IV, Nos. III-IV, pp. 234-241, pl. LIX, 1908.

[2]Williston, S. W. Some vertebrates from the Kansas Permian: Kansas Univ. Quart., ser. A, VI, No. 1, pp. 53, fig., 1897.

[3]Case, E. C., On some vertebrate fossils from the Permian beds of Oklahoma. 2nd Biennial Rpt. Dept. Geol. and Nat. Hist. Territory Oklahoma 1901-1902, pp. 62-68, 1902.
Jillson, W. R., Preliminary Note on the occurrence of vertebrate footprints in the Pennsylvanian of Oklahoma. Amer. Jour. Sci., XLIV, pp. 56-58, 1 fig., 1917.

[4]Case, E. C., The Permo-Carboniferous beds of North America and their vertebrate fauna: Pub. No. 207, Carnegie Inst., Washington, 1-176. pls. 1-24, 1915.

[5]Case, E. C., The vertebrates from the Permian bone bed of Vermilion County, Illinois. Jour. Geol. VIII, 693-729, 5 pls., 1900.

[6]Newberry, J. S., On some fossil reptiles and fishes from the Carboniferous strata of Ohio, Kentucky and Illinois: Abs: Proc. Amer. Assoc. Adv. Sci., 15th meet. 1867, pp. 144-146, 1868.

[7]Carman, J. Ernest, 1927. Fossil Footprints of Pennsylvanian Vertebrates from Ohio. Full descriptions and figures will be published in the bulletin of the Geological Society of America.

Pennsylvanian vertebrates were made seventy-five years ago, have been summarized by Cope[8], and Newberry[9].

The Pennsylvanian vertebrates so far known from regions immediately adjacent to Kentucky represent diverse faunas[10].

Marine fishes are represented by the sharks. The *Crossopterygian* fishes indicate a salt and brackish water fauna; while the lung fishes indicate a fresh water and swamp fauna. An interesting phase of the Pennsylvanian vertebrates is the minute size of some of the animals found in the nodules at Mazon Creek, near Morris, Illinois. Interesting palaeoniscid skulls showing well preserved brains, internal ears, blood vessels, nerves, etc., contained within oval nodules have been found in Kansas, and in the Caney shales of Oklahoma. The amphibians represent a shore, fresh water, and swamp as well as a brackish water fauna. None of the vertebrate species are completely known although some of the fossils found at Mazon Creek are amazingly perfect, showing soft parts as well as skeletons.

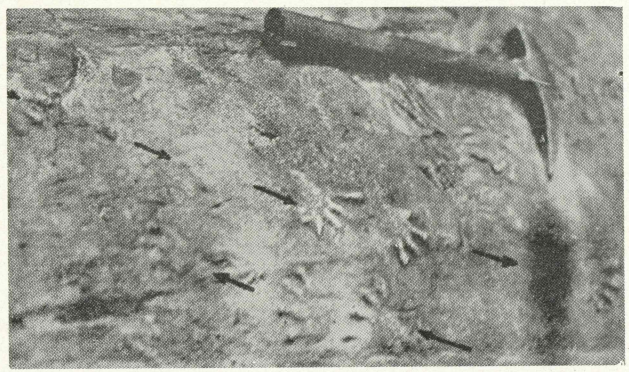


Fig. 30. Fossil footprints found by W. R. Jillson in Pennsylvanian rocks of Oklahoma. These remarkable tracks may be either amphibian, of an unknown type, or reptilian. The absence of claw marks may indicate an amphibian affinity. The size may be judged by the hammer. After *Jillson*.

[8]Cope, E. D., Synopsis of the extinct Batrachia from the Coal Measures. Geol. Survey Ohio, II. pt. II, 351-410, pls. XXVII-XLV, 1875.

[9]Newberry, J. S., Paleozoic fishes of North America. Monograph U S. Geol. Survey, XVI, p. 228. See also: Paleontology of Ohio, Ohio Geol. Survey, I, 1873, 1889.

[10]The close relationship between the Pennsylvanian rocks of Ohio with those of Kentucky is shown in the geological map published by W. R. Jillson. Agricultural Perspective of Kentucky Geology: Pan-American Geologist, XLIV, 295-308; 387-396, with map, 1925. Here the eastern Coal-Field is shown to consist of three sections; the Pottsville, the Allegheny, and the Conemaugh; all standard divisions of the geological column.

CONODONTS

Geological Range: Confined to the Paleozoic.

Certain small (about 1 mm. in length) glistening black or brown, tooth-like objects, found abundantly in the Devonian and Mississippian, and known as *conodonts*, still remain an enigma in their nature. Newberry regarded them as the teeth of lampreys; later he regarded them as annelid teeth; Owen regarded them as mollusc teeth; Ulrich and Bassler[11] believe the objects to be the teeth of primitive and extinct fishes, supporting their view by illustrations of teeth and dermal plates of recent fishes. Irrespective of their zoological relations conodonts are regarded as valuable index fossils[12] for the determination of stratigraphy. They have been found in the Mississippian of Kentucky.

Long before the opening of the Pennsylvanian certain chordates had become extinct. These were not true fishes. They are known as the *Cycliae* (genus *Paleospondylus*), the *Ptyctodontidae* and a diverse group called the *Placodermata* (genera *Dinichthys* and *Bothriolepis*). So far as we know these forms left no descendants.

Class Pisces

Geological Range, Ordovician to Recent.

The fishes of the Pennsylvanian represent a diverse fauna. The sharks of the several families recognized by Eastman[13], are known chiefly from scattered and often isolated teeth and spines, but not all of them are marine, since a tiny shark, *Acanthodes*, is known from the Mazon Creek shales, which are probably of brackish water origin. Shark teeth have been differentiated according to form into groups, known as *Cladodont*, *Petalodont* and *Cochliodont*; terms which are convenient but meaningless as indicating the relationships of the fishes which bore them. A few of the more important families of sharks are:

[11]Ulrich, E. O. and Bassler, R. S., A Classification of the Tooth-like Fossils, Conodonts, with Descriptions of American Devonian and Mississippian Species: Proc. U. S. Natl. Mus., 68, 1-63, 11 pls., 1926.

[12]Bryant, William L. The Genesee Conodonts with Descriptions of new Species: Bull. Buffalo Soc. Nat. Sci., XIII, No. 2, 1-27, pls, I-XVI, 1921.

[13]Eastman, Charles R. Fossil Fishes in the Collection of the United States National Museum: Proc. U. S. Nat. Mus., Vol. 52, pp. 254-276, plates 1-23, 1917.

Order ELASMOBRANCHII

Geological Range, Silurian to Recent.

Family Cladodontidae

The genus *Cladodus*, representing this family, occurs in rocks of lower Pennsylvanian age. An incomplete example is figured by Eastman[13], on Plate LXII, fig. 7. The genus *Dicrenodus* is known from the Pennsylvanian strata of Texas, shown in Pl. LXI, fig. 4, of Eastman's paper.

Identification of Carboniferous shark teeth may best be made by reference to the published reports of Illinois[14] and Ohio[15].

Family Petalodontidae

This extinct family of sharks is known from a single genus, *Janassa*, in which other skeletal parts have been found in natural association with the dentition; a rare condition. No fin-spines are known, and it is suggested that the so-called fin-spines of *Stichacanthus* and *Physonemus* are probably dental elements of the same shark.

Family Psammodontidae

The genus *Psammodus*, well known from the Mississippian rocks of Illinois, Michigan and Missouri, is based on large, nearly square teeth, arranged in a pavement in the upper and lower jaws. Eastman[13] figures one on Pl. LXI, fig. 8.

Family Cochliodontidae

This family of pavement-tooth sharks is fairly well known, and is represented by several genera. Branson[16] described and figured a number of forms. Eastman[13] takes exception to many of Branson's views, leaving the subject confused to the uninitiated. The genera *Psephodus*, *Deltodus* and *Sandalodus* seem well established, and are figured by Eastman, Pl. LXII, figs. 2, 3.

Other types of sharks are indicated in rocks of Carboniferous age by isolated, and often fragmentary spines, known as

[14]St. John, Orestes H. and Worthen, A. H., Descriptions of fossil fishes; Geol. Surv. Illinois, VI, 245-488, pls. 1-22; Vol. VII, 1883, pp. 55-264, pls. 1-26, 1875.

[15]Newberry, J. S., Fishes of the Coal Measures: Ohio Geol. Survey I, pt. II, pp. 283-355, pls. 38-40 Conodonts, II. p. 41, pl. LVII. Fishes of the Carboniferous System: II, pp. 41-64, pls. LVII-LIX, 1873.

[16]Branson, E. B., Notes on some Carboniferous cochliodonts, with descriptions of seven new species: Journ. Geol., XIII, no. 1, pp. 20-34, 2 pls., 1905.

Ichthyodorulites, a term meaning simply a fish fragment. Although many of these objects have been given generic names, they are meaningless, since it is clear that a fin-spine known by one generic name may belong to a fish which is known under another name based on teeth; or even the so-called spines may belong in the mouth. This has been clearly shown by the progress of discoveries in the development of our knowledge of the fossils known as *Edestus*, given on page 269 of Eastman's paper[13]. One of these objects is shown on plate LVI, fig. 4, of this report.

A tiny shark, whose restoration is shown on plate LVII, fig. 1, occurs in the Mazon Creek shales[17], where it is associated with twenty-four species of crossopterygian and other types of fishes.

Class TELEOSTOMI

Order CROSSOPTERYGII

Geological Range, Devonian to Permian

Family Coelacanthidae

This family of "fringe-finned ganoids" is known from Nebraska, Ohio and Illinois. In Ohio, at the Linton locality which has yielded so many amphibians, twenty-seven species of fossil fishes were described by Newberry[18], among which three were members of this family. A species from Mazon Creek is shown here in Plate LVI; A. The genus *Coelacanthus* is of world-wide distribution, ranging upward from the Devonian. An eel-shaped fish, known as *Palaeopichthys*, found at Mazon Creek, is possibly a member of this family.

Family Palaeoniscidae

An interesting feature of this family of small fishes is that in the Devonian and in the Coal Measures nodules are found containing well-preserved brains and other soft structures[19].

A great number of fossilized feces, known as *coprolites*, and consisting of remains of food of fishes supposedly of a type closely allied to *Paleoniscus* have been described by Price[19].

[17]Eastman, C. R., The Carboniferous fauna of Mazon Creek, Illinois: Jour. Geol., vol. X, pp. 535-541, figs. 1-4, 1902.

[18]Newberry, J. S., 1873. Palentology of Ohio. Ohio, I. Geol. Survey.

[19]Moodie, Roy L., A new fish brain from the Coal Measures of Kansas, with a review of other fossil brains: J. Comp. Neurol., XXV, pp. 135-181, with 19 figs., 1915.

[19]Price, Paul H. The Coprolite Limestone Horizon of the Conemaugh Series in and around Morgantown, West Virginia: Annals of the Carnegie Museum, XVII, 211-231, plates X-XXI, 1927.

Similiar objects are known from other horizons and Renault, especially, has studied their bacterial content. *Elonichthys* is represented by four species from the Pennsylvanian shales of Mazon Creek. Two of them are figured on Plates LVI and LVII. An example, enlarged, of the paleoniscid fish brain is given in Plate LVI, C.

Family Platysomatidae

An example of this family is shown on Plate III, C. The species is small, as are many of the vertebrate species from the nodules at Mazon Creek.

The above groups of Crossoptervgian fishes are important because they are now regarded as having characters ancestral to the Tetrapoda[20]. This is especially true of the Devonian forms.

Order DIPNOI

Lung fishes. Geological range, Devonian to Recent.

The lung fishes[21] would be expected in such a swamp and fresh water deposit as existed at or near Yellow Creek in eastern Ohio. Williston[22] found lung fish remains in Kansas embedded in a matrix of exceedingly hard limestone, associated with a fossil sponge, *Gomphospongia*, which might indicate a marine habitat. Scales in the iron-stone nodules from Mazon Creek[23] indicate a wider distribution of the dipnoan fauna. Lung fishes are no longer regarded as ancestral to the air-breathing vertebrates but are an independent group of great antiquity.

Class AMPHIBIA

Geological Range, Devonian (represented by a footprint) to Recent.

The primitive tetrapods of the North American Pennsylvanian, most of which are doubtless amphibian, are known

[20]Gregory, W. K., Present status of the problem of the origin of the Tetrapoda with special reference to the skull and paired limbs: N. Y. Acad. Sci. Annals, vol. XXVI, pp. 317-383; plates, 1915.

[21]Hussakof, L., The Lungfish remains of the Coal Measures of Ohio, with special reference to the supposed Amphibian Eurythorax of Cope. Bull. Amer. Mus. Nat. Hist., XXXV, pp. 127-133 figs., 1916.

[22]Williston, S. W., A new Species of Sagenodus from the Kansas Coal Measures: Kansas Univ. Quart., vol. VIII, pp. 175, pls. 1889.

[23]Cockerell, T. D. A., Additional Note on reticulated Fish Scales: Science, N. S., vol. XXXIV, p. 865; The Scales of the Dipnoan fishes: Science N. S., vol. XXXIII, pp. 831-2, 1911.

chiefly from three faunas, with other scattering evidences. The fauna at Mazon Creek, Illinois, agrees with the fishes in being of small size; the eastern Ohio fauna is a very rich one, both in individuals and in species; and the Joggins fauna at Nova Scotia seems to incline toward the reptilian phase of development. Since the publication of my monograph[24], some years ago, nothing has been added to our knowledge of the morphology of the group. New discoveries have related entirely to footprints, and these are detailed in the section on Ichnology. Since the Canadian fauna is remote to our interests, that of the Pennsylvanian vertebrates which may be found in Kentucky, both in structure of the species and geographical relationships, our remarks in this section will be largely restricted to the faunas from Ilinois and eastern Ohio.

The Mazon Creek fauna[25] consists entirely of skeletons and impressions of soft parts of ten species of Amphibia, representing five families. None of the species are based on complete material. The ironstone nodules in which the Mazon Creek fossils occur, are found in the shale which forms the roof of the Morris Coal of Illinois, which is somewhat lower than the Lower Kittanning Coal of Pennsylvania.

The nature of the amphibian remains discovered in these nodules may be seen in Plate LVIII, B, LIX, A & B; LX, F; LXI, A, C, D. The following discussion will enable one to locate new material representing primitive tetrapods.

Family BRANCHIOSAURIDAE

This family of small, salamander-like animals has long been known from the late Paleozoic rocks of Europe. Its species in North America are confined to the Illinois fauna. The bodies of these primitive salamanders were covered with small scales above and a complicated pattern of myocommatous rods beneath. The short ribs, broad flat head with large orbits; short, weak limbs; and a long, flattened tail, are all characteristic of the members of this family. In agreement with Euro-

[24]Moodie, Roy L., The Coal Measures Amphibia of North America: Publication No. 238, Carnegie Institution of Washington, pp. 1-222, 26 plates, 42 figs, 1916.

[25]Moodie, Roy L., The Pennsylvania Amphibia of the Mazon Creek, Illinois, Shales: Kansas Univ. Sci. Bull., VI, No. 2, pp. 323-359, pls. 1-14, 1912 The Mazon Creek, Illinois, Shales and their amphibian fauna: Amer. Journ. Sci, vol. XXXIV, pp. 277-285, 2 figs, 1912.

pean specimens, those found in Illinois show the general contour of the body, the character of the dermal covering, the color markings, the lateral line system, and in three specimens the molds of the entire alimentary canal (Plate LX, F). Two of the known species do not exceed 50 mm. in length.

The genera *Micrerpeton*, *Eumicrerpeton*, *Mazonerpeton* are the chief representatives of this family and are fully described in my monograph[24].

Family COCYTINIDAE

This family is based on material discovered in eastern Ohio, with which is associated an Illinois species *Erierpeton*, indicating a close relationship between the two faunas. This must be accepted with the caution that the two known species of the family are based on very incomplete material.

Family AMPHIBAMIDAE

This group is known from the Illinois locality by two genera, *Amphibamus* and *Cephalerpeton*. They show a tendency toward the reptilian type of tetrapod. A restoration is given in Plate LIX, above, and the skeletons are shown in Plate LXI, A, D. None of the species exceed six inches in total length.

The skull is abruptly truncate posterior, limbs very long; toes provided with claws; ventral armature highly developed.

Two other families are suggested by incomplete remains from the Mazon Creek shales; the *Molgophidae* and the *Cricotidae*. Our knowledge of the entire fauna is badly in need of strengthening by the study of additional material.

The amphibian fauna of eastern Ohio, from the locality long known as Linton, near Yellow Creek, presents many fascinating features. In association with many types of fishes and a possible reptile we have at the Ohio locality a view of Pennsylvanian vertebrate life such as can be found no where else.

Fifty-one species have been described from this locality in eastern Ohio; gathered in part from the dump, as well as from the systematic splitting of hundreds of tons of cannel coal. J. S. Newberry was then (1869) director of the Ohio Geological Survey, and to him we owe our present knowledge of this wonderful vertebrate fauna of the Pennsylvanian. The flora was also of the greatest interest. These organic remains of a past fauna and flora were carefully described in Volumes I and II of the Ohio Geological Survey. These volumes are of the greatest value in interpreting the life of the Coal Measures. Although there is some slight evidence of a relationship between the Mazon Creek fauna and that of eastern Ohio, yet it seems more probable that the three North American amphibian faunas, that of Mazon Creek, of Linton, Ohio, and of the South Joggins, Nova Scotia, were all distinct.

A brief review of the fauna found in the cannel coal will suffice to show the nature of the amphibians therein. No branchiosaurs are known from eastern Ohio. All the species are apparently members of the group Microsauria with reptilian tendencies.

The family *Tuditanidae* may be considered as fairly typical of the Ohio beds, as well as the neighboring Cannelton shales of Pennsylvania. Three genera with thirteen species represent this family. The dorsum of the skull and the pectoral plates have a characteristic sculpture, consisting of pits and radiating grooves. The members of the genus *Erpetosaurus* have a broad flattened head, with clearly indicated lateral line canals.

The family *Urocordylidae* agrees with certain species from Ireland in some of its members being provided with horns which are out-growths from the squamosal bone of the skull. An example of a horned amphibian is found in *Diceratosaurus*, a genus which is known from fairly complete material. They were small animals, with skulls measuring 35 mm, including the horns.

A family, *Nyraniidae*, is of great interest in that its members are covered with fish-like scales (Plate VII, B.) a character which they share with species from the Coal Measures of Ireland[26]. The species of the family are known from incomplete material, and future discoveries will clear up many points.

[26]Huxley, T. H., On a collection of fossil vertebrata from the Jarrow Colliery, County of Kilkenny, Ireland: Trans. Roy. Irish Acad. 1871. vol. XXIV. pp. 351-369, pls. XIX-XXIII. 1867.

Still another family, the *Ptyoniidae*, is likewise apparently common to Ohio and Ireland, as well as to Bohemia. They are extremely snake-like in form and structure, some of the species having the skeleton reduced to the skull and elongated vertebral column. *Ptyonius* was the most abundant of all the amphibians in the Ohio Coal Measures. Some of the individuals possessed over 100 vertebrae, but evidently did not exceed a total length of 200 mm.

The modern frogs are apparently represented in the Coal Measures by the *Peliontidae*, the single species of which is shown in Plate LVIII, A; plate LX, G. This species, *Pelion lyelli* was described in 1858, and we like to think it shows ancestral characters to the modern Salientia.

A family of large animals is that of the *Sauropleuridae*, some of which may have attained a length of several feet. The best preserved of the members of this family is *Saurerpeton lutithorax* although only the anterior half of the animal is preserved.

Many other species of diverse character are indicated in the Pennsylvanian by fragmentary remains of large and small animals, some of which are shown on Plate LX. Fragments of teeth, vertebrae, jaws, and scattered skeletal material form the evidence on which our conclusions may, for the present, be based. It is a matter of great importance to discover new material, since this though fragmentary, will supplement that which is known.

Class REPTILIA

Geological Range, Pennsylvanian to Recent

Amphibians and reptiles of the Pennsylvanian are hard to discriminate. These animals were then at the parting of the ways, and their structural features are often similar. Our knowledge of these two groups during the Pennsylvanian is based on such fragmentary material that more complete data will doubtless clear up many matters, now obscure.

Williston[27] thought that the incomplete skeleton (here shown on Plate LXIV) of a small tetrapod, described by Cope as

[27]Williston, S. W., The oldest known Reptile: Journ. Geol. vol. XVI, pp. 175-192, fig., 1908.

Tuditanus punctulatus, represented the oldest known reptile, and proposed the name *Eosauravus copei*[28]. Case, Watson[29] and others have accepted the form as reptilian, and regard it as a member of the Cotylosauria, a group already known from the Permian of Texas. Other forms of reptiles are suggested by fragmentary skeletal remains and by footprints.

The type specimen of *Eosauravus* is less than six inches in length. It was probably subaquatic. The hind limbs are very strong, with the foot much expanded. The tarsus is well developed and osseous. This is not in itself a reptilian character since some of the Pensylvanian amphibians have an ossified tarsus.

Other, larger, reptiles or reptile-like amphibians, have been indicated in the Pennsylvanian of Pennsylvania[30] of West Virginia[31], and of Maryland. The cast of a bone[32], named *Pareiasauroides henneni* (White), in very fine sandstones, possibly represents an animal of a type known from South Africa; a group of clumsily built reptiles known as the Pareiasauria.

ICHNOLOGY

Since 1828 when the Rev. Dr. Duncan read his paper on fossil footprints from the New Red Sandstone of Scotland, before the Royal Society of Edinburgh, our knowledge of foot impressions has grown to a considerable body of knowledge. Dean William Buckland suggested the term *Ichnology* for the science of tracks and additions to our knowledge are still being made. Unsatisfactory as footprints are, they form our only evidence of the presence of tetrapods during the Devonian and the greater part of the Misissippian. There are many records of footprints in the Pennsylvanian rocks and these records indicate a broad distribution of early vertebrate life. It is not always posible to determine from the impressions alone whether the animal was amphibian or reptilian, hence the word *tetrapod*,

[28]Bull. Geol. Soc. Amer., XXI, 272, 1910.

[29]Watson, D. M. S., On Seymouria, the most primitive known reptile: Proc. Zool. Soc. London, pp. 267-300, figs. 1-15, 1918.

[30]Matthew, W. D., Amer. J. Sci., (4), 11, 199, 1911.

[31]Case, E. C., West Virginia Geological Survey, Rept. Braxton and Clay Counties, pp. 817-822, 1917.

[32]Lull, R. S. and White, I. C. Paleontology. West Virginia Geological Survey, Rept. Mineral and Grant Counties, pp. 733-734, pls. XLII-XLIIII, 1927. In connection with Lull's discussion of large footprints from the Coal Measures.

which may be either. Even with the skeletons at hand paleontologists are not yet able to discriminate the amphibians of the Pennsylvanian from the reptilians.

Lull[33] has described footprints from the Pennsylvanian of Massachusetts, which may be reptilian. Martin[34] has discussed the nature of some large footprints from the Pennsylvanian of Kansas. Jillson[35] discovered tetrapod footprints in the Pennsylvanian of Oklahoma. Henderson[36] described footprints of unusual tetrapods from the Pennsylvanian of Colorado. Lull[37] and Noble[38] have discussed the vertebrate footprints of the Grand Canyon of the Colorado. Mr. Charles W. Gilmore has made an extensive collection of these Ichnites for the U. S. National Museum, and will discuss them fully. Some of these indications of vertebrate life are later than the Pennsylvanian. I have discussed[39] an impression from Pennsylvania and others have added to the subject. The indications are that we may still hope to discover vertebrate remains of entirely different types to any now known. Recent discoveries from the Osage limestones of Kansas show that the knowledge of the footprints themselves is still incomplete. No footprints are known from the Pennsylvanian rocks of Kentucky itself but such discoveries may be confidently expected, since the state lies in the belt across the continent in which other discoveries have been made.

On Plate LXII are given illustrations of an unusual discovery of fossil footprints. They are derived from the Pennsylvanian of eastern Kansas. Martin[22] suggested the term *Onychopus gigas* as a name for the animal which made the footprints. Remington Kellogg has called attention to the previous use of the generic term so the name of *Wakarusopus* is proposed as a new generic name.

[33]Lull, R. S., An Upper Carboniferous Footprint from Attleboro, Massachusetts: Amer. J. Sci. L, pp. 234-236, figs., 1920.

[34]Martin, H. T., Indications of a gigantic Amphibian in the Coal Measures of Kansas: Sci. Bull. Uni. of Kan. vol. XIII, No. 12, pp. 103-114, 3 pls., 1922.

[35]Jillson, W. R., Preliminary Note on the Occurrence of vertebrate Footprints in the Pennsylvanian of Oklahoma: J. Sci., vol. XLIV, pp. 56-58, 1 fig., 1917.

[36]Henderson, Julius, Footprints in Pennsylvanian Sandstone of Colorado: Jour. Geol. vol. XXXII, no. 3, pp. 226-229, 3 figs., 1924.

[37]Lull, R. S., Fossil Footprints from the Grand Canyon of the Colorado: Amer. J. Sci., vol. XLV, pp. 537-346, 1918.

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[39]Moodie, Roy L., New or little-known forms of Carboniferous Amphibia in the American Museum of Natural History: Bull. Amer. Mus. Nat. Hist., vol. XXVI, pp. 347-357, 1909.

This discovery of huge footprints, possibly reptilian, in the Coal Measures of Kansas is rendered more interesting by the recent description by Lull[40] of similiar, clawed, footprints in the Pennsylvanian of Maryland. The probable presence of large reptiles in the Pennsylvanian is further strengthened by the occurrence of a large cast of a reptilian bone found in West Virginia.

Bibliography

More than seven hundred books and papers have been written about the animals and plants of the Coal Period. Since it is not possible or necessary to give a complete list here, a few titles are given from which the interested student may follow further the discussion of the life of the Pennsylvanian.

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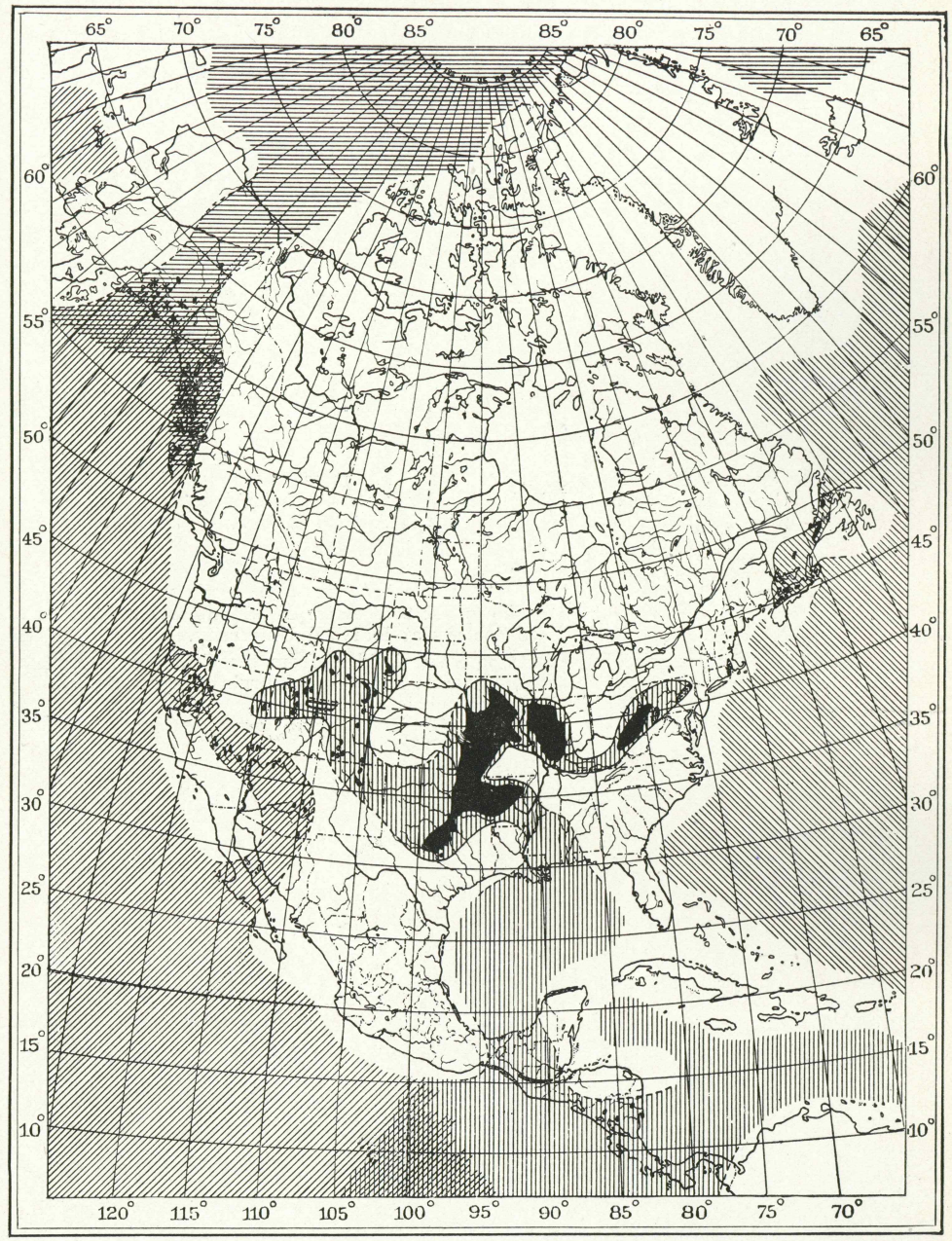
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[40]Lull, R. S., Probable reptilian Footprints from the Maryland Carboniferous: West Virginia Geol. Survey, Mineral and Grant County Report, pp. 731-734, 6 pls., 1927.

Explanation of Plate LV

A Map of North America during the Upper Pennsylvanian showing land and water conditions under which the Coal Measures fish and amphibian fauna lived. It will be noted that the chief deposits which have furnished amphibian remains are on the margins of the heavily shaded areas. The state of Kentucky was in this area of land a swamp during the periods when coal was being formed. After Schuchert.

Explanation of symbols: Lands are white. Water areas are lined. Formation outcrops are black or dotted. Known shore lines are solid lines: probable ones broken. vertical lines in middle of continent indicate Gulf marine. During the coal period and the life of the amphibians the Pennsylvanian water areas were either fresh or somewhat brackish waters. No amphibian has ever been proved to be marine, although Wiman has suggested such for the fauna of the Trias of Spitzbergen and the Mazon Creek fauna of Illinois may have been brackish. The evidence is not clear enough in either case to warrant making a positive statement.



Geological map of North America during the Pennsylvanian.

Explanation of Plate LVI

PENNSYLVANIAN FISHES

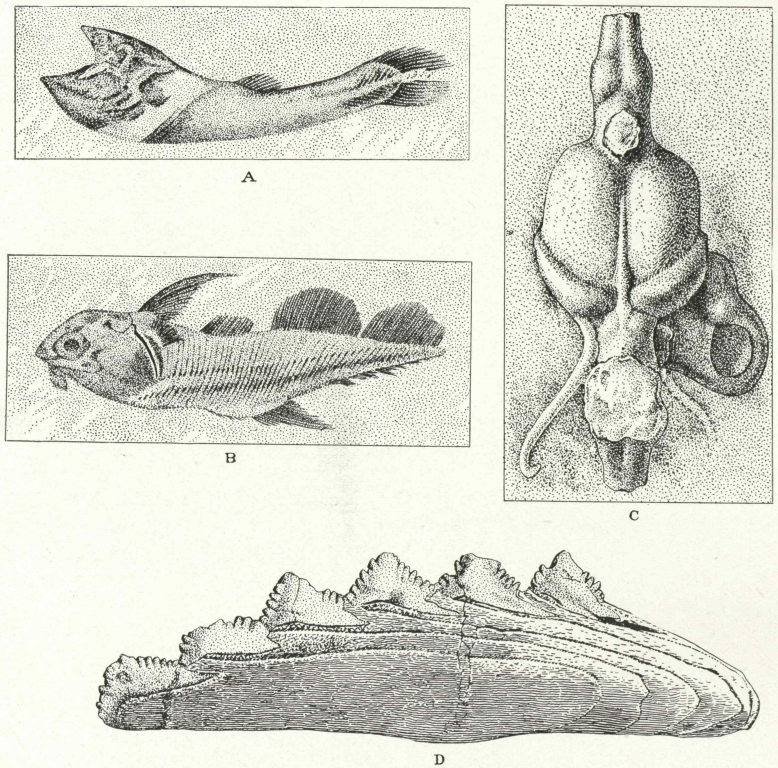
A. *Coelacanthus exiguus* Eastman. Coal Measures shales of Mazon Creek, near Morris, Illinois. Nearly complete individual, lacking posterior dorsal and anal fins. X 2/1 After Eastman. Original in Yale Museum.

B. *Elonichthys perpennatus* Eastman. Pennsylvanian shales of Mazon Creek, near Morris, Illinois. Complete individual, the distal portion of medium fins not fully shown. X 2/1 After Eastman. Original in Museum of Comparative Zoology at Harvard University.

C. A fish brain, possibly one of the Paleoniscidae, from the Coal Measures shales near Lawrence, Kansas. The original brain was about 18 mm. in length. The brains are enclosed in small rounded nodules and they occur in abundance at two localities in Douglas County, Kansas. Some of the Kentucky shales also may have these same fossils.

D. A salt water fish from the Pennsylvanian of Illinois; a shark-like animal known as *Edestus crenulatus*. The right portion of the dental armature of a large fish. Original in the U. S. National Museum. After Hay.

PLATE LVI



Fishes from the Pennsylvanian Rocks

Explanation of Plate LVII

PENNSYLVANIAN FISHES

A. *Acanthodes beecheri* Eastman. A tiny shark from the Coal Measures shales of Mazon Creek, near Morris, Illinois. Restoration showing outline of body and position of fins. X 2/1. After Eastman.

B. *Cheirodus orbicularis* Newberry and Worthin. A fairly well-preserved specimen, from the Pennsylvanian shales of Mazon Creek near Morris, Illinois. Nat. Size. After Eastman.

C. *Elonichthys hypsilepis* Hav. A nearly complete specimen from the Pennsylvanian shales at Mazon Creek, near Morris, Illinois, X 1/3. After Eastman.

D.-G. Lung fish remains from the Coal Measures of Ohio. After Hussakof.

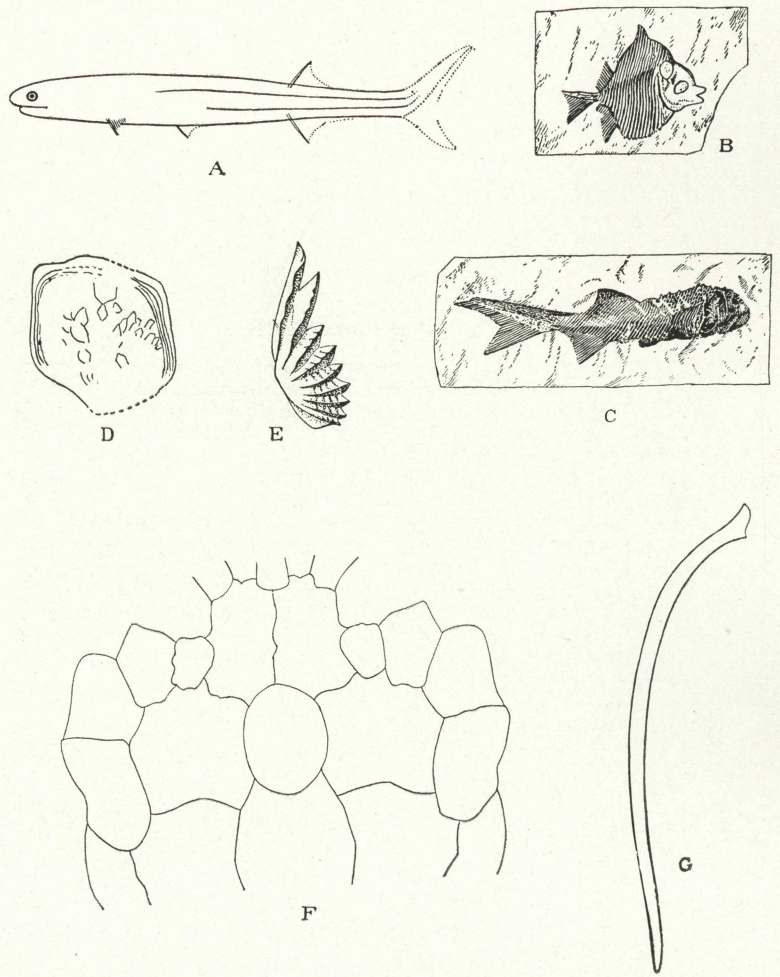
D. Scale of *Sagenodus*. Natural size.

E. Tooth of *Sagenodus serratus*. Natural size.

F. Part of cranium of *Ctenodus ohiensis*. X 1/2.

G. Rib of *Sagenodus*. Natural size.

PLATE LVII



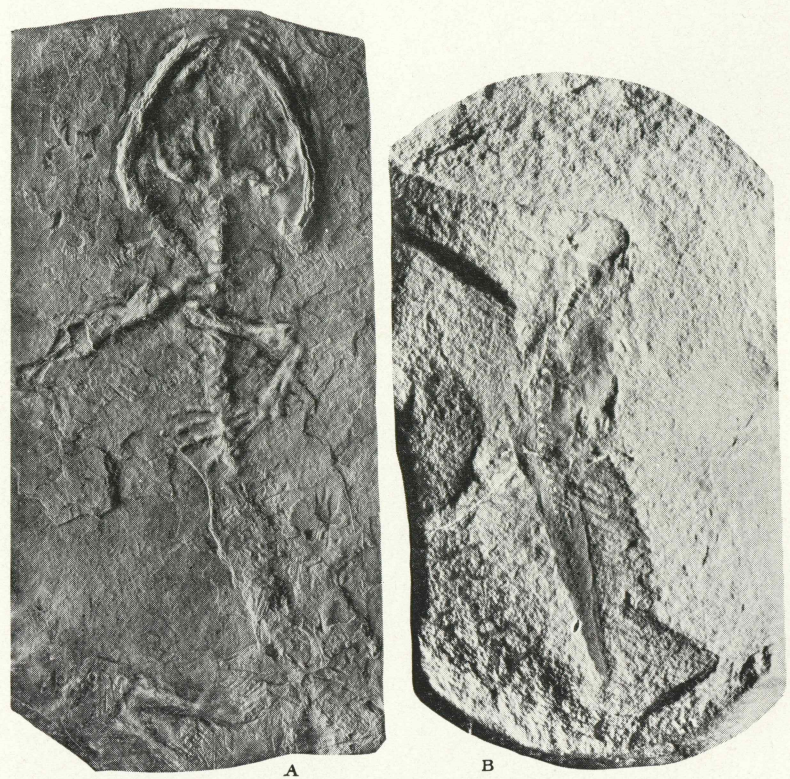
Sharks among fishes from the Coal Measures

Explanation of Plate LVIII

A. Type specimen (and the only one known) of *Pelion lyelli* Wyman, from the Ohio Coal Measures at Linton. This animal is thought to represent the ancestral group from which the frogs were derived. Original in the American Museum of Natural History. length of specimen as preserved 110 mm.

B. Type and only specimen of a true branchiosaur, *Micrerpeton caudatum* Moodie, from the Coal Measures of Mazon Creek, near Morris, Illinois, showing skeletal elements, preserved as kaolin form of head and tail, the lateral-line sense organs, banded color markings, ventral scutellae, and small body scales. On the edges of the tail impression are indications that in life the tail had a thin fold of skin above and below the fleshy portion, much as in the larvae of modern salamanders. Original in Walker Museum, University of Chicago. Length of entire animal as preserved 49 mm.

PLATE LVIII



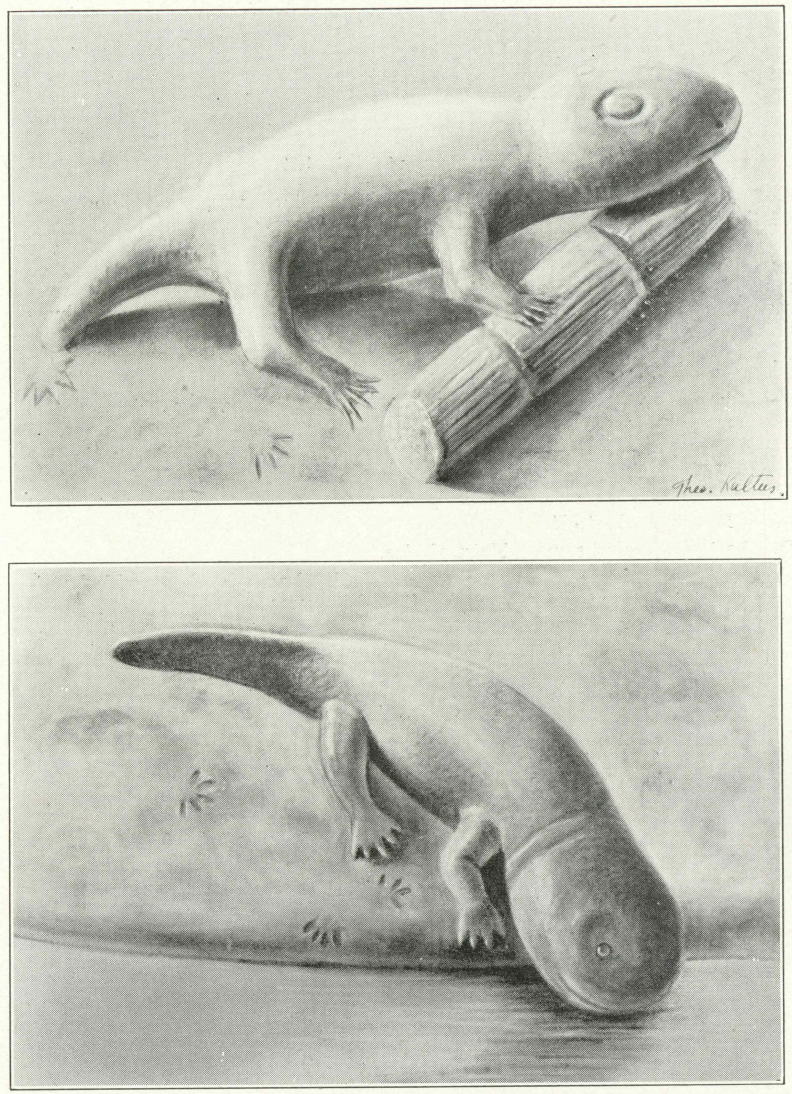
Fossils of two Pennsylvanian Amphibians

Explanation of Plate LIX

Upper. Restoration of probable appearance of a small (slightly longer than five inches) reptile-like amphibian from the Mazon Creek shales of Illinois and known as *Amphibamus grandiceps* Cope. The restoration is based on complete material at the University of Chicago and at Yale University. *Amphibamus* was a low, flat, short, creeping or crawling animal, possibly spending a part of the time in the water.

Lower. A reconstruction of the possible appearance of the small branchiosaurian *Micrerpeton caudatum* Moodie from the Mazon Creek shales of Illinois. The animal was about two inches in length. This figure is based on a single example now preserved in Walker Museum, University of Chicago, aided by an examination of other specimens of a related species, *Eumicrerpeton parvum* Moodie, the originals of which are preserved in the Peabody Museum at Yale University. The animal was a small, salamander-like amphibian frequenting the borders of pools in the marshes of Coal Measures time.

PLATE LIX



Restorations of Pennsylvanian Amphibians

Explanation of Plate LX

This plate shows the usual type of material on which our knowledge of the Pennsylvanian amphibians is based. Some of these animals may, originally, have been represented by fairly complete skeletons, but the accidents of mining, weathering and collecting account for the loss of much of the skeleton. Most of the material from the Ohio Coal Measures was collected from the dump. Some of it was derived from splitting hundreds of tons of cannel coal, both methods liable to result in loss.

A. A portion of the left mandible of a large amphibian, *Macrerpeton deani* Moodie, the largest animal of the Ohio coal. Type specimen, No. 2934, American Museum of Natural History. Length of specimen, 115 mm.

B. Fore-limb of an amphibian uncertainly identified as *Pleuroptyx clavatus* Cope, X 0.75.

C. Interclavicle of *Sauropleura pauciradiata* Cope from the Ohio Coal Measures, Nat. Size.

D. Left clavicle of same. Natural size.

E. Part of the body of a snake-like amphibian known as *Molgophis brevicostatus* Cope. Linton, Ohio, Coal Measures.

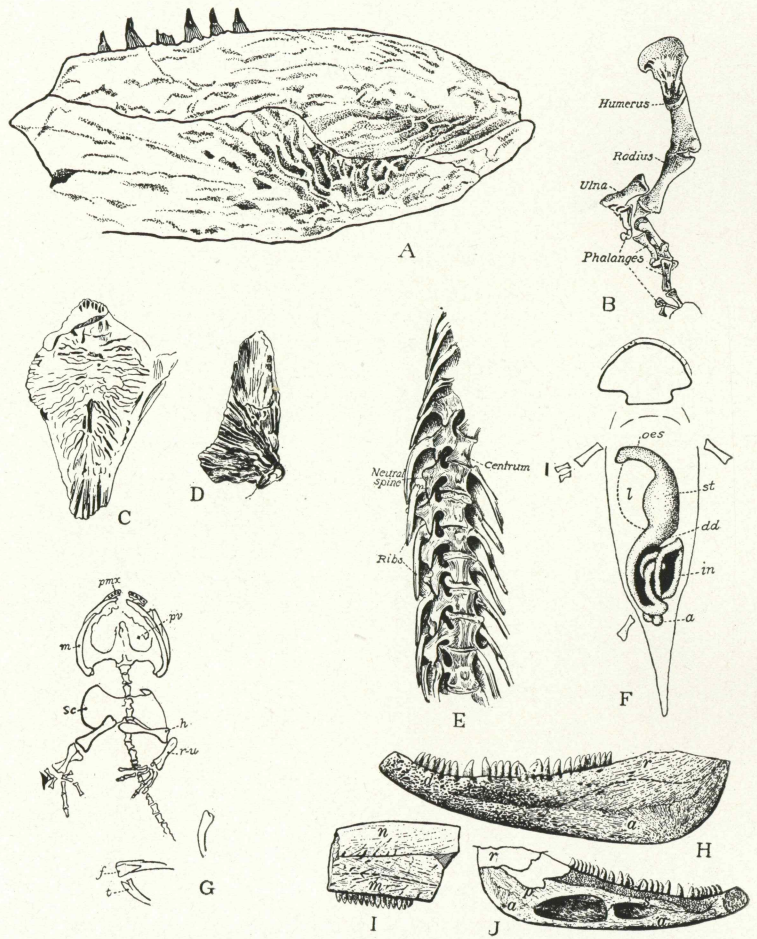
F. A small branchiosaur, *Eumicrerpeton parvum* Moodie, showing preservation of alimentary tract. Mazon Creek shales, near Morris, Illinois. Yale University Museum.

a=anus
in=intestine
l=liver
st=stomach
oes=oesophagus

G. *Pelion lyelli* Wyman, an amphibian from the Coal Measures of Ohio, the supposed ancestral salientian (After Wyman) Slightly less than natural size.

H. I. J. Remains of *Eobaphetes kansensis* Moodie, from the Coal Measures of Washington County, Kansas. Originals in U. S. National Museum.

PLATE LX



The imperfect skeletal remains of Pennsylvanian Tetrapoda

Explanation of Plate LXI

Much of our knowledge of the Pennsylvanian Tetrapoda is based on very fragmentary remains or impressions, but in the plate shown herewith are drawings of our unusually well preserved Coal Measures Amphibians.

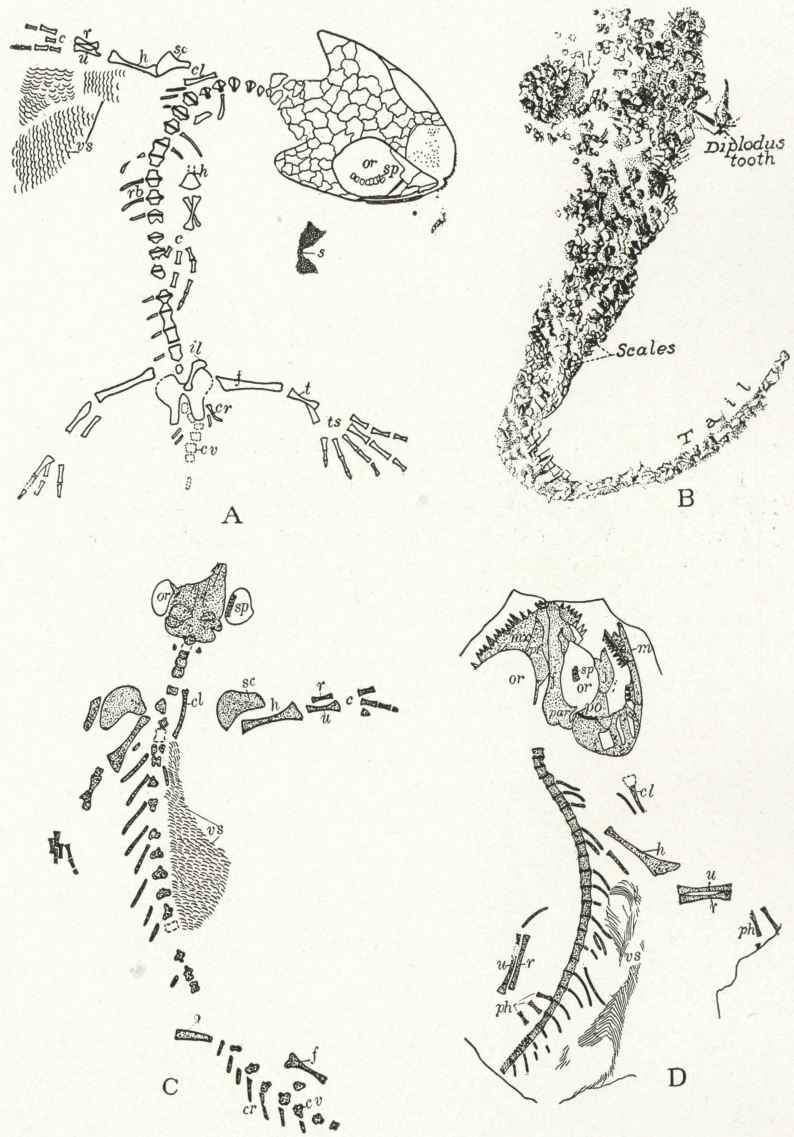
A. A Skeleton of *Amphibamus grandiceps* Cope, Mazon Creek shales, near Morris, Illinois. About natural size. Original specimen is No. 794, Marsh Collection, Peabody Museum, Yale University.

B. An amphibian whose body was scaled. Type specimen of *Cercariomorphus parvisquamis* Cope, from the cannel coal of the Ohio, Linton, Coal Measures. The original is in the American Museum of Natural History, Length of entire specimen is 180 mm.

C. Skeleton of *Mazonerpeton longicaudatum* Moodie, a Coal Measures branchiosaur, from the Mazon Creek shales at Morris, Illinois. Specimen No. 795, Yale Museum; length of entire specimen is 64 mm.

D. Skeleton of *Cephalerpeton ventriarmatum* Moodie, Mazon Creek shales of Illinois. Natural size. Specimen in Yale University; length of entire specimen 98 mm.

PLATE LXI

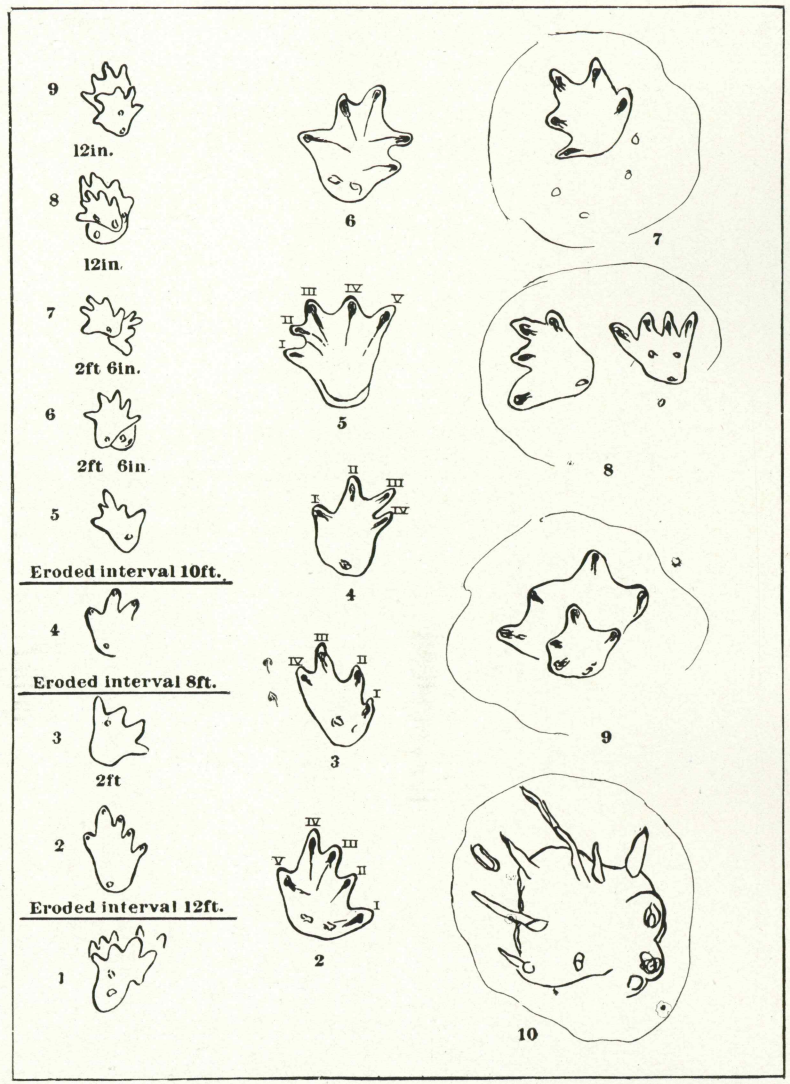


Four of the most perfect skeletons of Pennsylvanian Tetrapods

Explanation of Plate LXII

Footprints of a gigantic amphibian, *Wakarusopus* (*Onychopus*) *gigas* Martin as they occur in the sandstone ledge of the Upper Coal Measures, just above the Weston shales. Wakarusa Creek at Dightman's crossing, Douglas County, Kansas.

PLATE LXII



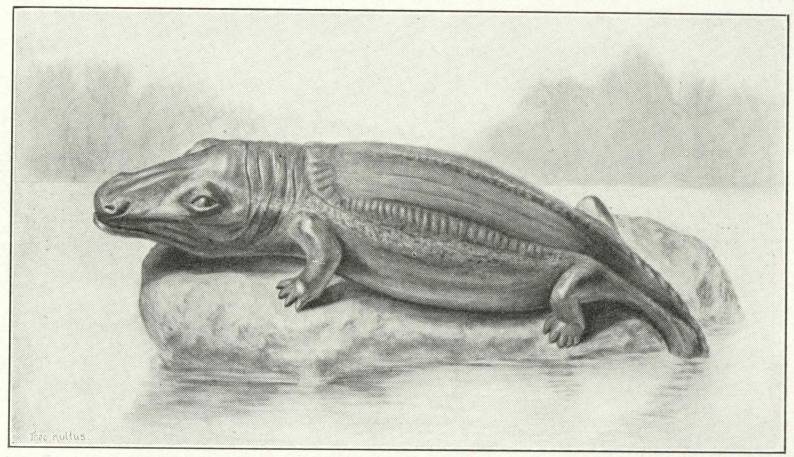
Gigantic footprints from the Pennsylvanian

Explanation of Plate LXIII

Reconstruction of the probable appearance of one of the large labyrinthodonts which lived at the close of the Pennsylvanian period and on through the Permian and Triassic. Several discoveries in North America, in rocks of undoubted Pennsylvanian age, indicate that these large, reptile-like amphibians, from six to fifteen feet in length, existed in the borders of swamps with their smaller relatives. The skeletal material, on which this supposition is based, is scanty, consisting of parts of ribs, vertebrae, skulls and jaws of the genera: *Baphetes, Eobaphetes, Eosaurus, Macrerpeton, Eryops* and others.

Adapted from Fraas.

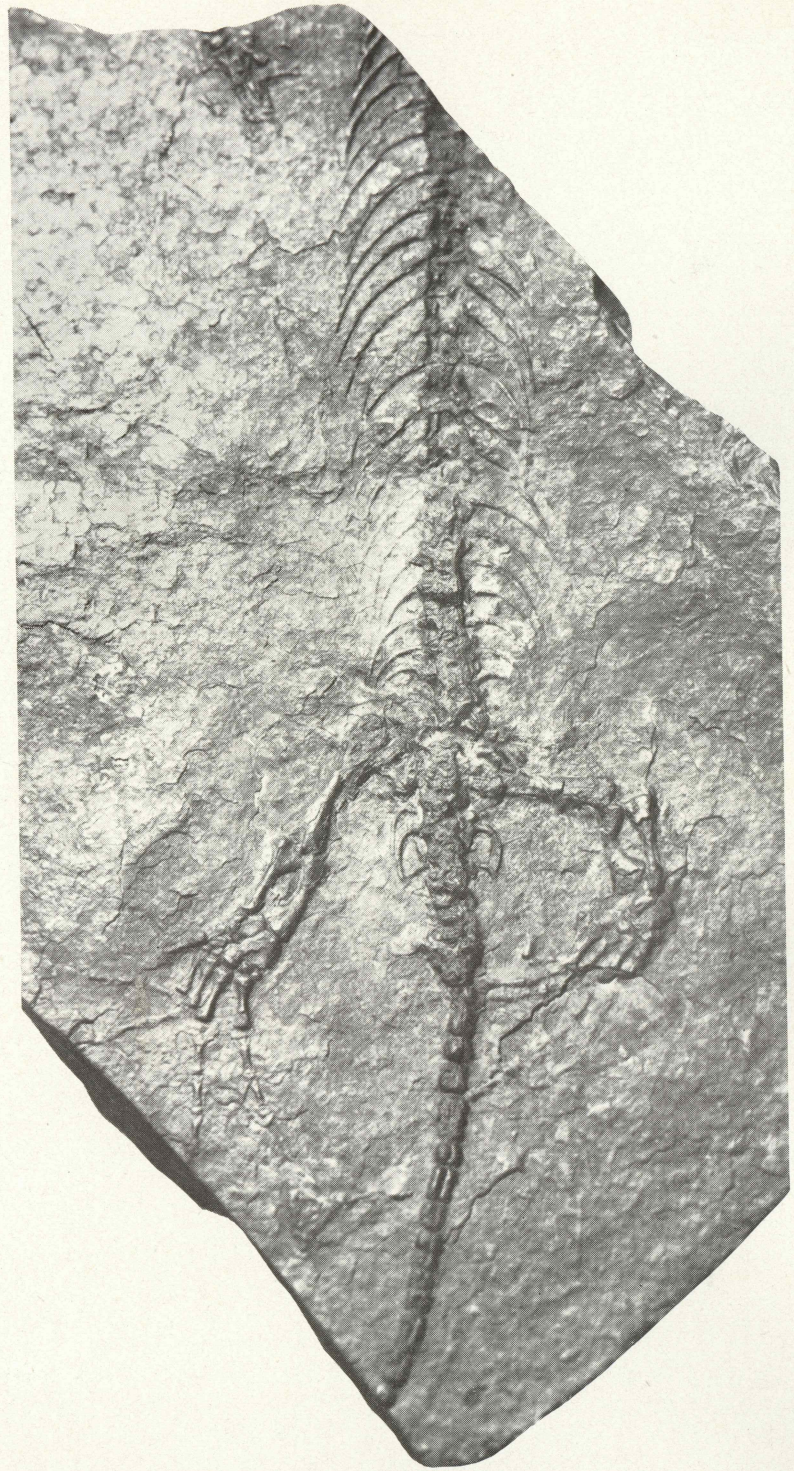
PLATE LXIII



A Labyrinthodont

Explanation of Plate LXIV

Type and only specimen of the *"oldest known reptile"* Cannel coal at Linton, Ohio; known as *Eosauravus copei* Williston. The Original is in the United States National Museum. No. 457. The fossil animal as it is preserved measures 132 mm. in length.



The oldest known reptile

VIII

MESOZOIC FAUNA AND FLORA

By

JOSEPH KENT ROBERTS

THE MESOZOIC FAUNA AND FLORA OF KENTUCKY

By

JOSEPH K. ROBERTS

The Mesozoic era is represented by beds of Upper Cretaceous age, which rests unconformably upon limestones and cherts of Mississippian age. During Triassic, Jurassic, and Lower Cretaceous time land conditions prevailed, or if any sediments were accumulated, they were removed by contemporaneous erosion to such an extent that no record of them remains. Rocks of early and middle Mesozoic time are absent over the entire embayment region, and the Jurassic is not represented east of the Mississippi River by any sedimentary rocks known at the present time. The unconformity at the base of the Upper Cretaceous represents a vast thickness of rocks in the geologic record. This great break is not only marked by differences in the physical characteristics of the sediments below and above the unconformity, but also by the profound change in the floras and faunas.

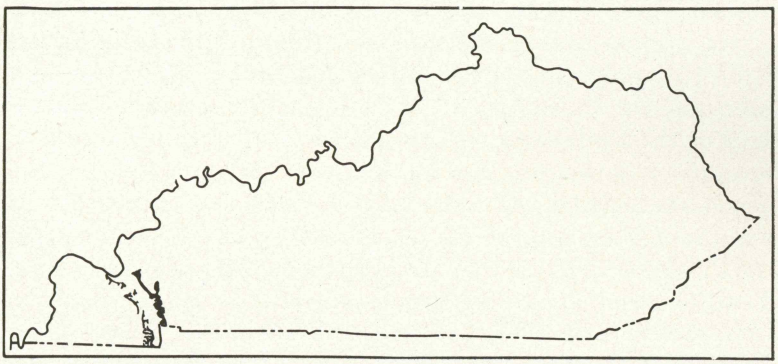


Fig. 31. Map of Kentucky showing outcrop of Cretaceous rocks. Scattered quartzite boulders of appalachian derivation also occur sparingly in Eastern Kentucky.

UPPER CRETACEOUS

Beds of Upper Cretaceous age extend across the State of Kentucky in a north-northwestern direction and the central portion or general axis of the beds lies about coincident with the Tennessee River. The belt extends from Tennessee and on

the State line it is approximately 25 miles wide. It narrows towards the north to only a few miles where most of it is covered by Plio-Pleistocene and alluvial deposits, but reappears in southern Illinois in a few places, and shown in many instances by well logs. In many localities in Kentucky the Upper Cretaceous beds have been eroded, another factor in causing the belt not to be continuous across the State.

The beds occur over portions of Trigg, Lyon, and Livingston counties mainly between the Tennessee and Cumberland Rivers, but small areas east of the Cumberland River as well; also west of the Tennessee River in Calloway, Marshall, and McCracken counties. The deposits occuring between these two rivers and to the east of the Cumberland River are the oldest, and the beds become younger towards the west, as is the case with the Tertiary and younger sediments.

The Upper Cretaceous sediments consist of gravel, sand, greensand, and sandy, micaceous, and lignitic clays, high grade commercial clays, and some lignite. These sediments for the most part are little consolidated if any, and the only instances of any note are the beds in which iron oxides have been the agents of consolidation. They rarely show any appreciable dip, and when they do it is to the west in the southern portion of the region, and to the southwest towards the Ohio River. Faulting, while pronounced in the underlying limestones and cherts of the Paleozoic, is not observed in the unconsolidated beds of the Cretaceous. The formations of Upper Cretaceous recognized in western Kentucky are as follows: between the Tennessee boundary to which point both the Selma and Eutaw with very thin beds of Ripley near the Ohio River; east of the Cumberland River thin beds of the Tuscaloosa; west of the Tennessee and Eutaw with very thin beds of Ripley near the Ohio River; east of the Cumberland River thin beds of the Tuscaloosa; west of the Tennessee River the Tuscaloosa and Ripley with problematical Selma, which is mapped with Ripley. The entire Cretaceous west of the Tennessee is so thin and the beds so much alike that it is not possible to differentiate them and without faunas or floras one cannot differentiate them even at the Kentucky-Tennessee boundary to which point both the Selma and Eutaw have been mapped on the west side of the Tennessee River by Wade.

Upper Cretaceous Formations

FORMATION	CHARACTER OF SEDIMENTS	COUNTIES WHERE EXPOSED
Ripley	Sand, clay, and lignite	Livingston, McCracken, Marshall & Calloway
	Unconformity	
Eutaw	Sand	Trigg, Calloway & Marshall
Tuscaloosa	Gravel with small masses of clay	Trigg, Livingston, Lyon & Marshall
	Unconformity	

TUSCALOOSA FORMATION

The name, Tuscaloosa, was proposed in 1887 by Smith and Johnson[1] for the basal beds of the Upper Cretaceous in the vicinity of Tuscaloosa river (Black Warrior river), Alabama. The Tuscaloosa is best developed and exposed in Alabama where its maximum thickness is approximately one thousand feet acocrding to Stephenson[2].

The Tuscaloosa extends in a lunate form from Alabama across Tennessee to Kentucky. In Kentucky this formation is found mainly in Trigg, Lyon, and Livingston counties and a very small area in Marshall County. The great bulk of Tuscaloosa lies between the Tennessee and Cumberland Rivers; a few detached areas on the eastern side of the latter river may have been continuous at one time but have been separated by erosion. On the average the Tuscaloosa belt is about four miles wide and forty miles long. The thickness ranges upwards to 170 feet, the average being much less.

The Tuscaloosa consists almost exclusively of gravel and this in an unconsolidated condition except in a very few cases. Sellier mapped Cretaceous gravel west of Golden Pond, Trigg County in 1915, shown on the current map of Kentucky (1929). In 1920 Bruce Wade[3] showed isolated deposits of

[1]Smith, E. A., and Johnson, L. C., Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee, and the Alabama rivers: U. S. Geol. Survey, Bull 43, pp. 95-116, 1887.
[2]Stephenson, L. W., The Mesozoic rocks: The Cretaceous system: Geology of Alabama, Alabama Geol. Survey, Special Rept. 14, pp. 231-250, 1926.
[3]Wade, Bruce, Recent Studies in the Upper Cretaceous of Tennessee: Tennessee Geol. Survey, Bull, 23, pp. 52-58, 1920.

Tuscaloosa gravel in Stewart County, Tennessee, extending to the Kentucky line, and mentioned the section west of Golden Pond, and at Canton, Trigg County.

The Tuscaloosa gravel consists of reworked Mississippian chert and limestone, and the chert, composes the great bulk of the gravels. These gravels are all well rounded, many of them roughly spherical, one of the distinctive marks from the Plio-Pleistocene gravels, the other being their white and light gray color in contrast to the reddish brown colors of the younger gravel. The gravels vary up to three inches on the average, though there are cobbles which reach as much as fifteen inches. The matrix is a fine clay with small chert gravels which become as small as coarse sand. This matrix is sometimes indurated by iron oxides but this is not nearly so common as in the case of the Plio-Pleistocene gravels. Locally a few lenses of light gray to white clay is contained in the gravel beds, such being the case in the gravel pits at Grand Rivers. For a fuller description of the Tuscaloosa beds, see the reports of the writer[4]. So far observed, the Tuscaloosa gravel yields no fossils, nor do the clay lenses show any. There are numerous reworked fossils in the gravels, and these consist of fragments of crinoid stems and plates, bryozoa, brachiopods, and other Mississippian forms from which the gravels are derived. Farther south in the embayment region, in Alabama, fossil floras are found, but in all such instances the formation carries beds of clay, much of which is lignitic with some sand. Some of the fossil localities are listed below, and certain diagnostic fossils listed in the plates from other localities, not that such represent the Tuscaloosa in Kentucky but the formation as a whole over the embayment region.

Extensive collections of plants have been made by Smith, Langdon, Ward, Berry, and others, and Ward named some thirty-five species. In 1919 Berry[5] decribed a number of Tuscaloosa plants and below are listed the localities with the number of species from each.

[4]Roberts, Joseph K., The Tuscaloosa formation of Kentucky: Am. Jour. Sci., vol. 14, pp. 465-472, 1 map, 1927.
Roberts, Joseph K., The Cretaceous deposits of Trig, Lyon, and Livingston Counties, Kentucky: Kentucky Geol. Survey, vol. 31, pp. 281-326, 8 figs., 2 maps, 1929.

[5]Berry, E. W., Upper Cretaceous Floras in Tennessee, Mississippi, Alabama, and Georgia: U. S. Geol. Survey, Prof. Paper 112, 141 pp. 33 pls. 12 figs., 1919.

Tuscaloosa Plant Collecting Localities

LOCALITY	NUMBER OF SPECIES
Glen Allen, Alabama	39
Shirley's Mill, Alabama	98
Tuscaloosa, Alabama	11
Cottonwood, Alabama	48
Southwest of Northport, Alabama	5
Snow Place, Alabama	43
Robertson's Landing, Alabama	1
Sanders Ferry Bluff, Alabama	5
Whites Bluff, Alabama	6
Soap Hill, Alabama	1
Maplesville, Alabama	2
Jones Ferry, Alabama	1
Centerville, Alabama	1
Near Iuka, Mississippi	4

The plants described from the above localities are distributed over 87 genera and 150 species of which 44 genera are not represented in present day floras. Since the Tuscaloosa furnishes no fossil floras in Kentucky, only a few of the most widely distributed forms in Alabama will be given in the plates. This floral belt must have extended northward into and across Kentucky, but the gravels are not suited to the preservation of fossils.

EUTAW FORMATION

The name, Eutaw, was used by Hilgard for beds near Eutaw,[6] Alabama, which were first recognized and studied by Tuomey and described by him in his "First Biennial Report on the Geology of Alabama," published in 1850. Hilgard included what is now the Eutaw and Tuscaloosa under this term, and it remained for Eugene A. Smith and L. C. Johnson to recognize and make a separation in 1887.

There are two belts of the Eutaw in Kentucky; the best developed and easiest one to recognize occurs in Trigg County between the rivers, extending from Stewart County, Tennessee, and it terminates about the middle of Trigg County; the other occurs west of the Tennessee River in what is known as "The Jackson Purchase Region", and here it is difficult to differentiate it from the Ripley sands with which it is mapped. Neither of these occurrences are more than a mile wide. The sediments are poorly exposed compared to those of Tennessee and the states farther south. Very few exposures are found

[6]Hilgard, E. W., Report on the Geology and Agriculture of Mississippi: Jackson, Mississippi, pp. 60-95, 1860.

west of the Tennessee River, and Glenn reported some years ago in his studies of the underground water supply of western Kentucky that no sediments of Eutaw age occur in the wells at Paducah, and Hickman, Kentucky, and at Cairo, Illinois. In 1920 Wade[7] noted a small thickness of Eutaw in Henry County, Tennessee, and a fifteen foot exposure on the Tennessee river at Paducah, and his map accompanying the reports shows a narrow belt of Eutaw extending to the Kentucky line west of the Tennessee river.

The Kentucky deposits consist of brownish red sand, micaceous in most instances, and the textural range is from medium to coarse. The determination of the age of this sand was made by tracing it into Tennessee where the age relation was established by Wade, and he traced the beds into localities where they carry a marine fauna.

Wherever bedding is shown, the dip of the beds is to the west or southwest at low angles. The sands are not cross-bedded east of the Tennessee River but more to the west. The sediments are unconsolidated for the most part except where iron oxides have cemented the grains into a fairly resistive rock. Wade recognized two members in the Eutaw in Tennessee, namely, the Tombigbee or basal member, and the Coffee sand or younger member; these are difficult to separate even in regions where well developed, and the Tombigbee appears to terminate south of the Kentucky line in Hardin County, Tennessee. It is possible that the Eutaw in Kentucky is an equivalent of the Coffee sand but without any clay lenses, and there are no fossils to indicate its stratigraphic position.

The absence of Eutaw fossils in Kentucky does not indicate that they were never present; they have probably been leached out by ground waters. The sand is composed of quartz largely with variable amounts of feldspars, muscovite and other minerals. Occasionally small grains of chert occur in the sand. The brownish red color is due to iron oxides, which forms an envelop around the grains and colors the matrix of clay.

In Tennessee 16 species of leaves, some poorly preserved wood, and a few specimens of fossil amber have been collected

[7]Wade, Bruce, Recent Studies in the Upper Cretaceous of Tennessee: Tennessee Geol. Survey, Bull., 23, p. 58, 1920.

from the Coffee sand and clay, and Eutaw fossils are fairly abundant in Alabama. No fossils have been reported from Kentucky, but some of the more representative ones are given in the plates. Some of the plant localities are given below with their number of species, as given by Berry[8].

Eutaw Plant Collecting Localities

Locality	*Number of Species*
McBride's Ford, Georgia	19
Broken Arrow Bend, Georgia	5
Chimney Bluff, Georgia	7
Havana, Alabama	14
Coffee Bluff, Tennessee	16

The flora so far described from the embayment region comprises forty-three species, most of which are flowering plants. There are some marine invertebrate fossils along the Chattahoochie River in Alabama, and near Montgomery, Alabama. The fossils are not well preserved, and are only casts and molds.

RIPLEY FORMATION

In 1860 Hilgard used the term, Ripley,[9] for certain sandy marls and limestone near Ripley, Mississippi, and regarded it as an equivalent of the "Lower Cretaceaous" of Tuomey. In 1887 Smith and Johnson used the name, Ripley, for similar beds of the same horizon in Alabama, but Stephenson pointed out that the Ripley of northern Mississippi, and of east and central Alabama is represented in west Alabama and east Mississippi by chalk deposits, which are correlated according to our present knowledge with the Selma chalk.[10]

South of the state line, the Tennessee Ripley shows four members, namely, the Owl Creek, McNairy, ferruginous clay, and Coon Creek. The name, McNairy was introduced by Stephenson[11] from his studies in the Cretaceous of NcNairy County, Tennessee. Towards the Kentucky line both the Owl Creek and the ferruginous clay members cannot be differentiated from the McNairy sand. In Calloway and Marshall counties there are certain sands, which may be the equivalent of the McNairy member, and these along with the clays, which are of Ripley age beyond a doubt are mapped as one unit.

[8]Berry, E. W., op. cit., pp. 44-48.
[9]Hilgard, E. W., op. cit. pp. 3, 62, 83-95.
[10]Stephenson, L. W., op. cit., pp. 240-241.
[11]Stephenson, L. W., Cretaceous Deposits of the Eastern Gulf Region: U. S. Geol Survey, Prof. Paper 81, pp. 17-18, 1914.

There is no way of differentiating these. It might be well to add here that the Selma cannot be differentiated in Calloway County, although Wade shows it to be a mile or so wide at the state line.

The Ripley has both sands and clays, and the sand predominates. The clay occurs as lenses in the sand. The sand is a brown, and sometimes it assumes a dark gray. It is cross-bedded, and well bedded. Locally the sand may be indurated. The matrix is clay, and iron oxides act as the principal cementing agent. The texture of the sand varies from a relatively fine to a coarse, but no gravels occur.

There are several large clay lenses in the Ripley, which are used commercially in the vicinity of Briensburg, Marshall County. The clay is a dark variety, the coloring matter being organic materials. South of Benton, Marshall County, a few fossil leaf impressions occur, but they are not well preserved. Similar clays occur near Bruceton, Tennessee, which yeild a number of fossil plants. This clay is well laminated, and contains quite a bit of marcasite and pyrite.

No Ripley faunas have been found in Kentucky, but they are fairly abundant in Alabama, Georgia, and Tennessee, and have been described by Berry[12]. The plants are distributed over 40 families, 71 genera, and 135 species. Of this total number 105 species are dicotyledons. The localities from which these collections have been made, the number of species from each are as follows:

Ripley Plant Collecting Localities

Locality	*Number of Species*
Near Eufala, Alabama	1
Cawikee Creek, Alabama	3
Near Beuna Vista, Georgia	6
Byron, Georgia	3
Perry Place, Tennessee	66
Cooper Pit, Bruceton, Tennessee	65
Near Beuna Vista, Tennessee	4
Near Mifflin, Tennessee	5
Northwest of Camden, Tennessee	2
Near Camden, Tennessee	1
Coon Creek, Tennessee	2
Near Selmer, Tennessee	13
Big Cut, Tennessee	3

[12]Berry, E. W. The Flora of the Ripley Formation. U. S. Geol. Survey, Prof. Paper, 136, 90 Pp. 23 pls. 6 figs., 1925.

Some of the faunas of the Ripley of Tennessee have been described in detail by Wade, and they have been collected chiefly from the Coon Creek and Owl Creek members; the Coon Creek faunas have been described and figured by Wade.[13] Most of the fauna consists of molluscan forms; there are 313 species exclusive of the bryozoa and crustacea. No fossil faunas were found near the Kentucky line by Wade, and no traces of any were found during the field work in Calloway, Marshall, and McCracken counties.

CONCLUSION

The Upper Cretaceous beds of western Kentucky represent an oscillation of the sea, trangressing from the south and southwest, reaching its maximum near the close of Eutaw time, and withdrawing by the close of Ripley time. The Tuscaloosa gravel deposits represent according to Berry[14] delta deposits, and this most likely is the case in Alabama where tree roots with entangled cobbles and rocks are found embedded in the gravels. This condition does not appear in Kentucky. The chert pebbles are more perfectly rounded than the terrace gravels of the Plio-Pleistocene, and they indicate a marine origin. Some of the Tuscaloosa might be augmented by delta agencies but it does not appear probable that all this deposit from the Tennessee line to the Ohio River could have been formed exclusively by delta action. Both the Eutaw and Ripley are of marine origin as is shown in the embayment region farther south. The sea did not begin its withdrawal until the close of the Midway Stage in Kentucky, when the last of the marine deposits were formed, namely, the Porters Creek clay and sand.

[13]Wade, Bruce, The Fauna of the Ripley formation on Coon Creek, Tennessee: U. S. Geol. Survey, Prof. Paper 137, 192 pp., 72 pls., 2 figs., 1926.

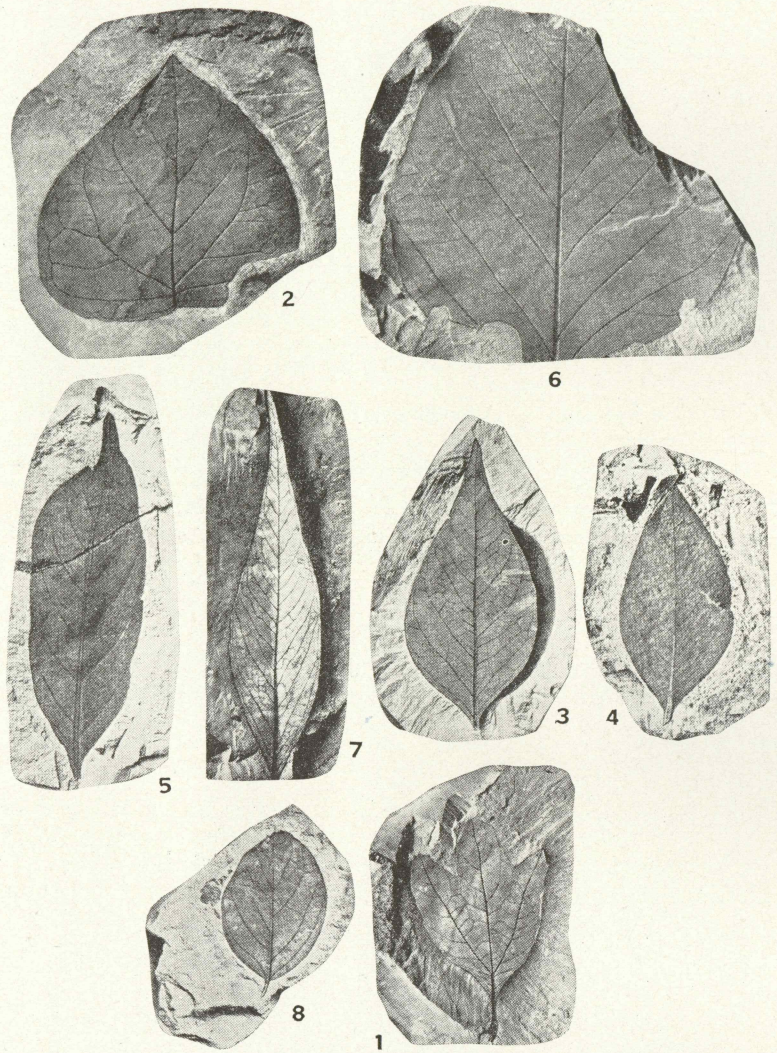
[14]Berry, E. W., The Delta Character of the Tuscaloosa Formation: Johns Hopkins Univ. Circ., n. s., pp. 18-24 (216-222), 1917.

Explanation of Plate LXV

Tuscaloosa Floras

1. *Platanus shirleyensis* Berry: Tuscaloosa formation at Shirley's Mill, Fayette County, Alabama. U. S. Geol. Surv., Prof. Paper 112, Pl. XV, fig. 1.
2. *Menispermites integrifolius* Berry. Tuscaloosa formation from Cottondale, Tuscaloosa County, Alabama. U. S. Geol. Surv., Prof. paper 112, Pl. XX, fig. 1.
3. *Ficus inaequalis* Lesquereux. Tuscaloosa formation from Shirley's Mill, Fayette County, Alabama. U. S. Geol. Surv., Prof. Paper 112, Pl. XII, fig. 1.
4. *Andromeda wardiana* Berry. Tuscaloosa formation from Shirley's Mill, Fayette County, Alabama. U. S. Geol. Surv., Prof. Paper 112, Pl. XXVII, fig. 6.
5. *Sapindus variabilis* Berry. Tuscaloosa formation from Shirley's Mill, Fayette County, Alabama. U. S. Geol. Surv., Prof. Paper 112, Pl. XXVII, fig. 3.
6. *Magnolia lacoeana* Lesquereux. Tuscaloosa formation from Shirley's Mill, Fayette County, Alabama. U. S. Geol. Surv., Prof. Paper 112, Pl. XVII, fig. 9.
7. *Ficus daphnogenoides* (Herr) Berry. Tuscaloosa formation from Shirley's Mill. Fayette County, Alabama. U. S. Geol. Surv., Prof. Paper 112, Pl. XIII, fig. 6.
8. *Diospyros rotundifolia* Lesquereux. Tuscaloosa formation from Cottondale, Tuscaloosa County, Alabama. U. S. Geol. Surv., Prof. Paper 112, Pl. XXX, fig. 5.

PLATE LXV



Plant Fossils of the Tuscaloosa—Cretaceous

Explanation of Plate LXVI

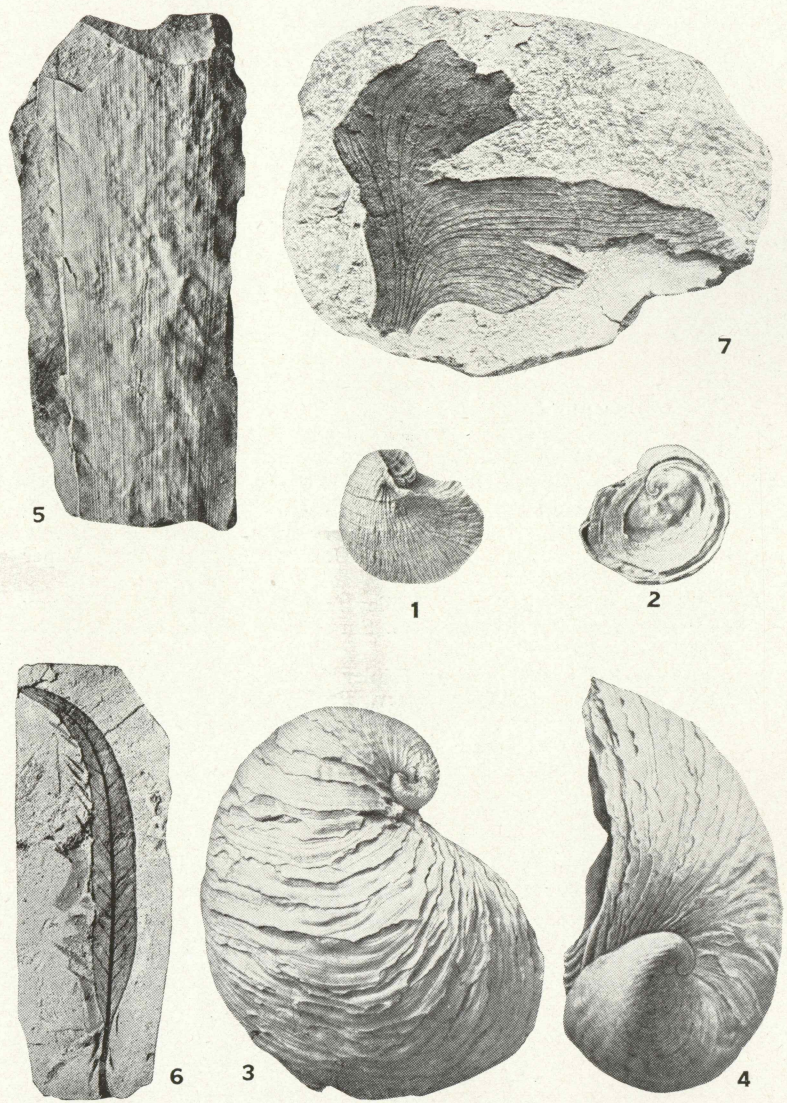
Eutaw Faunas

1. *Exogyra upatoiensis* Stephenson. Basal Eutaw beds, Broken Arrow Bend, Chattahoochie River, 10½ miles below Columbus Georgia. Left valve. U. S. Geol. Surv., Prof. Paper 81, Pl. XIII, fig. 1.
2. Same specimen as above (Fig. 1), showing right valve.
3. *Exogyra ponderosa* Roemer. Tombigbee sand member of the Eutaw formation, bluff on the Chattahootchie River at Blufftown, 31¼ miles below Columbus, Georgia. Shows the costae only on the apical region. U. S. Geol. Surv. Prof. Paper 81, Pl. XIII, fig. 6.
4. Same specimen as above (Fig. 3), showing a small attachment scar on the beak. U. S. Geol. Surv., Prof. Paper 81, Pl. XIII, fig. 7.

Eutaw Floras

5. *Doryanthites cretacea* Berry. Eutaw formation at Havana, Hale County, Alabama. U. S. Geol. Surv., Prof. Paper 112, Pl. XIII, fig. 1.
6. *Myrica havanensis* Berry. Eutaw formation at Havana, Hale County, Alabama. U. S. Geol. Surv., Prof. Paper 112, Pl. XXVIII, fig. 7.
7. *Phyllites asplenioides* Berry. Coffee sand member of the Eutaw formation at Coffee Bluff, Hardin, Hardin County, Tennessee. U. S. Geol. Surv., Prof. Paper 112, Pl. XXXIII, fig. 1.

PLATE LXVI



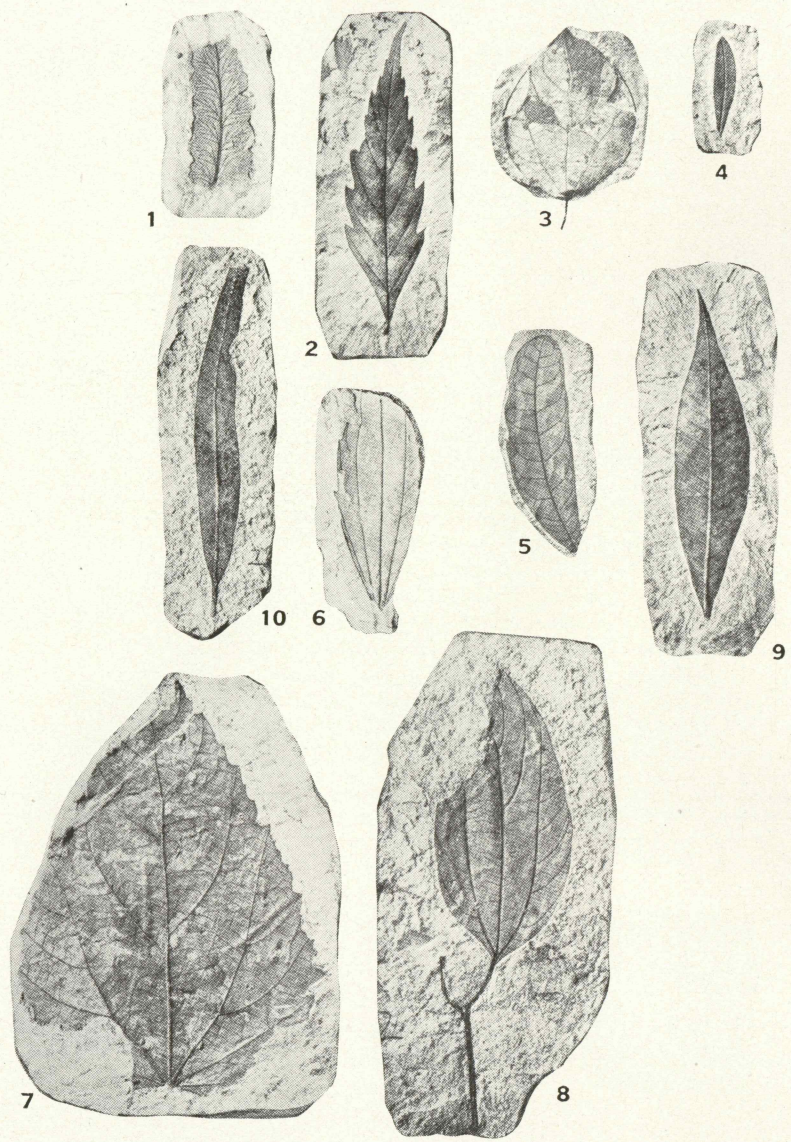
Fossil Faunas and Floras of the Eutaw—Cretaceous

Explanation of Plate LXVII

Ripley Floras

1. *Raphaelia neuropteroides* Debey & Ettingshausen. Ripley formation, Cooper Pit, Bruceton (Hollow Rock Junction), Tennessee. U. S. Geol. Surv., Prof. Paper 136, Pl. I, fig. 8.
2. *Myrica ornata* Berry. Ripley formation, Cooper Pit, Bruceton (Hollow Rock Junction), Tennessee. U. S. Geol. Surv., Prof. Paper 136, Pl. VI, fig. 5.
3. *Ficus celtifolius* Berry. Ripley formation, Cooper Pit, Bruceton, Tennessee. U. S. Geol. Surv., Prof. Paper 136, Pl. X, fig. I.
4. *Mimosites cooperensis* Berry. Ripley formation, Cooper Pit, Bruceton, Tennessee. U. S. Geol. Surv., Prof. Paper, 136, Pl. X, fig. 7.
5. *Euphorbiophyllum tennesseensis* Berry. Ripley formation, Perry Place, Henry County, Tennessee. U. S. Geol. Surv., Prof. Paper 136, Pl. XII, fig. 4.
6. *Zizyphus ripleyensis* Berry. Ripley formation. Perry Place, Henry County, Tennessee. U. S. Geol. Surv., Prof. Paper 136, Pl. XIII, fig. 9.
7. *Grewiopsis ripleyensis* Berry, Ripley formation, Cooper Pit, Bruceton, Tennessee. U. S. Geol. Surv., Prof. Paper 136, Pl. XV, fig. 2.
8. *Cinnamomum newberryi ellipticum* Berry. Ripley formation, Cooper Pit, Bruceton, Tennessee. U. S. Geol. Surv., Prof. Paper 136, Pl. XVI, fig. 7.
9. *Laurophyllum ripleyensis* Berry. Ripley formation, Perry Place, Henry County, Tennessee. U. S. Geol. Surv., Prof. Paper 136, Pl. XVIII, fig. 7.
10. *Myrtophyllum angustum* (Velenovsky) Berry. Ripley formation, Cooper Pit, Bruceton, Tennessee. U. S. Geol. Surv., Prof. Paper 136, Pl. XIX, fig. 1.

PLATE LXVII



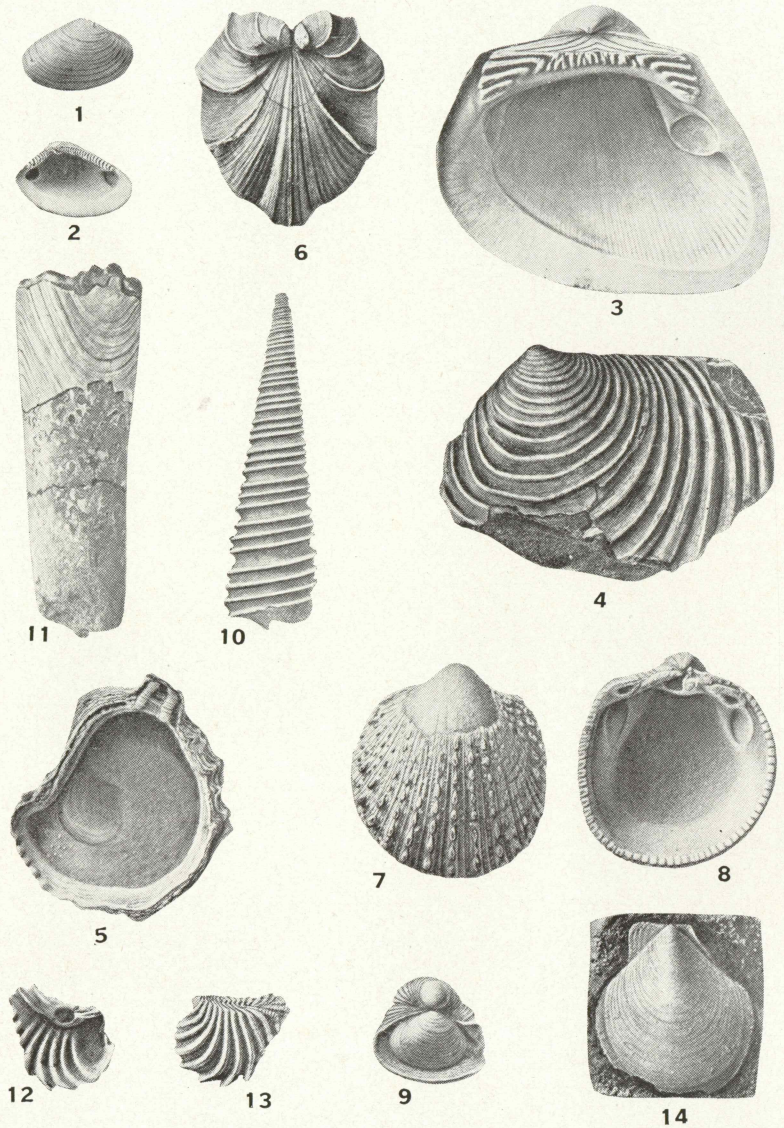
Fossil Floras of the Ripley—Cretaceous

Explanation of Plate LXVIII

Ripley Faunas

1- 2. *Nucula percrassa* Conrad (1, exterior view; 2, interior view). Coon Creek, Tennessee.
3. *Cucullaea vulgaris* Morton. Coon Creek, Tennessee.
4. *Inoceramus proximus* Tuomey. Coon Creek, Tennessee.
5. *Ostrea plumosa* Morton. Coon Creek, Tennessee.
6. *Veniella conradi* (Morton). Coon Creek, Tennessee.
7- 8. *Cardium kummeli* Weller. Coon Creek, Tennessee.
9. *Corbula crassiplica* Gabb. Coon Creek, Tennessee.
10. *Turritella trilira* Conrad. Coon Creek, Tennessee.
11. *Baculites ovatus* Say. Coon Creek, Tennessee.
12-13. *Trigonia eufalensis* Gabb. Coon Creek, Tennessee.
14. *Pecten simplicius* Conrad, Coon Creek, Tennessee.

All specimens are from the Coon Creek horizon of the Ripley formation, Tennessee, and are described and figured in U. S. Geol. Surv., Prof. Paper 137 by Wade. All figures are taken from this professional paper.



Fossil Faunas of the Ripley—Cretaceous

IX

CENOZOIC FAUNA AND FLORA

By

JOSEPH KENT ROBERTS

THE CENOZOIC FAUNA AND FLORA IN KENTUCKY

By

JOSEPH K. ROBERTS

The Cenozoic era is represented in Kentucky by sediments of the Tertiary and Quaternary, but the sequence is not complete. Almost all of the sediments are limited to the Jackson Purchase area, that is, the region lying between the Tennessee and Mississippi Rivers, bounded on the north by the Ohio River and on the south by the State of Tennessee, though there are some deposits of sand, gravel, and loam between the Tennessee and Cumberland Rivers and to the east of the latter river. By far the greater portion of these sediments are unconsolidated, and like the Upper Cretaceous beds, they are not intruded by any forms of igneous rocks.

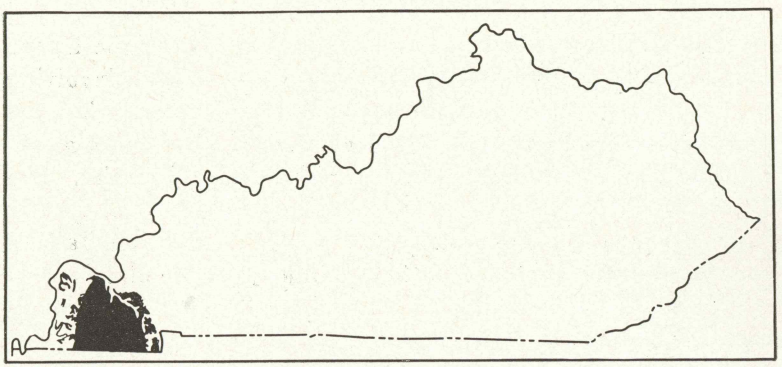


Fig. 32. Map of Kentucky showing outcrop of Cenozoic rocks.

The Tertiary sediments lie unconformably upon the Upper Cretaceous and from a standpoint of origin they represent marine, near shore, partly inland, and continental deposits. The Tertiary deposits cover much more territory than the Cretaceous. The time represented by the unconformity at the base of the Tertiary is of great length, as indicated by the changes in flora below and above the Cretaceous-Eocene contact shown in portions of the embayment area farther south in

Tennessee, Alabama, and Mississippi. Only a few floras survived this interval, and as the faunal record of the Tertiary is relatively nothing, little can be said of any faunal changes. The Tertiary beds become progressively younger towards the Mississippi River, and dip at a very low angle to the west in the southern part of the State, to the southwest near the middle, and almost south in the northern and northwestern portions. The structure is that of a gentle monocline. The Eocene beds are mostly covered by a blanket of sand and gravel of Plio-Pleistocene age, the socalled "Lafayette formation," and the Eocene members are only exposed in clay pits, a few streams, road and railroad cuts, and erosion exposures, thus making the study of the Eocene beds difficult. The Quaternary beds in addition to the Plio-Pleistocene sand and gravel consist of loess and a weathered phase of the loess, the loam, and the alluvial deposits of the Mississippi, Ohio, Tennesee, and the many smaller streams.

TERTIARY SYSTEM

The Tertiary sediments cover the region west of the Upper Cretaceous to the Mississippi river for the most part, involving the western portions of Calloway and Marshall counties, the southwestern portion of McCracken County, and most all of Ballard, Carlisle, Fulton, Graves, and Hickman counties. The Tertiary belt is an extension of the same belt of the embayment from Tennessee, and it disappears in McCracken and Ballard counties on the north beneath the Ohio river floodplain, but reappears in southern Illinois. A number of good plant localities are known over the region, particularly in Graves and Ballard counties. The sediments consist of clay, lignite, sand, gravel, and beds of consolidated clay, sand, and gravel, in which the consolidating agent is iron oxides, the latter beds being rather small in amount but large in extent.

As to age the sediments range from the Midway through the Wilcox to the Jackson, and most likely represented in the basal portions of the so-called "Lafayette" sand and gravel. The middle Eocene or Claiborne deposits are not represented in Kentucky nor in the surface exposures in Tennessee, so far observed. The deposits of Wilcox (Holly Springs and

Grenada) comprise the major portion of the Jackson Purchase region. The areal extent of the deposits of Jackson age is very small, as they outcrop only along the bluff of the Mississippi River in the vicinity of Hickman and Columbus.

Table of Tertiary Formations in Kentucky

EOCENE AGE	FORMATION	TYPE OF SEDIMENTS	COUNTIES WHERE EXPOSED
		Unconformity	
JACKSON	Jackson	Sand, Clay, Lignite, Indurated clay	Fulton, Hickman, Carlisle
		Unconformity	
WILCOX	Grenada	Sand, Clay, Lignite Indurated Sand & Clay	Hickman, Graves, Fulton
	Holly Springs	Sand, Clay, Lignite, Indurated Sand & Clay	Calloway, Marshall, McCracken, Graves, Ballard, Carlisle
		Unconformity	
MIDWAY	Porters Creek	Clay, sand, with sandstone dikes	Calloway, Marshall, McCracken, Graves

The earliest reconnaissance report on the Tertiary of western Kentucky was that of Loughridge.[1] Loughridge recognized in the region the following formations or units:

Lagrange group (of Safford's Tennessee)

Lignitic (Safford's Porters Creek and Bluff Lignite)

Hickman (provisional)

He evidently confused what he termed the Hickman with the clay and sand of Jackson age, and such a confusion probably arose over the consolidated beds of clay which occur in the bluffs at Hickman and to the south of this town. He was also confused over the age of the Porters Creek and the so-called "Bluff Lignite" and placed them as of the same age. At present the Porters Creek is known to be lower Eocene, and the Bluff Lignite upper Eocene.

The Lagrange was used by the earlier geologists to embrace a vast thickness of sand, clay, and consolidated material, which at the present time is divided into the Grenada and Holly Springs. Safford's work in western Tennessee was used by

[1]Loughridge, R. H., Report on the geological and economic features of the Jackson Purchase region: Kentucky Geol. Survey, Frankfort, 357 Pp. 21 figs, 3 maps, 1888.

Loughridge as a basis for his units in western Kentucky. The Lagrange as a term has been shown to cover too large a thickness in Tennessee and Mississippi. The use of this term in the early days of embayment studies was due to there being no fossil faunas in the Lagrange; though there were many fossil floras, and some were known to Safford, Owen, Loughridge, and others, yet such fossils were not studied and made use of as at present.

MIDWAY SERIES

The term, Midway, was proposed in 1896 by Harris[2] for the lower Eocene deposits farther south in the embayment region. In Kentucky the Midway is represented only by the Porters Creek clay with a small thickness of grayish sand at or near its top and numerous sandstone dikes, whereas in the southern portion of western Tennessee and Mississippi the Clayton (impure) limestone is present as its basal member.

The Porters Creek clay extends from the Tennessee line in a very broken manner through Calloway, Marshall, and McCracken counties. Alluvium and the Plio-Pleistocene deposits conceal it in many places, and while it is quite certain from well records that it occurs as a belt through Calloway, Marshall, McCracken, and Ballard counties, yet it has been mapped only where it is exposed on the surface. The Porters Creek belt is nowhere more than two and one-half to three miles wide, and only a small area of it occurs in Graves County in the extreme northeastern part.

The name, Porters Creek, was introduced by Safford during the sixties of last century from the occurrence of the clay along Porters Creek, west of Middleton, Hardeman County, Tennessee. This clay is very persistent in its lithologic character throughout Kentucky and Tennessee. It is known locally as "soapstone" from its greasy feel when dry. At the top of the Porters Creek clay in McCraken County there is a two-foot bed of sand, which carries marine pelecypoda and gastropoda.

The Porters Creek clay is a light gray to a dove color, the lighter color prevailing when it is dry. It is not indurated to any extent though it is very hard when dry and surprisingly light in weight. It is the easiest Tertiary unit to recognize

[2]Harris, G. D., The Midway Stage: Am. Pal., Bull., Vol. 1, pp. 18-22, 1896.

in western Kentucky, from it conchoidal fracture, its hackly nature of weathering, color, and its field relations. It contains small muscovite flakes at times, but it is usually very fine grained and no particles except mica showing. It is of marine origin as shown by a few moluscs, forminifera, and fish scales. Three miles south of Paducah, McCracken County near the old Paducah-Mayfield road the clay contains beautifully preserved fish scales, and casts of marine mullusca. A few plant remains have been found by L. C. Glenn near Middleton, Tennessee. The Porters Creek where the thickest exposure is known to occur, 2½ miles southeast of Elva, Marshall County, measures 35 feet. According to L. C. Glenn, the Porters Creek is as much as 150 feet thick[3] at Wickliffe, Ballard County. The only contact of the Porters Creek clay and the overlying Holly Springs formation found in Kentucky is in the railroad cut of the Illinois Central new freight line between Fulton and Metropolis, in what is known as the Coleman Cut, southwestern part of McCracken County. Here the clay beds dip almost south and strike about east and west.

Section in Illinois Railway Cut, 2½ miles north of Graves County line, McCracken County

	Feet
Gray loam and soil, the loam grading downward into gray to white gravels of upwards one-half inch in diameter	6
Plio-Pleistocene gravel and sand; gravels for most part are rounded and flattened in lower portion coated with iron oxides, gravels composed of chert, numerous quartzite fragments of 15 inches or more; sand coarse to medium with clay pellets towards the base, cross bedded, and a number of thin indurated bed	10-12
Unconformity	
Holly Springs formation:	
c. Yellowish red and gray sands interbedded, medium to fine texture, banded, and cross bedded at times	2-20
b. Light to medium gray clay, sandy in places, well bedded, with a few fairly well preserved plants	0-15
a. Yellowish brown sand, laminated, little indurated, composed chiefly of quartz	2- 5
Unconformity	
Porters Creek clay—dark to medium gray when wet, light gray when dry, few stem fragments, shaft of 28 feet sunk in the clay; exposed	10

WILCOX GROUP

The Wilcox in the embayment region farther south is composed of the Akerman, Holly Springs, and Grenada. The Akerman wedges out south of the Tennessee-Mississippi line, certainly it is not exposed in western Tennessee. The Grenada and Holly Springs extend from Tennessee into Kentucky.

[3]Glenn, L. C., Underground Waters of Tennessee and Kentucky west of Tennessee river and of an adjacent area in Illinois: Water Supply & Irrigation Paper 164, p. 31. 1906.

Among the earlier geologists this group was known as the Lagrange. The separation into the above units has been brought about within the last quarter of a century, chiefly through the paleobotanic studies of Berry, which will be referred to later. The name, Wilcox, takes its source from Wilcox County, Alabama, and was first used as a lithologic term for the Nanafolia, Tuscahoma, Bashi, and Hatchetigbee of Alabama by Crider[4]. The Holly Springs and Grenada were named after towns in Mississippi and were proposed in 1913 by Lowe[5]. The Holly Springs and Grenada have been mapped, and studied in western Tennessee by the writer and R. L. Collins[6].

The Holly Springs sediments consist of coarse to fine sand and lenses of light and lignitic clay with all gradation of colors and several varieties of commercial clays, such as wad, sagger, and ball, which can be blended, and both the sand and clay may be consolidated by iron oxides. The sand is well rounded down to certain sizes and consists largely of quartz. Nowhere have any fossils been observed in the sand except a few fragments of silicified wood. The clay when free from sand is mined and shipped from six pits at present, five of which are located in Graves County and the sixth near Wickliffe, Ballard County.

The Holly Springs clay in certain beds abounds in leaf impressions a few fruits, cones, flower petals, and stem fragments. The massive ball clay does not show any leaf impressions to any extent. They are the most abundant in the yellowish gray clay and in the lighter varieties of the lignitic clay. A number of localities have been collected from as is shown in subsequent pages. The following localities have been examined and a great number of specimens collected during the summer of 1929, but as yet all these have not been determined and described by E. W. Berry:

LeCleade Christy clay pit, Wickliffe, Ballard County.

Abandoned clay pit south of Boaz, Graves County.

Pit of the Kentucky Clay Company, Viola, Graves County.

[4]Crider, A. F., Geology and Mineral Resources of Mississippi: U. S. Geol. Survey, Bull. 283, p. 25, 1906.

[5]Lowe, E, N., Preliminary Report on the Iron Ores of Mississippi: Mississippi Geol. Survey., Bull. 10, pp. 23-25, 1913.

[6]Roberts, Joseph K., and Collins, R. L., The Tertiary of west Tennessee: Am. Jour. Sci., Vol. 12, pp. 235-243, 1926.

Roberts, Joseph K., Tertiary Stratigraphy of west Tennessee: Geol. Soc. Am. Bull., Vol. 39, pp. 435-446, 1928.

Pit No. 4, Ky.-Tenn. Clay Mining Co., Pryor, Graves County.

The Grenada consists of sand and clay and thin layers of indurated sand and clay. On the average, the sand of the Grenada is distinctly finer than that of the Holly Springs, and yields no fossils. The clay varies in color from a light gray and almost white to lignitic. In Kentucky the Grenada furnishes very few fossil floras. The clay is more of a hackly nature on weathering, and is difficult to differentiate from the Holly Springs clay.

The Wilcox beds are fairly thick, but no one section of either exposes the entire individual series. Sections have been recorded by Loughridge, Glenn, and Berry, and a number of well records are available. The total thickness of the Wilcox in western Tennessee is probably less than 2,000 feet, and the thickness in Kentucky is less than this.

Section in LeCleade-Christy Clay Pit, ¼ mile south of Wickliffe, Viola, Graves County.

	Feet
Loam, medium gray when dry, porous, few rounded pebbles near the base	2-4
Plio-Pleistocene gravel and sand: gravels vary up to 2 inches in diameter and average around ½ inch, sand fills the pores and is a reddish brown, both sand and pebbles are iron stained, quartzite boulders up to 14 inches, mass little indurated	10-16
Unconformity	
Holly Springs formation:	
7. Gray, sandy clay, few leaf impressions	8
6. Sagger clay with abundant leaf impressions	6
5. Better grade of sagger clay, excellent leaves	4
4. Sandy clay with a six-inch ferruginous layer	1½
3. Ball clay, dark, lignitic, abundant leaves, carbonized leaves and stems	6
2. Wad clay with few leaves	5
1. Sand, gray to yellowish red, reached by auger.	

Section in Lecleade-Christy Clay Pit, ¼ mile south of Wickliffe, Ballard County.

	Feet
Loess, yellowish gray where weathered and medium gray where unweathered, numerous concretions, very few gastropods	20
Unconformity	
Holly Springs formation:	
6. Yellowish, sandy clay	3
5. Lignitic clay, dark to black, some lignite	½
4. Gray clay, abundant plants	6¾
3. Black to dark brown clay, few carbonized forms	2¾
2. Dark gray clay, numerous leaves, iron concretions	10½
1. Sand, gray color with layers of clay reach by auger.	

Section in Illinois Central Railway Cut, at Baltimore, Hickman County.

	Feet
Loam, light gray, gritty, very porous and full of cavities and root channels, close resemblance to loess, shows tendency to vertical weathering	2-8
Plio-Pleistocene gravel and sand; the gravel is contained in a sand matrix, upper gravel is gray and lower gravel reddish brown, the upper gravel smaller than lower; rounded and flattened, gravels orientated and bedded	3-20
Unconformity	
Grenada formation:	
c. Indurated layer of dark gray to blue clay resembling blue shale	1-10
b. Light gray sand, very quartzitic, rounded, cross-bedded, top surface very uneven when in contact with gravel	0-9
a. Clay, dark dove color when wet, finely laminated, lignitic, shows a few plant remains many of which are carbonized, a typical clay lens	0-15

List of fossil floras described by E. W. Berry[7] collected at Wickliffe, Ballard County.

Anacardites metopifolia Berry
Banisteria pseudolaurifolia Berry
Banisteria wilcoxiana Berry
Banksia saffordi Berry
Banksia tenuifolia Berry
Carapa eolignitica Berry
Cassia fayettensis Berry
Cassia glenni Berry
Cassia marshallensis Berry
Cupanites eolignitícus Berry
Cupanites loughridgii Berry
Dryophyllum moorii Berry
Dryophyllum puryearensis Berry
Dryophyllum tennesseensis Berry
Engelhardtia ettingshauseni Berry
Exostema pseudocaribaeum Berry
Ficus denveriana Berry
Ficus wilcoxensis Berry
Inga wickliffensis Berry
Juglans berryi Berry
Juglans schimperi Berry
Mespilodaphne pseudoglauca Berry
Mimosites variabilis Berry
Sapindus eolignitícus Berry
Sapindus formosus Berry
Sapindus linearifolius Berry
Sapindus mississippiensis Berry

As regards the age of the beds near Wckliffe from which these plants listed above were collected, Berry remarks as follows: "These species indicate a stratigraphic position at about the boundary between the Holly Springs sand or middle

[7]Berry, E. W., The Lower Eocene Floras of Southeastern North America: U. S. Geol. Survey, Prof. Paper 91, pp. 51-52, 1916.

Wilcox and the Grenada formation or upper Wilcox of the northern Mississippi section or slightly higher (younger)."

Somewhat prior to 1888, the date of the publication of the report by Loughridge, a collection was made at Wickliffe, Ballard County and another from Boaz Station, Graves County by Loughridge, and submitted to Lesquereux for determination. These forms are listed by Loughridge.[8] Lesquereux determined these forms and later they were arranged by Knowlton and published in Volume 11 of the Proceedings of the U. S. National Museum, only two forms being figured. These forms are as follows given according to Lesquereux and according to Berry: (See Prof. Paper, op cit., pp. 23-24).

Flora from Wickliffe, Ballard County

LESQUEREUX'S BERRY'S DETERMINATIONS

Myrica elaenoides Lesq.	Myrica elaenoides Lesq.
Myrica copeana Lesq.	Cupanites loughridgii Berry
Ficus multinervis Herr	Ficus myrtifolius Berry
Sapindus falcifolius Herr	Ficus wilcoxensis Berry
Sapindus dubius Herr	Mixed forms: Engelhardtia ettingshauseni Exostema pseudocaribaeum Banisteria wilcoxiana Ficus wilcoxiana, and Carapa eolignitica
Sapindus angustifolius Lesq.	Sapindus mississippiensis Berry
Laurus californica? Lesq.	Mespilodaphne pseudoglauca Berry
Quercus saffordi Lesq.	Banksia saffordi Berry
Juglans rugosa Lesq.	Juglands schimperi Lesq.
Salix angusta Herr	Sapindus linearifolius Berry
Salix media Al Braun	Not recognized
Ailanthus leaf fragment	Not afterward referred to and lost

FROM BOAZ, GRAVES COUNTY

Sapindus falcifolius Herr	Ficus wilcoxensis Berry
Quercus nervifolia Al Braun	Banksia saffordi Berry
Quercus cuspidata Ung.	Dryophyllum tennesseensis Berry
Laurus californica Lesq.	Mespilodaphne pseudoglauca Berry
Ficus multinervis Herr	Ficus myrtifolius Berry

During July 1925, the writer and R. L. Collins made a collection of Holly Springs plants from the clay pit of the Bell City Pottery Company, at Bell City, southeastern Graves County; these plants have been determined by Professor E. W. Berry of the Johns Hopkins University, and very kindly furnished by him for this report.

[8]Loughridge, R. H., op. cit., App. II, p. 198.

List of Holly Springs plants from the pit of the Bell City Pottery, Graves County

Anacardites metopifolia Berry
Anacardites puryearensis Berry
Anoma robertsi Berry
Apocynophyllum sapinifolium Hollick
Aralia (?) semina Berry
Banksia tenuifolia Berry
Bombacites eocenicus Berry
Carpolithus kentuckyensis Berry
Cassia puryearensis Berry
Dryophyllum tenneseensis Berry
Glyptostrobus europaeus (Brongn.) Herr
Juglans schimperi Lesq.
Nyssa wilcoxiana Berry
Oreodaphne obtusifolia Berry
Oreodaphne pseudoguianensis Berry
Parrotia cuneata (Newb.) Berry
Rubiacites sphericus Berry
Sabalites grayanus Lesq.
Sterculia knowltoni Berry
Taxites sp.
Terminalia vera Berry
Ternstroemites ovatus Berry

JACKSON DEPOSITS

The name, Jackson, was proposed for beds of upper Eocene age occurring near Jackson, Mississippi, and was first used by Hilgard in 1860.[9] The Jackson deposits or uppermost Eocene occur along the bluffs of the Mississippi River. These beds are of lower Jackson age as indicated by their floral content. In Mississippi the Jackson consists of two members namely, the Moody marl or basal member, and the Yazoo clay, and here the Jackson beds are conformable on the Claiborne and at their top with beds of Oligocene age. In Tennessee the Jackson deposits lie unconformably upon the Grenada, and presumably this holds true for Kentucky, though no actual contact was seen..

The age of the Jackson deposits was not recognized by the earlier geologists as has been pointed out. The first work of any note to be done was a result of the visit to the Columbus locality, Hickman County by Lesquereux in company with Sir Charles Lyell and D. D. Owen. After making a study of the collection of fossil floras found near Columbus, Lesquereux

[9]Hilgard, E. W., Report on the Geology and Agriculture of Mississippi: Mississippi State Geol. Survey, Report, pp. 107, 128-138, 1860.

assigned them to the Pleistocene.[10] Later the deposits from which these plants were collected were given the name, Hickman group by Loughridge[11] and were regarded by him as the oldest of the Eocene sub-divisions.

In 1903 L. C. Glenn collected plants near Columbus, Hickman, and Wickliffe, and sent them to Knowlton for determination, and the latter assigned them to the Pliocene.[12] It remained for E. W. Berry to describe the plants from these beds in 1924 from collections made from a number of localities. These plants are described and figured in a recent publication.[13]

The beds of Jackson age have not been found to outcrop anywhere in Kentucky except in a broken manner along the Chickasaw Bluffs. The southernmost exposure begins about one mile south of the town of Hickman, Fulton County, extends through the town and about one-half mile north; the other exposure extends along the bluffs in Hickman County. To the east of the bluffs the Jackson does not appear exposed and it is covered by the Plio-Pleistocene deposits.

The sediments consist of sand, clays, and beds of considerable thickness of indurated clay; some lignite occurs in places, more so in Tennessee than in Kentucky. The sand is distinctly finer in texture than the sands of the Holly Springs and Grenada, and has a greenish color. It contains a great deal of clay and angular fragments of lignite. Lamination and cross bedding are very common. The clay is usually light gray, light brown to black, grading into lignite. The lignite is thin and quite impure. In Tennessee thick exposures of Jackson are found at Mayberry Leap, Richardson's Landing, Randolph, and Fulton, also north of Reelfoot Lake and at Lenox, and sections have been measured which attain as much as 120 feet. South of Hickman, Fulton County, the Jackson beds are between fifty and sixty feet in thickness and have about the same general sequence as in northwestern Tennessee.

[10]Lesquereux, L., On some fossil plants of Recent formations: Am. Jour. Sci., Ser. 2, Vol. 27, pp. 364-365, 1859.

[11]Loughridge, R. H., op. cit., pp. 37-41.

[12]Glenn, L. C., op. cit., pp. 38-39. 1906.

[13]Berry, E. W., The Middle and Upper Eocene Floras of southeastern North America: U. S. Geol. Survey Prof. Paper, 92, 1924.

Section on the Chickasaw Bluff, 1 mile south of Hickman, Fulton County

	Feet
Soil weathered from the underlying loess	3-4
Loess, yellow towards the top, gray at the base, shows vertical weathering and jointing, abundant and large gastropods, and concretions	35
Plio-Pleistocene gravel and sand: gravel contained in a sand matrix, and grades upward into the loess, gravels contain Paleozoic corals, bryozoa, brachiopods, crinoid stems, gastropods; well rounded and flattened, coated with iron stain	20
Unconformity	
Jackson formation:	
3. Shaly clay of light gray color, little indurated, fragments of leaves and stems	14
2. Highly indurated clay, gray, massive, exposed	10
1. Concealed by talus extending down to the Mississippi river floodplain	30

Section on the Mississippi river, 2½ miles south of Columbus, Hickman County.

	Feet
Soil and Loess mostly covered with vegetation, the loess shows a gray color	20
Plio-Pleistocene gravel and sand; gravels rounded also flattened, coated with iron stain, with an average diameter of ½ inch, contained in a sand matrix; quartzite boulders as large as 14 inches in length	5-8
Unconformity	
Jackson formation:	
2. Jackson clay, light to medium gray mostly covered with talus material	18-28
1. Sand, fine texture, gray color, cross bedded, ripple marked, contains lenses of fossil clay which show fossil floras, exposed	16-20
Concealed by slumped sand and clay	10

List of fossil plants collected from near Columbus, Hickman County by Owen and Lesquereux, and determined by Lesquereux. [14]

Quercus vireus Michx.
Castanea nana, Muhl.
Ulmus alata Michx.
Ulmus minuta? Gopp.
Planera gmelini, Michx. (P. Hickmanensis, Berry)
Prinos integrifolia Ell.
Caenothus americanus Lesq.
Carya olivaeformis Mitt. (Hicoria jacksoniana, Berry)
Gleditschia trecanthos Lesq.
Acorus calamus Lesq.
Alnus or Betula catkins

[14]Lesquereux, L., On some fossil plants from the Recent formation: Am. Jour. Sci., Ser. 2, vol. 27, pp. 359-366, 1859.

List of Jackson floras from near Columbus.
(E. W. Berry, U. S. Geol. Survey Prof. Paper 92, pp. 107-110, 1924.)

Hicoria jacksonia Berry
Menispermites carolinaformis Berry
Tecoma preradicans Berry

List of Jackson plants from Hickman.
(E. W. Berry, U. S. Geol. Survey Prof. Paper 92, pp. 107-110, 1924.)

Palmocarpon sp.
Palm rays
Hicoria jacksonia Berry
Hicoria rostrataformis Berry
Planera hickmanensis Berry
Menispermites carolinaformis Berry
Capparidocarpus sphericus Berry
Bauhania wadii Berry
Papilionites erythrinaformis Berry
Lonchocarpus anceps Berry
Liquidamber sp.
Fagura catahoulensis coriacea Berry
Fagara catahoulensis major Berry
Rhamnites krugiodendroides Berry
Grewiopsis wadii Berry
Tecoma preradicans Berry
Carpolithus bumeliaformis Berry

List of Jackson plants ½ mile north of Hickman.
(E. W. Berry, U. S. Geol. Survey Prof. Paper 92, pp. 107-110, 1924.)

Taxodium dubium (Sternb.) Herr?
Hicoria rostrataformis Berry
Planeria hickmanensis Berry
Banksia jacksonensis Berry
Liquidamber sp.
Fagara catahoulensis coriacea Berry
Fagara catahoulensis elongata Berry
Burserites fayettensis Berry
Grewiopsis wadi Berry

List of Jackson plants from 5 miles south of Hickman.
(E. W. Berry, U. S. Geol. Survey Prof. Paper 92, pp. 107-110, 1924.

Fagara catahoulensis elongata Berry
Planeria hickmanensis Berry
Hicoria jacksoniana Berry
Paliurus catahoulensis Berry

The Jackson plants have been collected and described from 40 localities, from Georgia as far north as Kentucky, and west to the Rio Grande. These plants comprise 133 species of which 18 species have been found in Kentucky. These plants probably represent coastal plain forms, living around small ponds and bays of Jackson seas according to Berry.

No fossil faunas have been described from western Kentucky. The wing of a termite was found in the sandy clay,

2½ miles south of Columbus, Hickman County in July 1929. The Moody marl member of the Jackson in Mississippi contains well preserved fossils, and the Yazoo furnishes Zeuglodon remains. Something like 214 species of marine invertebrates have been found in the Jackson of Mississippi.

QUATERNARY SYSTEM

The Quaternary system is made up in part by the gravel and sand of Plio-Pleistocene age, the loess, and the alluvium. The writer regards the Columbia loam not as a separate formation but a weathered phase of the loess and more especially as an eastward extension of the loess, as it becomes coarser from the Mississippi river to the east and from the Ohio river to the south. A table of the Quaternary formations is as follows:

Quaternary Formations

	FORMATION	TYPE OF SEDIMENTS	COUNTIES WHERE EXPOSED
Quaternary	Recent	Alluvium: sand, gravel, muds, clays	Found along streams of all eight counties
	Loess & Loam	Fine material with concretions and gravel	Found in all the counties, best developed towards central region
Tertiary (in part)	"Lafayette"	Gravel, sand, and indurated gravel and sand	All counties

PLIO-PLEISTOCENE (LAFAYETTE) DEPOSITS

The so-called Lafayette, which covers most of the Jackson Purchase region, constitutes by far the greatest unit of the areal geology. The name, Lafayette, was proposed in 1891 by McGee.[15] McGee in his discussion in reference cited under the footnote remarks as follows: "The Lafayette formation, as now defined, was fiirst discriminated in northern Mississippi in 1855 and 1856 by Dr. E. W. Hilgard, and was named by him after Lafayette County, in which it is typically developed."

[15]McGee, W. J., The Lafayette formation: U. S. Geol. Survey, 12th Ann. Rept., Part I, p. 497, 1891.

So, it appears that McGee revived the term, and placed it before the public to the extent that it was accepted.

These deposits consist of gravel and sand, reworked from the Tertiary, Cretaceous, and Paleozoic, in other words, from whatever material available at the time of the formation of the deposits. Since these deposits are found over the youngest of the Eocene beds, the Jackson, and immediately under the loess, which is regarded as Pleistocene, the writer is inclined to interpret their age as suggested in 1925 by E. W. Berry, namely that they are of Plio-Pleistocene age.

The gravels are well rounded and many are flattened. Most of them are coated with reddish brown iron oxides, but in western Graves County and the eastern portions of Hickman, and Carlisle Counties the gravels are a light gray to almost white. Their general average size is approximately one-half an inch, thus differing in size with the Tuscaloosa gravel as well as in the degree of rounding. The gravel is composed chiefly of chert with a few of quartzite. They are contained in a matrix of sand, which varies from coarse to medium and even fine, and usually colored to about the same tone as the gravels. The gravels when broken show typical Paleozoic fossils, such as crinoid stems, brachiopods, bryozoa, pelecypods, gastropods, echinoid spines, etc. One of the interesting features is the occurrence in the gravel of large quartzite boulders, some of which measure 52 inches in their major diameter, and are about 16 inches thick. These are found in the gravels as far south as 2½ miles north of Murray, Calloway County.

The gravels are often consolidated into a conglomerate, the cementing agent being iron oxides. The sand is composed of quartz, and broken masses of chert, and a few black, heavy minerals. Often the sand does not occur mixed with the gravel, but may overlie or underlie it. Cross bedding is quite common, and bedding and orientation are frequent.

These deposits can be found resting on every older member in the Jackson Purchase region, including the St. Louis chert and limestone. In fact, these deposits have been found by the writer far to the east in Crittenden County, and south of

Owensboro. There are no means or correlation except by lithology and stratigraphic position. Gravel and sand on the Atlantic Coastal Plain have been termed Lafayette by McGee, Fontaine, Ward, and others, but correlation with these deposits in the embayment area in the absence of fossils is impossible. It is not necessary to tabulate any sections of these gravels and sands, for their characters are much the same over the entire area, and any of the sections given above except the one in the clay pit at Wickliffe, Ballard County, will show gravels.

LOESS AND LOAM

The loess occurs over most of western Kentucky when the loam is considered to be a weathered and an eastern extension of the loess. Whenever the so-called loam is found on the Mississippi River bluffs it shows as nothing more than an upward gradation of the loess, being slightly more porous, full of cavities of fairly large size, root channels, and having more yellow tones. The loam thins to the east, and often is not more than one to two feet thick. The loess along the bluffs reaches as much as 40 feet in thickness, and is well exposed along the river edge wherever the river is undercutting the bluffs, otherwise on the abandoned bluffs.

The loess is usually a grayish color to a brown, but upon weathering it assumes a yellowish brown. Along the bluffs it shows the vertical jointing feature very well. It is thickest south of Hickman and in the vicinity of Columbus. Much of the soil of the four counties bordering on the Mississippi river and McCracken County on the Ohio River is of loess origin, and it forms a very fine soil. It is very easy to know when one is on loess roads either in dry weather or in rain on account of the immense amounts of dust or mud respectively.

The loam is found far to the east in the three counties of Graves, Calloway, and Marshall, and it is found lying upon the chert and limestone of Mississippian age. It may be Recent in part, but everywhere it is found lying upon the Plio-Pleistocene gravel and sand. It never contains any fossils so far observed, and its only resemblance to the loess is its lithology and stratigraphic position.

The loess contains great numbers of gastropods in some localities, but the variety is small. The writer has collected loess fossils from western Tennessee, and from the deposits along Crowley's Ridge near Madison and Forrest City, Arkansas, and the Kentucky forms show a less variety than any of the others. The Arkansas localities show two pelecypods, but the Kentucky forms are all gastropods. The forms reach as much as one inch in diameter, some with a deep, others with a shallow umbilcus. The fossils are limited to the deposits near the river, and do not occur more than three miles east of the river.

RECENT ALLUVIUM

The alluvium occurs along all the permanent and many of the intermittent streams, and is very extensive along the Tennessee, Ohio, and Mississippi Rivers. It consists of clays, muds, silts, sands, and gravels. A considerable amount of the area of the Jackson Purchase region is covered with alluvium due to the fact that the region is so flat, and has such a net work of streams, the majority of which are active much of the year.

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Explanation of Plate LXIX

Wilcox Floras

1. *Juglans schimperi* Berry. Wickliffe, Kentucky. U. S. Geol. Surv., Prof. Paper 91, Pl. XIX, fig. 4.
2. *Myrica elaeanoides* Lesquereux. Boaz, Kentucky. U. S. Geol. Surv., Prof. Paper 91, Pl. XVIII, fig. 2.
3. *Dryophyllum tennesseensis* Berry. Puryear, Tennessee. U. S. Geol. Surv., Prof. Paper 91, Pl. XXI, fig. 4.
4. *Mespilodaphne puryearensis* Berry. Puryear, Tennessee. U. S. Geol. Surv., Prof. Paper 91, Pl. LXXXVII, fig. 1.
5. *Sapindus formosus* Berry. Wickliffe, Kentucky. U. S. Geol. Surv., Prof. Paper 91, Pl. LXVI, fig. 3.
6. *Carapa eolignitica* Berry. Wickliffe, Kentucky. U. S. Geol. Surv., Prof. Paper 91, Pl. LX, fig. 4.

PLATE LXIX

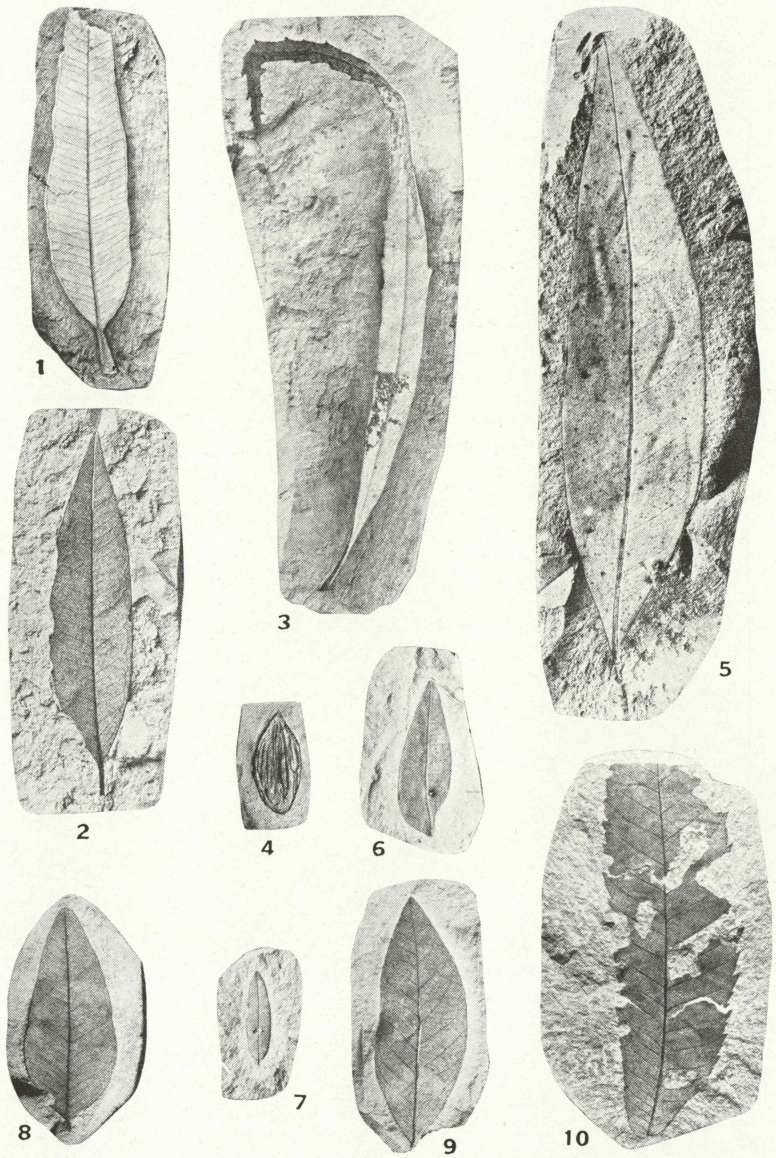


Plant Fossils of the Wilcox—Eocene

Explanation of Plate LXX

Wilcox Floras

1. *Ficus mytifolius* Berry. Holly Springs, Mississippi. U. S. Geol. Surv., Prof. Paper 91, Pl. XXX, fig. 1.
2. *Ficus wilcoxensis* Berry. Puryear, Tennessee. U. S. Geol. Surv., Prof. Paper 91. Pl. XXVII, fig. 6.
3. *Banksia saffordi* (Lesquereux) Berry. 1½ miles west of Grand Junction, Tennessee. U. S. Geol. Surv., Prof. Paper 91, Pl. XXXVI, fig. 5
4. *Nyssa wilcoxiana* Berry. Puryear, Tennessee. U. S. Geol. Surv., Prof. Paper 91, Pl. XCIX, fig. 7.
5. *Sapindus mississippiensis* Berry. Wickliffe, Kentucky. U. S. Geol Surv., Prof. Paper 91, Pl. LXIV, fig 10.
6. *Inga wickliffensis Berry.* Wickliffe, Kentucky. U. S. Geol. Surv., Prof. Paper 91, Pl. L, fig 8.
7. *Mimosites variabilis* Berry. Wickliffe, Kentuckv. U. S. Geol. Surv., Prof. Paper 91, Pl. XLV, fig. 10.
8. *Anacardites metopifolia* Berry. Puryear, Tennessee. U. S. Geol. Surv., Prof. Paper 91, Pl. LVIII, fig. 7.
9. *Engelhardtia ettingshauseni* Berry. Holly Springs, Miss. U. S. Geol. Surv., Prof. Paper 91, Pl. XIX, fig. 3.
10. *Cupanites loughridgii* Berry. Wickliffe, Kentucky. U. S. Geol. Surv., Prof. Paper 91, Pl. LXV, fig. 4.



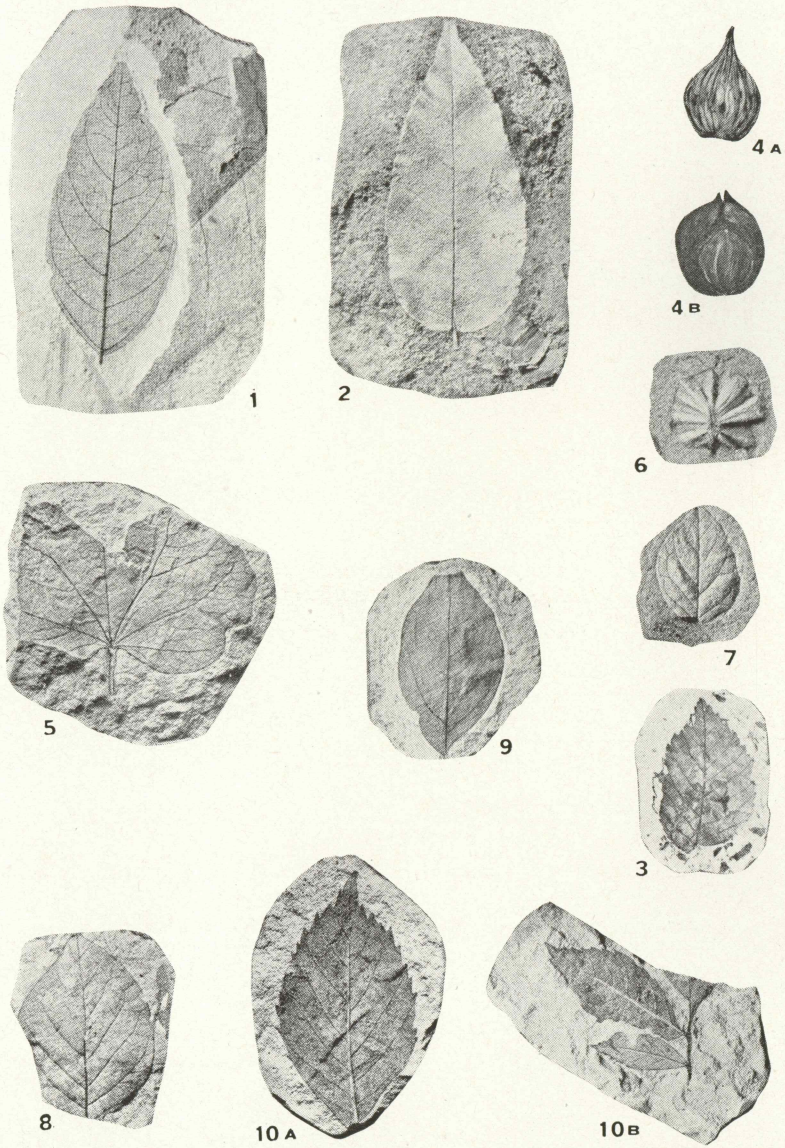
Plant Fossils of the Wilcox—Eocene

Explanation of Plate LXXI

Floras of Jackson Age

1. *Papilionites erythrinaformis* Berry. Fayette sandstone, Miraflores Webb County, Texas. U. S. Geol. Surv., Prof. Paper 92, Pl XXXIII, fig. 9.
2. *Burserites fayettensis* Berry. Catahoula (?) sandstone, Stryker, Texas. U. S. Geol. Surv., Prof. Paper 92, Pl. XLI, fig. 8.
3. *Planaria hickmanensis* Berry Upper Jackson (?) age. 5 miles south of Hickman, Kentucky. U. S. Geol. Surv., Prof. Paper 92, Pl. L, fig. 4.
4. *Hicoria rostrataformis* Berry (a)—husk. (b)—part of the husk with nut inside Upper Jackson (?) age. Upper bluff, Hickman, Kentucky. U. S. Geol. Surv., Prof. Paper 92, Pl. L, figs. 6 and 9.
5. *Menispermites carolinaformis* Berry. Upper Jackson (?) age. Hickman, Kentucky. U. S. Geol. Surv., Prof. Paper 92, Pl. LI, fig. 1.
6. *Liquidamber incerta* Berry. Upper bluff, Hickman, Kentucky. U. S. Geol. Surv., Prof. Paper 92, Pl. LI, fig. 8.
7. *Fagara catahoulensis coriacea* Berry. Upper Jackson (?) age, north of Hickman, Kentucky. U. S. Geol. Surv., Prof. Paper 92, Pl. LI fig. 10.
8. *Fagara catahoulensis major* Berry. Upper (?) Jackson age. North of Hickman, Kentucky. U. S. Geol. Surv., Prof. Paper 92, Pl. LI, fig. 11.
9. *Rhamnites krugiodendroides* Berry. Upper Jackson (?) age. Hickman, Kentucky. U. S. Geol. Surv., Prof. Paper 92, Pl. LII, fig. 2.
10. *Tecoma preradicans* Berry. Upper Jackson (?) age. (a) Single leaf; (b) Compound leaves. Hickman, Kentucky. U. S. Geol. Surv., Prof. Paper 92, Pl. LIV, figs. 1 and 2.

PLATE LXXI



Plant Fossils of the Wilcox—Eocene

X

PLEISTOCENE FAUNA

By

C. L. Cooper

THE
PLEISTOCENE FAUNA OF KENTUCKY

By
C. L. Cooper

INTRODUCTION

The Pleistocene is known as the great period of glaciation in North America. In fact there are five recognized advances with their corresponding retreats of the ice. This great ice sheet radiated from three centers or areas, from which each divisional sheet receives its name. The Labradorean is named from the area east of Hudson Bay. Ice from this sheet radiated to cover the eastern part of the United States and undoubtedly entered Kentucky. The Keewatin sheet eminating from the area just northwest of Hudson Bay covered central United States; and the Cordilleran sheet, located in the western part of the Dominion of Canada, failed to spread out nearly as much as the other two. The five glacial stages, beginning with the oldest are as follows: the Nebraskan, Kansan, Illinoian, Iowan, and Wisconsin. The intervening interval or period which existed between the retreat of one ice sheet and the advance of the next, were of unequal duration. It was during these interglacial epochs that the deposits containing the Pleistocene fossils accumulated. However, most of these deposits in Kentucky are not strictly glacial deposits, but are fluvio-glacial beds formed by the streams flowing from the edges of the melting ice. The first of these interglacial intervals, known as the Aftonian, occurred between the Nebraskan and Kansan invasions. The others in order were the Yarmouth, the Sangamon, and the Peorian. The last is thought to have occupied an interval about equal to the time that has elapsed since the retreat of the last ice sheet, the Wisconsin. The first three intervals probably were of much longer duration.

It is certain that the Illinoian sheet entered Kentucky in a small area in the northern part of the State in the counties bordering the Ohio River from Bracken to Jefferson. (see fig. 36). However, recent finds of pebbles and boulders from Canada and the St. Lawrence Valley brought in by an ice-sheet,

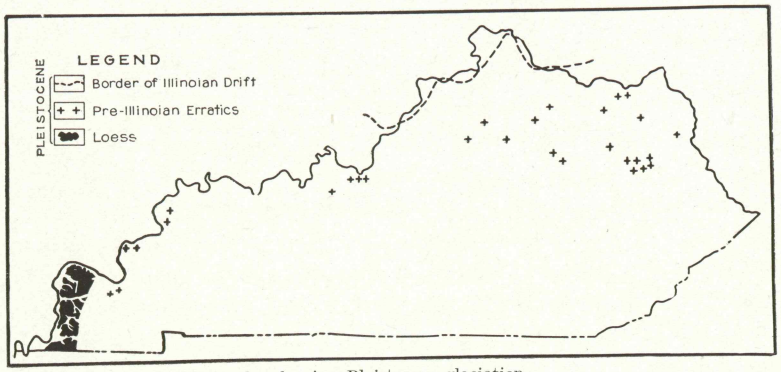


Fig. 33. Map of Kentucky showing Pleistocene glaciation.

floating ice, or an ice-dammed lake may have been deposited as debris from the Nebraskan sheet.[1]

During the time when the ice was most widespread the environments were very unfavorable for the development of life, in fact practically all life retreated before the advance of the ice-sheet, so that the sum total of life on the Continent was greatly reduced during those times. Such rigorous periods caused the complete extinction of certain species of plants and animals, and others developed very rapidly in order to maintain an existence in their rapidly changing habitat. Deposits of the Sangamon stage which immediately followed the retreat of the Illinoian sheet are known from Iowa to New York and as far north as Toronto.[2] The climate varied from cool to warm, being moist for the most part, resulting in a fauna that was most extensive and varied of the interglacial stages. The species of plants and animals in existence at that time are shown in the table following:

Fauna of the Sangamon Interglacial Stage[3]

	Living	Extinct	Total
Plants	65	3	68
Mollusks	132	1	133
Crustacea	2	0	2
Insects	2	83	85
Vertebrates	6	20	26
Total	207	107	314

[1]Jillson, W. R., Glaciation in Eastern Kentucky: Ky. Geol. Surv., Ser. VI., Vol. 30, p. 134. 1927.
[2]Chamberlain, T. C. and Salisbury, R. D., College Geology, Pt. II, Revised p. 834. 1930.
[3]Chamberlain, T. C., and Salisbury, R. D., op. cit., p. 835.

The most interesting and abundant fossil record from the Pleistocene is found among the vertebrates. Of the few now living species that were then in existence, practically all are to be found in the bone deposits of Kentucky, as are most of the 20 species of animals now extinct. The discovery of the remains of a polar bear in the Breck Smith Cave in the Bluegrass, shows that animals, now native to cold or arctic climates, migrated south with the advance of the ice. Great numbers of herbivorous animals grazed on the grasses and other plants which sprang up after the disappearance of the ice. This abundance of prey attracted many flesh-eating animals, all of which left a record in the form of their teeth, bones, and horns buried in swampy places near springs and salt licks. Our very abundant record of these various kinds of animals is found at such places, known today as Big Bone Lick Springs and other similar localities. The Indians first discovered the "big bones" which were to be found at these places, and in 1739 and 1751 explorers noted the bone deposits in their reports; one collected a mastodon's tooth from Big Bone Lick.

Invertebrate Fossils[4]

The collection of fossils listed below were collected at several localities and have been identified by Dr. F. C. Baker.

[4]The list of the invertebrates is taken from a manuscript on the geology of Henderson County, by C. V. Theis.

List of Pleistocene Fossils from Henderson County

SPECIES	LOCALITY														
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Polygyra multilineata wanlessi	x	x	x				x								
P. hirsuta yarmouthensis Baker	x	x				x				x			?		
P. monodon (Rackett)	x											x	x	x	x
P. monodon cf. peoriensis Baker		x													
P. fraterna (Say)									x				x		
P. sp.											x				
Hendersonia occulta (Say)	x	x			x	x	x		x		x				
Vallonia gracilicosta Reinh.	x		x				x	x							
Gonyodiscus anthoni (Pilsbry)		x	x				x	x	x						
Retinella hammonis (Strom)		x				x			x						
Columnella alticola (Ingersoll)		x	x												
Vertigo modesta (Say)		x	x				x								
V. ventricosa (Morse)		x													
V. loessensis Baker			x				x								
Strobilops virgo (Pilsbry)		x													
Euconulus fulvus (Muller)		x							x		x				
Succinea grosvenori gelida Baker		x	x				x	x				x			
S. ovalis pleistocenica Baker			x	x	x		x			x					
S. retusa fultonensis Baker														x	
S. cf. ovalis											x				
Gastrocopta armifera similis Sterki			x												
G. armifera												x			
Punctum pygaeum (Drap.)			x												
Carychium exile canadensis Clapp			x												
Helicodiscus paralellus (Say)						x									
Anguispira alternata (Say)									x						
Pomatiopsis lapidaria (Say)											x				
P. scalaris (Baker)												x			
Circinnaria concava (Say)									x				x		
Stagnicola caperata (Say)													x	x	x
S. umbrosa (Say)														x	
S. sp.															x
Cincinnatia cincinnatiensis (Anthony)											x				
C. emarginata (Kuster)											x				
Amnicola limosa (Say)											x				
Valvata tricarinata (Say)											x				
Fossaria parva (Lea)														x	
Helisoma trivolvis (Say)														x	
Gyraulus altissimus Baker														x	
Physella gyrina hildrethiana (Lea)														x	
Planorbula n. sp.														x	
Pisidium sp.											x		x	x	
Sphaerium sp.											x				

DESCRIPTION OF LOCALITIES

A-G: About 2 miles northwest of Smith Mills. The hill, in which the road cut exposure shows nothing but loess, excepting as noted below, rises from an elevation of 375 feet A. T. to 440 feet A. T. The lower elevation is the elevation of the probably late Wisconsin terrace, but the loess is probably older than this terrace. At an elevation of 400 feet A. T., a clay band, 2 to 8 inches thick, runs horizontally for the length of the exposure, about 100 feet. No difference in character between the loess above and that below this band was noted. The collections were taken from the following elevations:

A, 380 feet; *B*, 395 feet; *C*, 400 feet (fossils from perhaps both above and below the clay band); *D*, 410 feet; *E*, 415 feet; *F*, from 1 foot below the clay band; G, from 1 foot above the clay band.

H: From a mound about ½ mile below Dam 48. The loess occurs in a curving band about 4 feet thick, underlain and overlain by fine sand. The mound apparently represents a dune upon the early Wisconsin terrace.

I: From the base of a loess deposit about 20 feet thick capping a Tertiary gravel deposit about 2 miles north of Spottsville.

J: In river bluff about three miles below Mt. Vernon, on the Indiana side of the river. The material was taken from an 8-foot loess-like band of silt at an elevation of 385 feet, undelying horizontally bedded sand in a hillock rising to about 405 feet A. T. The fossils indicate that it is a true loess.

K: From the material underlying the Early Wisconsin terrace about 5 miles below Henderson. This material ranges here from a heavy, dark blue clay to a coarse sand with pebbles of crystalline rock.

L: From the Early Wisconsin fill in Sellers Ditch 2 miles south of Henderson. The material associated with the fossils is a heavy, dark blue clay.

M: On the Ohio River bank, about 3 miles below Mt. Vernon. The material appears in the field to be a typical loess but lies below the level of the Early Wisconsin terrace.

N: From the bank of a small drain, where crossed by the Uniontown road about 2 miles southwest of Mt. Vernon, in NE. ¼ SW. ¼ sec. 13, T. 7 S., R. 14 W., Uniontown quadrangle. The material underlies what appears to be the early Wisconsin terrace although not typically developed here. Dr. Baker is inclined to consider the fauna as of Sangamon or Peorian age.

O: From a loess-like material about two miles below Mt. Vernon. The collection was made from about 10 feet below the level of what is probably the Early Wisconsin terrace.

Occurrence of Vertebrate Fossils in Kentucky[5]

Of historical interest is the fact that President Thomas Jefferson first discovered and named *Megalonyx jeffersoni*, a ground sloth very abundant and of wide distribution during the Ice Age. The remains of this animal have been found at Big Bone Lick and near Henderson. *Mylodon harlani*, a smaller sloth, has been found at Big Bone Lick and at Blue Lick. A beaver as large as a black bear, *Castoroides ohioensis*, is known to have inhabited Kentucky streams, as its teeth and bones have been found in the eastern part of the State. Two odd-toed ungulates, the Perissodactyla, are represented by the remains of an ancient tapir and a prehistoric horse. The tapir, *Tapirus sinensis*, has been found at McConnell's Run in Scott County and at Yarnellton Station in Fayette County. These animals are now found in more southern latitudes, and differ little from their Pleistocene ancestors. The horse, *Equus complicatus*, found at Big Bone Lick, was very abundant during this time.

The even-toed ungulates, the Artiodactyla, are represented by a large variety of species from the fossil beds of Kentucky. The peccaries, or American swine have been found at Big Bone Lick and on Crooked Creek in Rockcastle County. *Platygonus*

[5]Webb, W. S. and Funkhouser, W. D., Ancient Life in Kentucky, Ky. Geol. Surv., Ser. VI., Vol. 34, pp. 40-46, 1928.

compressus, the species representing this class of vertebrates, is now extinct. The common Virginia deer (genus *Odocoilcus*) was living at that time, as shown by abundant Kentucky records. The "elk," or more properly the wapiti, *Cervus canadensis*, related to the great stag of Europe, is present as fossils at Big Bone Lick and in Wayne County. The caribou, *Rangifer tarandus*, another animal from the Old World, was present in Kentucky during this period. The Indians probably used the fossil caribou horns for ceremonial purposes, as horns that appear to be the same are found in many old Indian graves. The fossils are found at Big Bone Lick. Pleistocene moose have also been found in Kentucky, and are probably the same as the living species, *Alces americanus*. *Cervalces scotti* a very unusual "stag-moose," is quite different from any living species of stag or moose. This form is also found at Big Bone Lick, as is the musk-ox, *Bootherium bombifrons*. This ox, now found only in the far north, apparently had wide distribution in the Pleistocene. The bison came to America from Europe, and two Pleistocene species are found at Big Bone Lick, *Bison antiquus* and *B. latifrons*. The latter was very much larger than the living species, *B. bison*, had horns with a spread of 6 to 8 feet, and is thought to be the parent form of this genus. The presence of fossils of animals now living together with those of the extinct forms at Big Bone Lick shows that this locality was used by salt-eating animals for hundreds of centuries. Only one form of the carnivorous animals is found in the State, in contrast to the great number of herbivorous genera and species. This is a bear, *Ursus americanus*, although a fox (*Urocycon scotti*) now found only in warmer climates, may have lived in Kentucky during the Pleistocene. This form was found in Breck Smith Cave near Lexington.

The most interesting group of Pleistocene animals inhabiting Kentucky are the ancient elephants, which came to America over the old land bridge between Siberia and Alaska. The best known form *Elephas primigenius* roamed throughout the northern hemisphere. It was adapted to cold climates, being protected by a heavy coat of long wooly hair. Big Bone Lick and Blue Lick Spring have yielded perfect skeletons of this form. *Elephas columbi*, a huge beast standing 11 feet high at the shoulders, has been found at Big Bone Lick. The American mastodon, *Mammut americanum*, is one of the earliest of the ancient elephants, even antedating the early mammoths. In spite of this early ancestry, this form continued long enough to become contemporary with man in North America. Bones of this form have been found in abundance in Kentucky at Big Bone Lick, Blue Lick, in the Green River Valley and well within the Eastern coalfield.[6]

DESCRIPTION OF PLEISTOCENE VERTEBRATES FOUND IN KENTUCKY

ORDER CARNIVORA

FAMILY CANIDAE

UROCYCON CINEREOURGENTEUS SCOTTI

A skull of Scott's gray fox has been found in the Breck Smith cave, about 8 miles west of Lexington. Dr. Hays reports[7] the find indicates that the climate of central Kentucky was much warmer than it is now.

FAMILY URSIDAE

URSUS AMERICANUS

Plate LXXVI, fig. 2.

The only carnivore found in the bone deposits of Kentucky is the black bear, *Ursus americanus*. This is the same species of bear now living and which is all but exclusively northern in distribution. The family is very distinct, and although they live principally upon vegetable food, they have the dentition of the carnivorous animals. The Pleistocene representatives in America include the true bears (*Ursus*) and a large short-faced bear *Arctotherium bonoerense*.

FAMILY CASTOROIDIDAE

CASTOROIDES OHIOENSIS

Plate LXXIV, fig. 3.

This giant beaver attained the size of the black bear, and lived in the late Pleistocene. It came to North America, either from the Old World or South America, and became widely distributed in the eastern and middle states.

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[6]Jillson, W. R., Pleistocene Proboscideans Within the Cumberland Plateau in Kentucky: Bull. Geol. S. Am., vol. 40, No. 1, p. 253, 1929.

[7]Hays, —, —., Proc. Biol. Soc. Wash., March 20, 1922.

Order EDENTATA

Family MEGALONYCHIDAE

MEGALONYX JEFFERSONI

Plate LXXII, fig. 3.

The ground sloth is common to Pleistocene deposits in North America. The skull resembles that of the tree sloths in that it is short and broad. The lower jaw is short and massive and the chin vertical. The fore limb is shorter and slenderer than the hind, but of nearly the same length. The feet were connected to the limbs so that the animal must have walked on the outside of the foot in much the same manner as the living ant-bear. The very large club-shaped heel-bone formed the back portion of the outer edge of the foot. The teeth are 54 in number, the foremost separated from the others and more or less tusk-like in form. The grinding teeth are without ridges and worn smooth, showing that the animal fed principally on leaves.

Zittel[6] sums up the manner of life of this form as follows: "The hip-bones, hind legs, and tail are characterized by enormous strength. The entire structure of the extremities proves that the gigantic sloth could move over the ground but slowly and clumsily; on the other hand, the fore limbs served as grasping organs and were presumably employed to bend down and break off twigs and branches and even to uproot whole trees, while the weight of the body was supported upon the hind legs and tail."

MYLODON HARLANI

Plate LXXII, fig. 2.

This form is essentially similar to *Megalonyx*, in fact there is no wide range of variation among the three families of ground-sloths which lived at this time. The main differences are found in size, form and number of teeth, the shape of the skull, and the number of digits.

[6]Zittel, Karl, Handbuch der Paleontologie, Bd. IV, p. 132, 1893.

Order ARTIODACTYLA

Family DICOTYLIDAE

PLATYGONUS LEPTORHINUS

Plate LXXVIII, fig. 2.

The predominating peccary of the Pleistocene in North America was the genus *Platygonus*, which was thought to have been more advanced than the existing forms. It failed to survive, however, in spite of the fact that it was better fitted to continue. It was much a larger animal, with longer and heavier legs. The genus first appeared in middle Pliocene.

Family CERVIDAE

CERVUS CANADENSIS

Plate LXXIV, fig. 2.

The Roosevelt elk or wapiti is common to the northern part of North America and is plainly of Old World origin.

RANGIFER (CARIBOU) TARANDUS

Plate LXXV, fig. 2.

This form, the caribou, is also a northern form of Old World origin, and is still existant in North America.

ALCES AMERICANUS

Plate LXXVII, fig. 1.

The moose, *Alces americanus*, is essentially no different from the Old World species, and with the caribou and wapiti, are thought to have originated there.

CERVALCES SCOTTI

Plate LXXV, fig. 1.

This form is different from any now living. It is closely related to the moose and the neck, body, limbs, and feet are almost identical. However the skull and antlers are very much different; the nasal bones are shorter than the moose, indicating a smaller snout. The antlers in general, are like those of the moose, but are less palmate and carry a trumpet-like plate on the lower side of each antler. This form is sometimes called the "stag-moose," and is thought to have migrated from eastern Asia, although no identical forms have been found in the Old World.

ODOCOILEUS VIRGINIANUS

Plate LXXVI, fig. 1.

The Virginia deer is a southern form in contrast to the four previously described forms which are found in the northern part of the continent.

Family BOVIDAE

SYMBOS CAVIFRONS

This form of the musk-ox ranged from Alaska to Arkansas and is one of three extinct genera found in the American Pleistocene. *Symbos* differs from the living form *Ovibos* in its smaller and shorter horns. The skull of *Bootherium bombifrons*, another Pleistocene musk-ox, is shown in Pl. LXXIV, fig. 1.

OVIBOS WARDI

Plate LXXVII, fig. 3.

The remains of the musk-oxen have been found as far south as Oklahoma, but mostly along the terminal moraine formed by the front of the last ice invasion. This form, one of strictly arctic or cold region habitat, shows conclusively the character of the climate during the advance of the ice. The presence of bones of the extinct form, *Symbos*, and the two living forms, *O. moschatatus* and *O. wardi*, with those of the caribou in regions that are now warm or temperate is a good indication of the influence of the ice sheet upon climate.

BISON ANTIQUUS

This form was much larger than the living species, *B. bison* (See Pl. LXXVIII, fig. 1B) and is readily distinguished by the position of the horns at right angles to the axis of the skull. The remains of this species have been found only in California and Kentucky.

BISON LATIFRONS

Plate LXXII, fig. 1; Pl. LXXVIII, fig. 1A.

This early Bison was the giant of the race, and is thought to have far exceeded any of its living relatives in size. The largest skull found carries horns that measure 6 feet across from tip to tip or 8 feet 6 inches along the curve. An idea of its size as compared to the living form may be obtained from Pl. LXXVIII, fig. 1A. Its remains have been found as far south as Texas and Mississippi.

Order PERISSODACTYLA

Family EQUIDAE

EQUUS COMPLICATUS

Equus complicatus ranged in the western, southern, and middle western states is well known from the Pleistocene deposits of these areas. It is characterized by teeth as large as the living horse, although it was only intermediate in size, about 14 hands high. The species somewhat resembles the ass on account of its short muzzle.

Family TAPIRIDAE

TAPIRUS HAYSII

The fossil record of this class of animals is rather meager, and if the scarcity of specimens is an indication of their numbers in North America they could not have maintained themselves for a long time. It seems that they were most abundant during the Pleistocene, and had, in general, the same habitats as the existing species. *Tapirus haysii* was probably larger and heavier than the living species.

Order PROBOSCIDEA

Family ELEPHANTIDAE

MASTODON AMERICANUS

Plate LXXVII, fig. 2.

It has been estimated that the mastodon was as plentiful at one time as the bison. Their known range covers the entire United States northward to Lake Winnepeg and British Columbia, Alaska, and Nova Scotia. The American mastodon is distinguished by its low forehead, its short, massive limbs, very broad pelvis, the height at the shoulders not exceeding 9½ feet. It was probably covered with hair and an undercoating of wool. The tusks attained a length of 10 feet, the average in full-grown specimens being seven to eight feet long.

ELEPHAS PRIMIGENIUS

Plate LXXIII, fig. 2.

The northern or Siberian mammoth, *Elephas primigenius*, came into North America by way of the land bridge across Bearing Sea which connected Alaska with Siberia. It was adapted to a cold climate being covered with a dense coat of

wool with an outer covering of long, coarse hair. In size it is the smallest of the Pleistocene elephants, about nine feet high at the shoulder. Its teeth are of the grinding type, high, cement covered, and composed of many thin plates of enamel, dentine, and cement, very much like those of the Indian elephant living today.

ELEPHAS COLUMBI

Plate LXXIII, fig. 1.

This form is very much like *E. primigenius*, except it is a very much larger form, sometimes attaining a height of 11 feet at the shoulder. The head was very high, with a peaked appearance. The tusks curved inward, sometimes overlapping in old males. The species ranged, in general to the south of the Siberian mammoth, and is found as far south as Florida and the tableland of Mexico. It is thought, since this species is found more to the south, that if the animal was covered with hair, it was not so thick as that found on the northern form.

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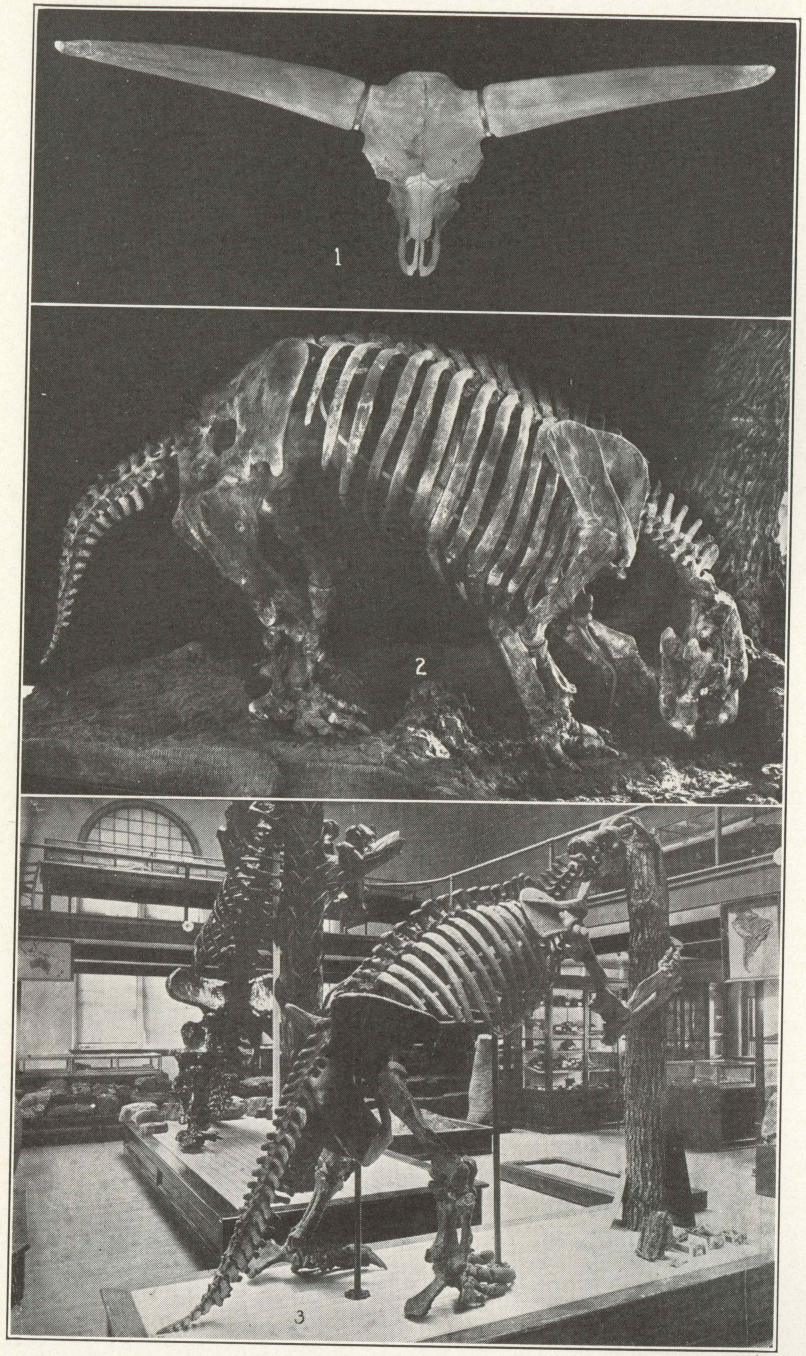
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Explanation of Plate LXXII

Figure

1. *Bison latifrons.* View of top of skull, showing the enormous spread of horns.
2. *Mylodon harlani.* Skeleton mounted in the American Museum of Natural History.
3. *Megalonyx jeffersoni.* Giant sloth described by Thomas Jefferson from a skeleton found at Big Bone Lick.

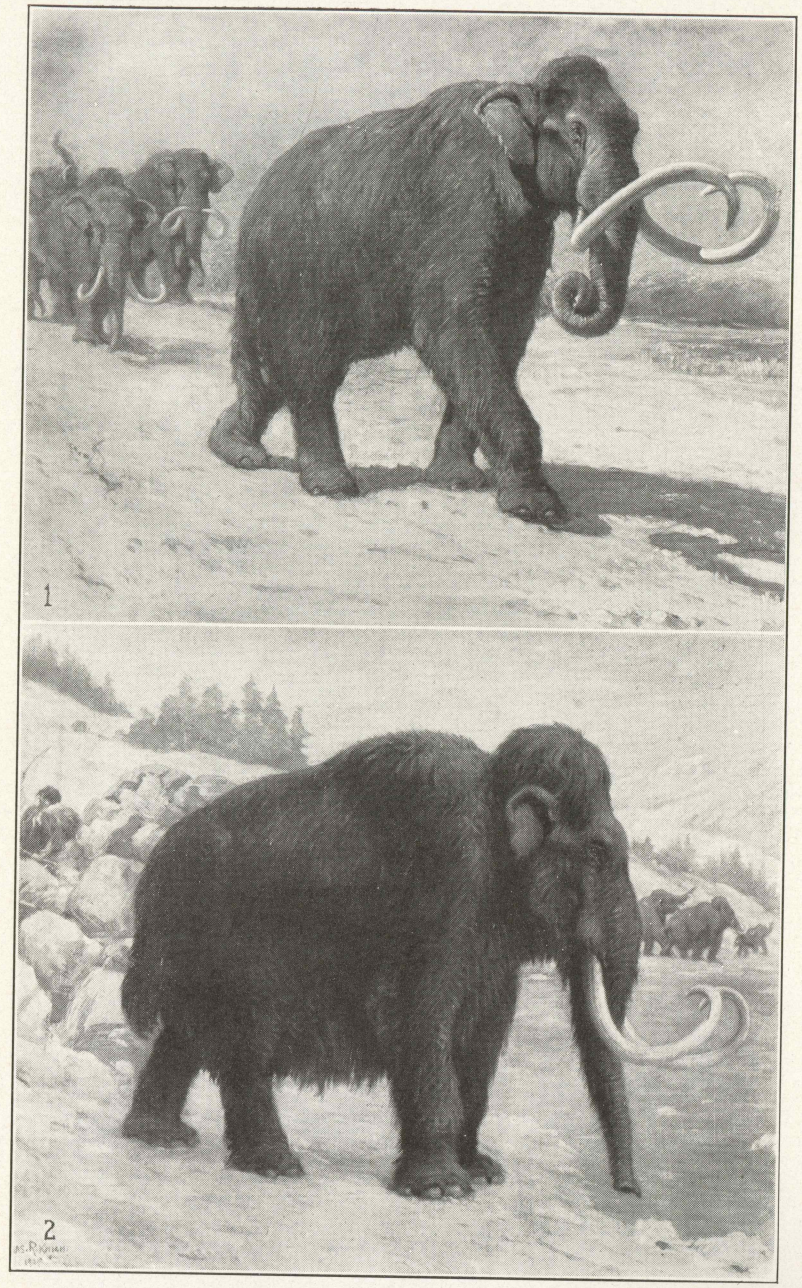


FOSSIL MAMMALS OF THE PLEISTOCENE
Photographs by American Museum of Natural History.

Explanation of Plate LXXIII

Figure

1. *Elephas columbi.* Painting of Columbian elephant by Charles R. Knight.
2. *Elephas primigenius.* Painting by Charles R. Knight.

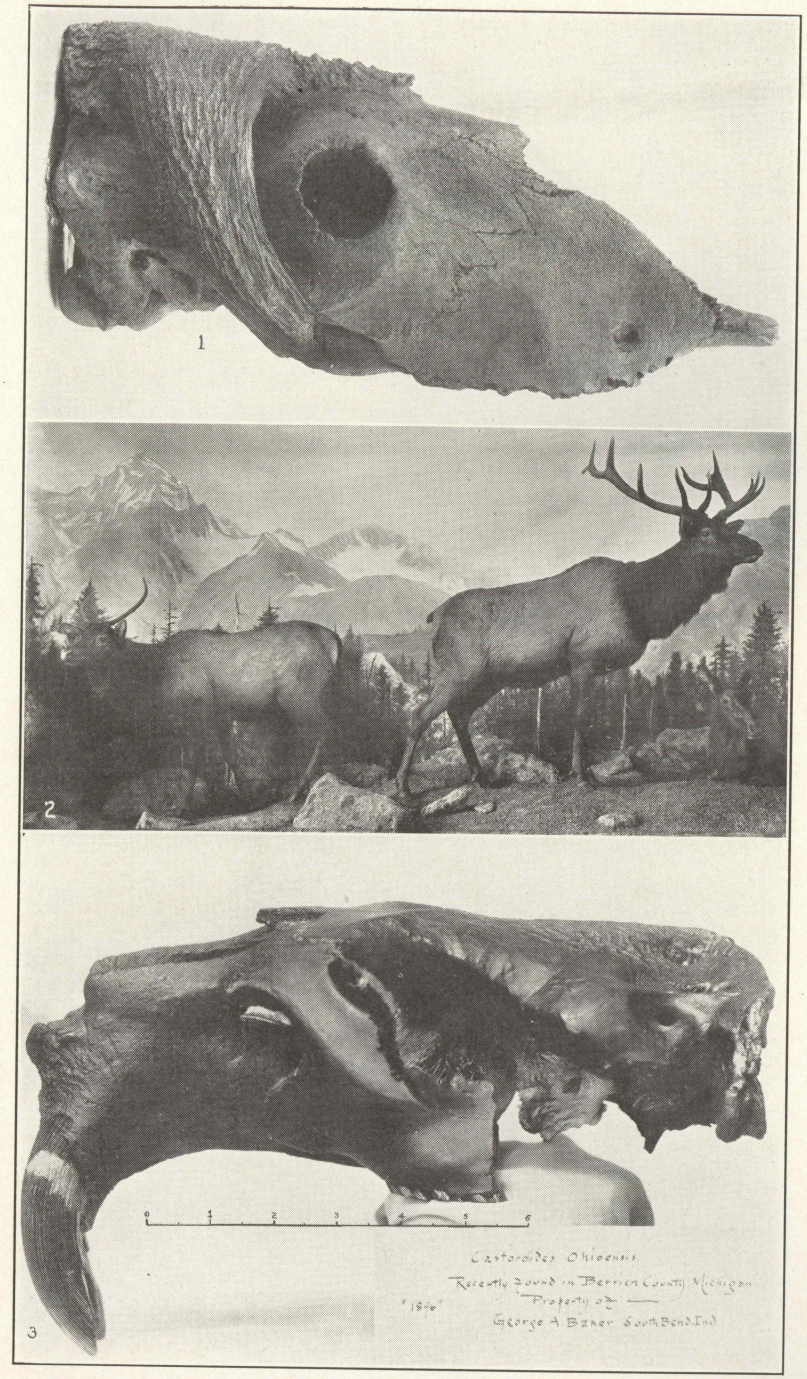


PAINTINGS OF THE PLEISTOCENE MAMMOTH IN AMERICA
Photographs by American Museum of Natural History.

Explanation of Plate LXXIV

Figure

1. *Bootherium bombifrons.* Skull of extinct musk-ox.
2. *Cervus canadensis.* Roosevelt elk, a living species which has been found with Pleistocene animals at Big Bone Lick.
3. *Castoroides ohioensis.* Skull of giant beaver, which sometimes grew to the size of the black bear.



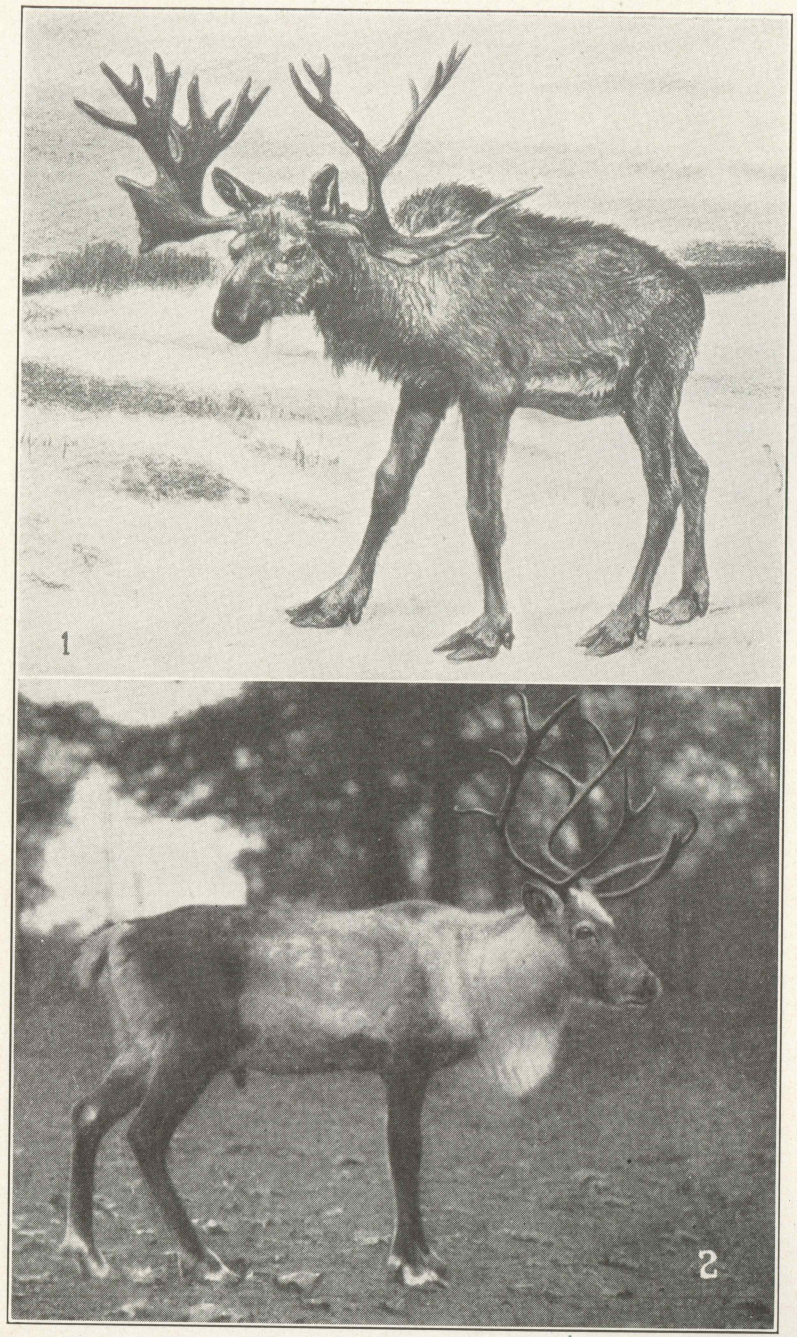
PLEISTOCENE VERTEBRATES
Photographs by American Museum of Natural History.

Explanation of Plate LXXV

Figure

1. *Cervalces scotti.* A painting made from the restoration of a skeleton of the "stage-moose" at Princeton University.

2. *Rangifer caribou.* Living species which was existant in the late Pleistocene.



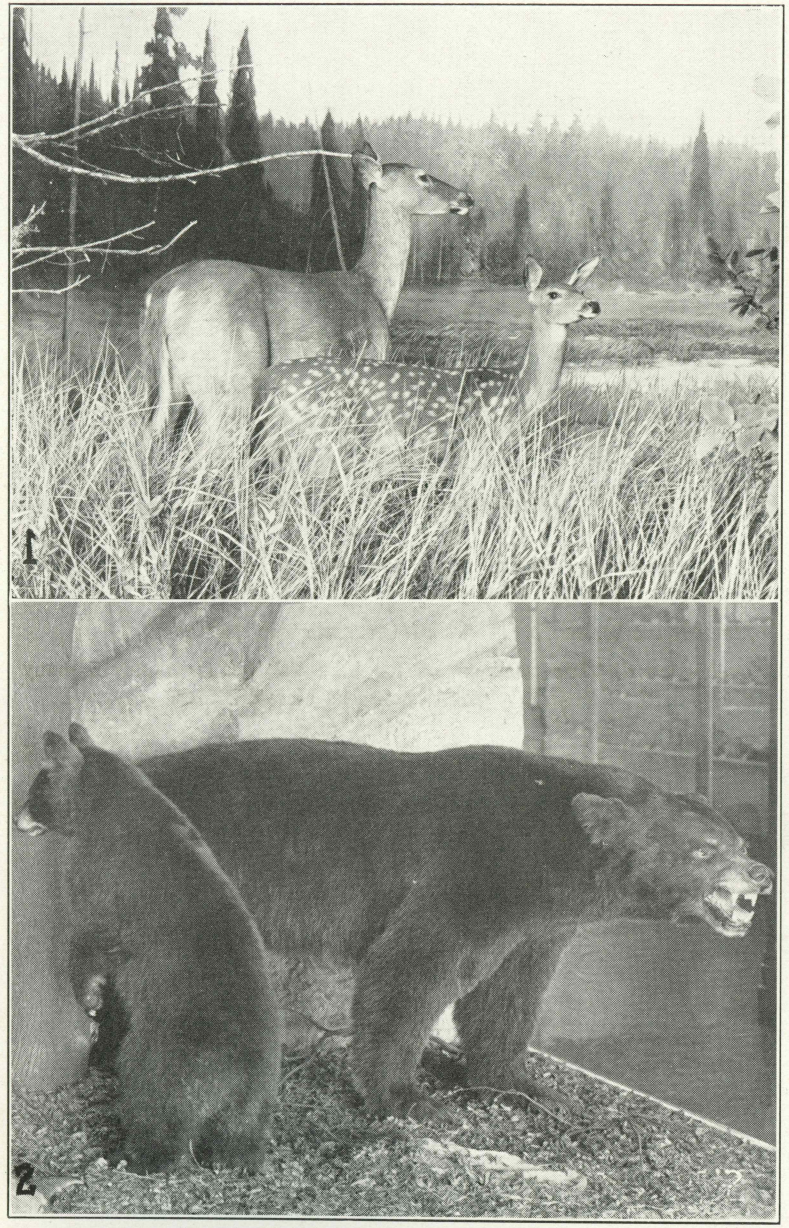
PLEISTOCENE VERTEBRATES
Photographs by American Museum of Natural History.

Explanation of Plate LXXVI

Figure

1. *Odocoileus virginianus.* The Virginia deer, also a living form, found in the late Pleistocene bone beds.

2. *Ursus americanus.* The only carnivore found at Big Bone Lick, the living species of black bear.

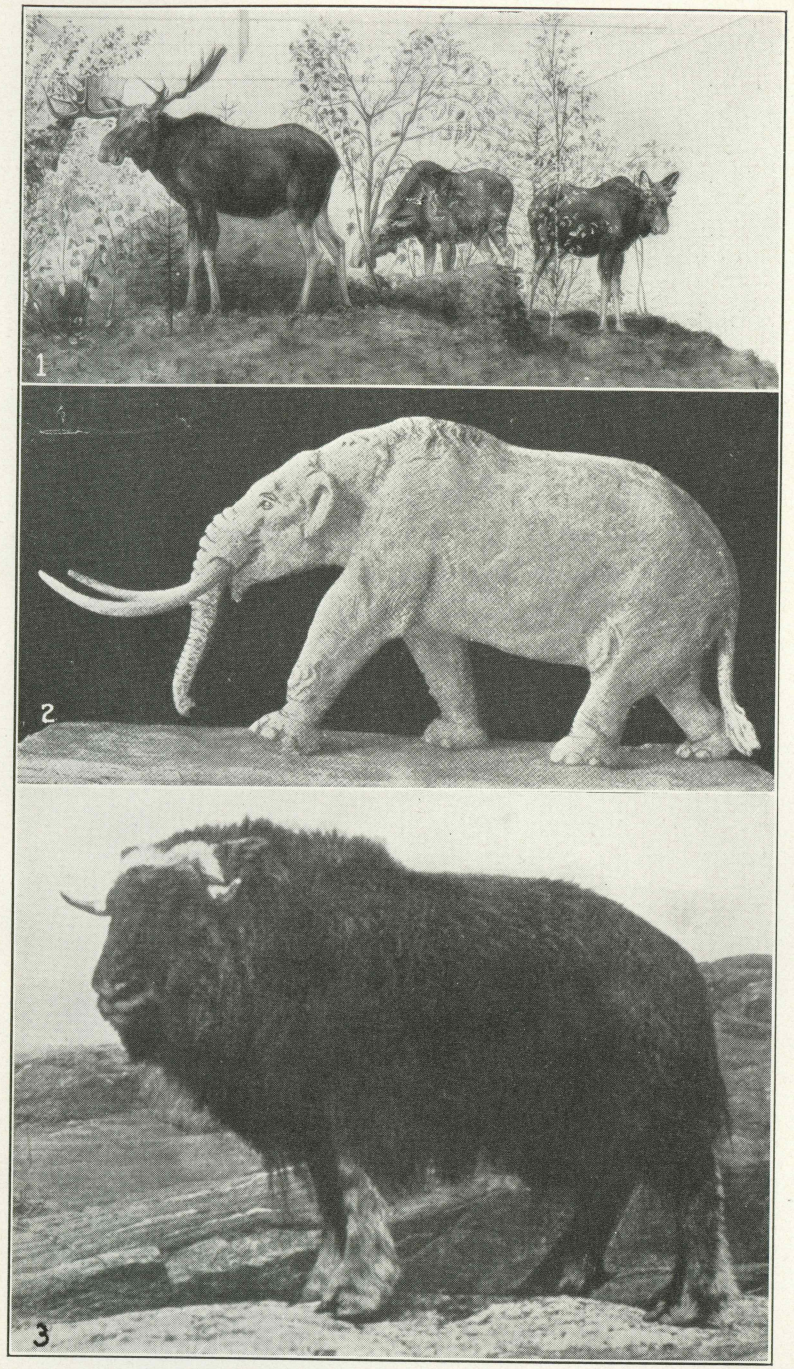


PLEISTOCENE VERTEBRATES
Photographs by American Museum of Natural History.

Explanation of Plate LXXVII

Figure

1. *Alces americanus.* Moose group, the living form, from the American Museum of Natural History.
2. *Mastodon americanus.* Model of the American mastodon.
3. *Ovibos wardi.* The musk-ox, of northern habitat, is found in many places in the Pleistocene beds of southern United States.



PLEISTOCENE VERTEBRATES
(Figures 1 and 2 by the American Museum of Natural History)

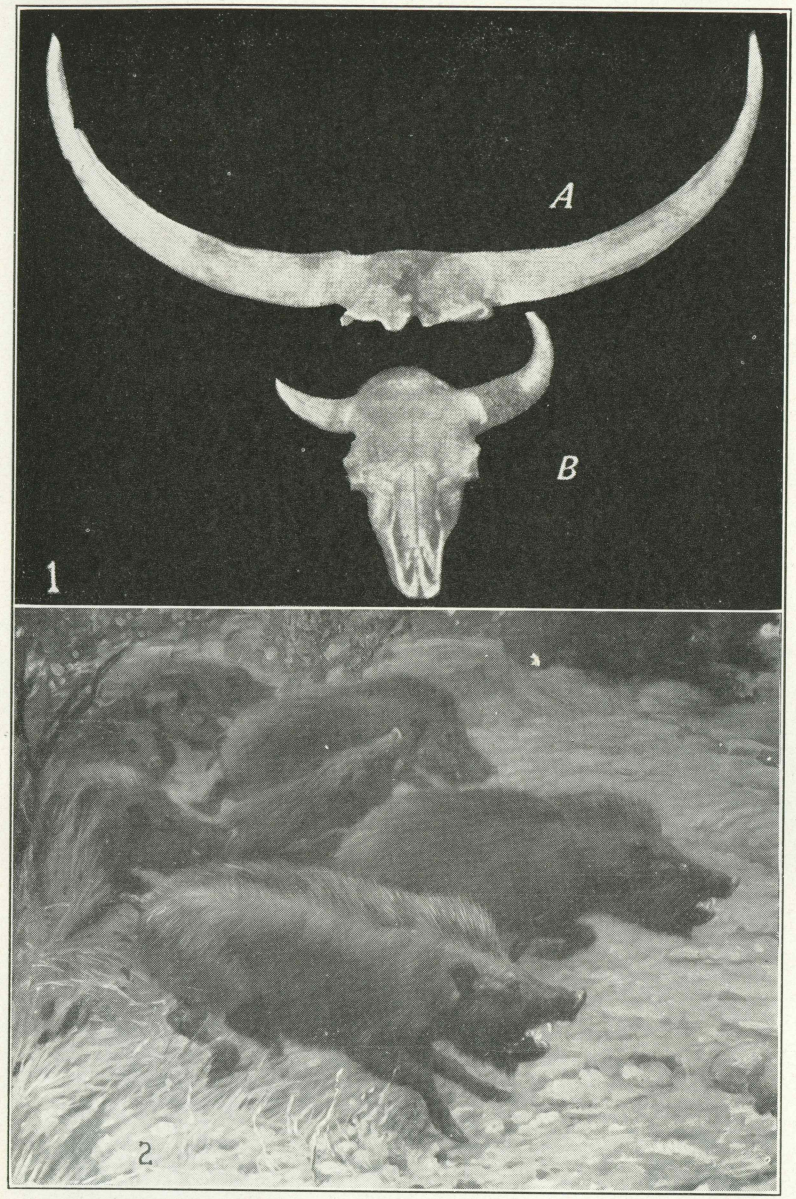
Explanation of Plate LXXVIII

Figure

1. A. *Bison latifrons.* Front view of skull showing large spread and curviture of the horns. Compare with skull of living bison shown in figure 1B.

   B. *Bison bison.* Skull of the living buffalo.

2. *Platygonus leptorhinus.* Extinct form of peccary which lived in late Pleistocene.



PLEISTOCENE VERTEBRATES

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