NOTES ON THE PALEONTOLOGY OF THE GARRISON FORMATION OF KANSAS

by

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INTRODUCTION

General Character of the Garrison Formation

The Garrison formation, consisting of interbedded shale and limestone, comprises the uppermost part of the Council Grove group.

According to the stratigraphic classification of the United States Geological Survey and the Kansas Geological Survey the Council Grove beds mark the base of the Permian. The lower formation of the group, the Cottonwood limestone, rests conformably on the Pennsylvanian. The Council Grove group is approximately 150 feet in thickness. Its outcrop, which is very narrow on account of the resistant character of the succeeding Wreford limestone, occurs on the east face of the Flint Hills.

The Garrison formation consisting mainly of shale with thin interbedded limestones constitutes the greater portion of the Council Grove group, having a thickness of 115 to 135 feet.

Prosser recognized two main divisions in the Garrison--a lower member consisting of shale called the Florena shale; and an upper member composed of green, chocolate, or yellow shales called the Neosho member.

In the first classification of the Upper Paleozoic rocks of central Kansas by Prosser,[1] the Cottonwood formation,

1. Prosser, C. S. "Classification of the Upper Paleozoic Formations of Kansas". Journ. Geol. Vol. 3, p. 764.

including the Cottonwood limestone and Cottonwood shales, now Florena shales, was placed at the top of the Upper Coal Measures; and the Neosho member as the base of the Permian.

In a revised classification of the Upper Paleozoic formations of Kansas, Prosser[1] regarded the base of the Permian as marked by the lower limit of the Wreford limestone first indicated by Dr. Frech.

Garrison formation.[2]--"This formation is composed of two members, the yellowish fossiliferous shales at the base, formerly called the Cottonwood shales, and the upper one, composed of the alternating gray limestones and various colored shales called the Neosho, with a total thickness of from 140 to 145 feet. The lower shales have a thickness of thirteen feet near Strong, but decrease to two or three feet in the northern part of the state. The lower part of these shales contains immense numbers of a few species of fossils and on this account may be readily identified wherever outcrops occur. Since the geographic name "Cottonwood" is preoccupied and the term "Cottonwood shale" is abandoned, and they are renamed the Florena shales from the exposures over the Alma limestone (Cottonwood limestone) in the quarries near Florena, in the Big

1. Prosser, C. S. "Revised Classification of the Upper Paleozoic Formations of Kansas." Journ. Geol. Vol. 10, pp. 703-737.
2. Prosser, C. S.; Journ. Geol. Vol. 10, p. 712.

Blue valley.

"The upper member of the formation is composed of green, chocolate, and yellowish shales, alternating with grayish limestone, while in the Big Blue valley a bed of gypsum occurs near the base. Certain layers of the coarser shales and limestones contain an abundant lamellibranch fauna, and the entire fauna is thought to be a mixture of species found in the western Coal Measures, together with others occurring in the division generally termed the Permian or Permo-Carboniferous. This member was originally termed the Neosho formation from the excellent outcrops in the Neosho valley near Council Grove. The Florena shales and Neosho member are now united to form the Garrison formation, so named on account of the good exposures from Garrison south in the Big Blue valley."

As has been indicated, the formation as classified by Prosser is removed from the top of the Upper Coal Measures and placed as the first member of the so-defined Permian.

This division of the Permian from the Pennsylvanian has caused considerable controversy and is a question which has not been entirely settled as yet. There is no distinct break between the Cottonwood limestone and the underlying Eskridge shale. The Cottonwood limestone rests conformably upon the shale. The Florena shale contains a fauna that is common to both the

Pennsylvanian and the Permian. In the middle and the upper shale of the Garrison formation is the first good evidence of the occurrence of a gradual faunal change from forms characteristic of the Pennsylvanian to those of the Permian.

In lithologic character the limestone layers are quite similar to those of the upper Pennsylvanian. There is a marked lithologic change at the base of the Chase stage where it begins with the Wreford limestone, which is the lowest one of the very cherty massive limestones. Prosser,[1] because of the noted change, concluded a more satisfactory classification could be made by regarding the base of the Permian at the lower limit of the Wreford limestone.

PREVIOUS WORK

There are a number of publications dealing with the Kansas Permian, particularly by the earlier geologists. It has not received, however, the study and investigation that the Pennsylvanian system has.

Several papers on the character, stratigraphic position and paleontology of the Garrison formation are to be found in publications of the State Geological Survey of Kansas and a few from those of Nebraska. Papers by Meek, Hayden, Swallow, Prosser, Beede and others on the Permo-Carboniferous are found

1. Prosser, C. S.; Journ. Geol. Vol. 10, p. 710.

in bulletins of the United States Geological Survey.

One of the earliest and most complete studies of the character and stratigraphy of the Garrison formation is that by Prosser[1] in his classification of the Upper Paleozoic rocks of central Kansas, published in 1895. A few changes in classification and nomenclature are made in his paper[2] on the "Revised Classification of the Upper Paleozoic Formations of Kansas", published in 1902.

In 1897, Prosser[3] published a paper on the Permian and Upper Carboniferous of southern Kansas. This is a report of studies of the sections of rocks exposed in the Flint Hills. In it an attempt is made to identify by means of the fossils and general lithologic characters, formations named and described by him in the Kansas and Cottonwood River sections.

The first part of Volume III of the University Geological Survey of Kansas deals with the stratigraphy of the Kansas Coal Measures and is a summary of all previous work done by the University survey. The larger part of the field work subsequent to the publication of Volume I, which furnished the basis for the revisions of the stratigraphy contained in this report, was done by George I. Adams. Beede's paper[4] "Reconnais-

1. Journ. Geology, Vol. 3, pp. 682-706, and pp. 764-801.
2. Journ. Geology, Vol. 10, pp. 703-737.
3. Kansas Univ. Quart., Vol. 6, 1896, p. 149.
4. Kansas Univ. Quart., Vol. 9, 1900, p. 191.

sance in the Blue Valley Permian" furnishes information concerning the extension northward to the Nebraska line of the formations (Wabaunsee, Cottonwood, Neosho, Chase) described by Prosser and others at localities along the Cottonwood and Kansas rivers.

No detailed faunal lists have been prepared by paleontologists for the Garrison formation. Several incomplete faunal lists of this formation are included in charts dealing with the invertebrate fossils from the Carboniferous section of Kansas.

A faunal list by George H. Girty[1] is included in Adams's paper on the "Stratigraphy and Paleontology of the Upper Carboniferous Rocks of the Kansas Section". The assignment of the collections upon which the tabulated lists are based to their proper positions in the section is entirely the work of Messrs. Adams, Beede, Bennett, and Prosser, who made the collections while studying the stratigraphy.

Another paper including a faunal study of the Garrison formation is "Faunal Studies, IV", from the Upper Coal Measures on the Neosho River section by Beede and Rogers.[2] They list twenty-eight species of fossils from the Florena member and twenty-one from the Neosho member.

PRESENT INVESTIGATION

The writer's work was undertaken with the purpose of making a study of the fauna from the Garrison formation, with particular

1. U. S. G. S., B. 211, pp. 73-84. (1903).
2. Kansas Univ. Sc. B., Vol. 3, No. 10, pp. 377-388 (1906).

emphasis upon the micro-fauna. Considerable work has been done on the macro-fauna, but very little attention has been given to the microscopic fossils. Beede and Rogers[1] list a few species of ostracodes, bryozoans and fusulinids in their faunal studies of the Coal Measures of Kansas. A general investigation of the literature, lithology and paleontology of the Permo-Carboniferous of Kansas was completed by the writer before undertaking the present investigation.

The study of this problem has been carried on during the past seven months. Collecting of fossils, studying of the lithologic character and stratigraphy of the formation was confined chiefly to the Manhattan area. Considerable material was collected from outcrops northwest of Strong City and southeast of Cottonwood Falls. One trip was made up the Big Blue valley to Garrison. A detailed study and measurement of a complete section was made from an exposure five and one-half miles south of Manhattan. A few incomplete sections were studied at localities previously mentioned.

ACKNOWLEDGMENTS

I wish to express my gratitude to Dr. Raymond C. Moore for his interest and help in identification of specimens. I am also indebted to Mr. W. L. Moreman for suggestions and

1. Kansas Univ. Sc. B., Vol. 3, No. 10, pp. 377-388 (1906).

helpful criticism in the preparation of this thesis.

STRATIGRAPHY

The Garrison formation extends from southern Nebraska across Kansas into Oklahoma. It is exposed in Marshall county at the Kansas-Nebraska line about fifteen miles east of Marysville, and continues south into Pottawatomie and Riley counties along Blue River. At Manhattan the line of outcrop swings west along Kansas River to Junction City, then east towards Alma and from there south to Council Grove. Excellent exposures are found from Council Grove south through Cottonwood Falls and from there in a southwesterly direction to the Kansas-Oklahoma line. In Chase and Butler counties the outcrop of the Garrison formation forms a band bordering the east line of the Permian, and it coincides with the east face of the so-called Flint Hills. In Pottawatomie county east of Blue River, a small outlier of the lower Permian has been cut off by the river flowing south to join Kansas River at Manhattan.

The Garrison formation varies from approximately 110 feet in thickness in the northern part of the state to 140 and 145 feet in the Neosho valley. Prosser[1] placed the total thickness at 140 feet. The lower shale, Florena member, has

1. Journ. Geology, Vol. 10, p. 712.

a thickness of 13 feet near Strong, but decreases to two or three feet in the northern part of the state. Adams[1] placed the total thickness of the Garrison formation mapped in the Cottonwood Falls quadrangle at about 120 feet.

In eastern Marshall county, near Beattie, the Cottonwood limestone is eight feet thick, the lower part being impure. At this locality the Florena shales are only two feet thick. The Neosho measures 70 feet. Allowing for the probable dip, the Garrison formation has a thickness of 110 feet in this vicinity. Southward from Florena, in the vicinity of Garrison there are 82 or more feet of the formation exposed in the bluffs by the town.

The following section measured by Beede[2], just east of Bigelow, gives an excellent idea of the Garrison formation in the north Kansas Permian. This section is well exposed and is given in minute detail. While the minute details vary in going a short distance, yet the general appearance does not vary greatly.

1. U.S.G.S., B. 211, p. 56.
2. Kansas Univ. Quart. Vol. 9, No. 3, pp. 191-202.

Dennis Section, east of Bigelow. (After Beede)

	Stratum Ft.	in.	Total Ft.	in.
21. Gray limestone near top of hill----?				
20. Shales, uppermost quite calcareous-	15	0	86	4
19. Gray limestone----------	1	2	71	4
18. Green and red shales----------	12	0	70	2
17. Gray, impure limestone----------	2	0	58	2
16. Dark red and yellow shales---------	10	0	56	2
15. Gray limestone in 4 thin layers----	1	8	46	2
14. Olive shales----------	3	6	44	6
13. Greenish-gray limestone, many small fragments of fossils----------	1	0	41	0
12. Yellowish arenaceous shales--------	1	6	40	0
11. Light gray sandstone----------	0	6	38	6
10. Green shales----------	10	0	38	0
9. Three-inch layer of clayey limestone	0	3	28	0
8. Olive to yellowish, mostly indurated shales, soft above----------	10	0	27	9
7. Mud-cracked limestone----------	5	0	17	9
6. Yellow gray, clayey limestone------	0	6	12	9
5. Yellow shale, fossiliferous--------	1	0	12	3
4. Shaly limestone----------	1	6	11	3
3. Yellowish fossiliferous shale------	4	0	9	9
2. Cottonwood limestone----------	5	9	5	9
1. Covered slope, about thirty-nine feet.				

At Manhattan, Prosser[1] gives the thickness of the Cotton-Wood limestone as five feet, and at Alma five and one-half feet. Just west of Manhattan, Meek and Hayden estimated the thickness of the Garrison formation at 109 feet. According to Swallow the thickness is from 124 to 153 feet, while Prosser reported it to be 122 feet. There is a variation of 44 feet in the different measurements given. It seems evident that in measuring they all did not restrict themselves to the same boundaries.

1. Am. Geol. Vol. 38, pp. 92-93.

A complete section which I measured five and one-half miles south of Manhattan totaled 114 feet in thickness. This section is exposed along the road to Alma where it cuts across the bluffs overlooking Kansas River.

Garrison Section, five and one-half miles, south of Manhattan.

	Stratum ft.	in.	Total ft.	in.
17. Yellowish shale	3	0	114	0
16. Shaly limestone	1	0	111	0
15. Yellowish shales	5	0	110	0
14. Red and chocolate colored shales	5	0	105	0
13. Limestone	3	0	100	0
12. Yellowish shales	17	0	97	0
11. Red, brown, and green shales	14	0	80	0
10. Shaly limestone	1	0	66	0
9. Yellowish shales	10	0	65	0
8. Limestone	1	6	55	0
7. Red and green shales	16	0	53	6
6. Shaly limestone	3	6	37	6
5. Shaly	6	6	34	0
4. Limestone	2	6	27	6
3. Shale	2	0	25	0
2. Shaly limestone	3	0	23	0
1. Yellow shale, fossiliferous	20	0	20	0

The region from Junction City to Cottonwood Falls has been well summarized by Prosser.[1] Taking the region as a whole he ascribes a thickness of 6 feet to the Cottonwood limestone and 140 to 145 feet to the Garrison formation.

At Reece, Beaumont and Grand Summit excellent exposures of all the important limestones of the Lower Permian section

1. Am. Geol. Vol. 38, pp. 95-96.

are shown, but nowhere is there a stone with all the characters of the Cottonwood limestone. The fauna of the general horizon is somewhat similar to that of the Florena shales but it is distributed through a fairly wide range of rocks and is not so pronounced as in the northern localities. In short the Cottonwood limestone ceases to be of a great value as a horizon marker south of Bazaar, Chase County.

Beede and Sellards[1] studied a section of the Flint Hills escarpment east of Beaumont and found the Garrison formation to measure about 138 feet in thickness.

Section of the Flint Hills Escarpment East of Beaumont

(After Beede and Sellards)

		Stratum ft.	Stratum in.	Total ft.	Total in.
29.	Covered to the base of the Wreford	20	0	138	6
28.	Red and blue shales, disintegrated	8	0	118	6
27.	Shale, blue calcareous	5	0	110	6
26.	Shale, calcareous	3	6	105	6
25.	Limestone, massive, chert con.	1	3	102	0
24.	Limestone, shaly, fossiliferous	5	9	100	9
23.	Limestone, impure chert	2	0	95	0
22.	Gray shale, thin limestone	1	6	93	0
21.	Limestone, hard bluish	2	0	91	6
20.	Shales, olive, clayey	5	0	89	6
19.	Crusty deposit	1	0	84	6
18.	Shales, blue	2	0	83	6
17.	Shales, calcareous, concretionary	2	0	81	6
16.	Shales, yellowish, concretionary	3	0	79	6
15.	Limestone, hard, blue, fossiliferous	6	0	76	6

1. Am. Geol. Vol. 36, pp. 100-101.

14. Limestone, Pseudomonotis----------	5---6	70---0
13. Blue, shale, hard, some fossils----------	3---0	65---0
12. Shales----------	1---6	62---0
11. Limestone----------	1---0	60---6
10. Shales, light colored----------	12---6	59---6
9. Limestone----------	1---0	47---0
8. Shale----------	2---0	46---0
7. Limestone----------	1---0	44---0
6. Covered----------	5---0	43---0
5. Shales, yellow, calcareous----------	12---0	38---0
4. Shales, crusty----------	2---0	26---0
3. Limestone, shaly and massive----------	8---0	24---0
2. Shales, light colored----------	10---0	16---0
1. Cottonwood limestone----------	6---0	6---0

The shale and limestone layers of the Garrison formation are remarkably persistent and uniform when the great extent of the outcrop is considered. This formation, weathering very readily, forms the slope of the escarpment made by the overlying Wreford limestone. Owing to the persistence of the overlying Wreford limestone, this formation can be readily recognized and traced with little difficulty across Kansas from the Nebraska to the Oklahoma line.

The Garrison formation extends across Kansas with but slight modification in the southern part of the state, such as the thickening of some of its limestones. These limestone layers vary in thickness from one to four feet and are of minor importance. Some of them are thick and persistent enough to form small escarpments within the band of outcrop of the formation. Benches formed by the limestone beds are quite noticeable along the bluffs south of Kansas River near Manhattan. The first prominent limestone

layer occurs about 15 feet below the base of the Wreford and is three feet thick. The second occurs near the middle of the formation and is one and a half feet thick. The third is 20 feet above the top of the Cottonwood and is five and a half feet thick with a thin shale between. These limestone layers weather at the surface into small rectangular blocks very similar in color and appearance to that of the Cottonwood.

Throughout the whole extent of the Garrison formation the general inclination of the strata is to the west. On account of a slight thickening in the Flint Hills area the maximum dip is to the northwest. The inclination reaches 14 to 16 feet to the mile, but probably the average for the whole formation is but little more than 10 to 12 feet.

CONDITIONS OF DEPOSITION

The shales and limestones of the Garrison formation are marine deposits. Conditions under which they were formed were not unlike those of the Pennsylvanian.

The shallow epi-continental seas existing throughout the Pennsylvanian continued to occupy much of the same area in Lower Permian times. Sediments were mainly derived from a land mass on the south, as shown by a thickening of the beds in that direction. The Garrison formation thins from 145 feet south of Cottonwood Falls to approximately 110 feet north of Garrison

in the Big Blue valley.

Study of the fauna of the Garrison formation shows it to be typical of a shallow marine environment. It seems evident that warm shallow seas existed prior to the deposition of the formation, suggested by the abundance of Fusulina found in the Cottonwood limestone and also in the Florena shale. The bryozoans and brachiopods are further evidence of a shallow water fauna. In some of the shale layers the bryozoans are unusually plentiful both in number and species. The brachiopods, especially one species, Chonetes granulifer, comprise the greater part of the fauna found in the Florena shale.

In the Garrison, beds of shale are predominant and the limestone layers, rarely more than four feet thick, of minor importance. Often a limy shale is found grading into a thin limestone. Moore[1] offers as possible causes for changes in lithologic character: (1) reworking and lateral shifting of fine clastic sediments from areas of rapid and somewhat irregular deposition; (2) slight relative elevation of land, rejuvenating streams and increasing supply of terrigneous material to the sea, and (3) climatic changes, such as periods of subnormal precipitation, when, because of reduction in capacity of streams

1. Moore, R. C. "Environment of Pennsylvanian Life in North America." Reprint from the Bulletin of the American Association of Petroleum Geologists.

deposition would be restricted largely to the lands, alternating with periods of super-ordinary rainfall when the loads of sediment previously dropped on the plains would be shifted by the enlarged streams to the sea.

Another interesting feature of the shale beds is their variation in color. The yellow and green shale beds are thicker, while the red and chocolate are thinner, but none the less persistent. The yellow and green layers of shale grade from one into the other, but the darker shales do not grade into the lighter, forming a distinct break so far as color is concerned. These changes in character and mineral content are no doubt due to a change in the type of sediments carried into the seas.

In conclusion, the shales and limestones of the Garrison formation were deposited in a widespread shallow epi-continental sea, in which conditions were almost constant except for slight oscillations of the sea on a submerging and emerging shore.

COMPARISON OF FLORENA AND NEOSHO FAUNAS

The Florena shale overlying the Cottonwood limestone constitutes one of the most fossiliferous horizons of the Permian. Although there are but few species present they are extremely abundant in number.

A study of this fauna with its abundance of Chonetes granulifer, Derbya crassa, Composita subtilita, Productus semireticulatus, Meekella striatacostata, and others shows it

to be typical of the Upper Carboniferous of the Mississippi Valley. Comparison with the fauna of the Wabaunsee formation shows that while the latter has many more species, every species of the Florena shale, with the exception of possibly two or three, occurs in the Wabaunsee formation.

An examination of the fauna of the Neosho member shows it to contain fossils typical of the Carboniferous along with a mixture of species more typical of the true Permian. Some of the shale layers and the dark gray limestone beds contain a Pseudomonotis fauna which is usually considered characteristic of the Permian. The presence of strata containing a mixed fauna led to the consideration of the Neosho as the lowest formation of the division generally called the Permo-Carboniferous.[1]

GENERAL FAUNAL OBSERVATIONS

An analysis of the faunal chart at the close of this paper brings to attention a few considerations concerning the fauna of the Garrison formation that are worthy of note.

Before collecting material a separation of the formation into three zones was arbitrarily established so that a comparative study, from the data gathered, might be made. The lower zone constitutes the Florena or yellow shale overlying

1. Meek and Hayden: Am. Journ. Science, 2nd series, Vol. XLIV., p. 37.

the Cottonwood limestone. The Neosho member comprises the middle and upper zones. The line of separation between the middle and upper zones was drawn at the base of a one foot layer of shaly limestone, which is bed No. 10 in the section measured south of Manhattan.

A study of the fauna from the three zones shows that the Florena member of the Garrison is more fossiliferous than either the Lower or the Upper Neosho beds. Wherever the shale has been exposed for some time, large numbers of nearly perfectly preserved loose fossils may be found. Another factor is the greater number of good exposures. At many localities the underlying Cottonwood limestone has been quarried for building purposes, thus affording good exposures of the Florena shale.

Fifty species of fossils were found in the Florena shale. The brachiopods are most abundant in number but not in species. The number of specimens of Chonetes granulifer is far in excess of that of any other species. At some localities thin layers made up almost entirely of these shells were observed. Several specimens of Productus semireticulatus, Pustula nebraskensis, Derbya crassa, and Composita subtilita were found. The bryozoans include twenty identified species, the most common ones being Fistulipora carbonaria, Tabulipora carbonaria, Thamniscus octonarius, and Septopora biserialis. Fourteen species of

ostracodes were found, the genus Bairdia being represented by six species, which are the most abundant in number. The genus Amphissites is second in numerical importance with three species. Climacammina antiqua and Tetrataxis palaeotrochus are the most common protozoans. Numerous crinoid stems and echinoid plates are contained in my collections. The trilobites are represented by fragments of a single species, Phillipsia sangamonensis, and are not common.

The Lower Neosho proves to be the least fossiliferous of the three horizons. Many thin beds of reddish brown or chocolate colored shale intercalated in the more massive yellowish shale layers are non-fossiliferous. Two species of Tetrataxis are common in this zone and specimens of Globivalvulina bulloides are rare. Twelve species of bryozoans are recognized, the genus Septopora being represented by four species. Rhombopora lepidodendroides is a common and abundant form. The brachiopods include five species but are less abundant. Chonetes granulifer is, however, the most common one. The gastropods are represented by one identifiable species, Schizostoma catilloides. Many microscopic specimens were found in some of the shale layers. Among ostracodes, Bairdia beedei and B. beedei abrupta are very abundant and the two species of Hollina less so.

The fauna from the Upper Neosho does not show much variation from that of the Middle. The same protozoans common to the Middle are found in the Upper with the exception of T. ventricosus. The bryozoans are very abundant while the brachiopods are about the same in number. The pelecypods include two species, Nuculopsis ventricosa and Allorisma subcuneata. Of the ostracodes, the genus Jonesina is represented by two species which are fairly abundant. Two other genera, Healdia and Cytherella each have one species common to this horizon.

The species contained in my collection are typical of the Pennsylvanian fauna. Every species, with the possible exception of one or two, has been reported from the Coal Measures by Beede and Rogers[1] or Girty[2] in their faunal studies.

The eight species of protozoans represented have been collected from formations in the Pennsylvanian. The same species of bryozoans, which I have identified, were collected and described by Condra[3] in his paper on "The Coal Measure Bryozoa of Nebraska". The brachiopods are all wide ranging forms and although not represented by many species they are nearly all

1. Beede and Rogers, "Coal Measures Faunal Studies," Kans. Univ. Sc. B., Vol. 3.
2. Girty, G. H., "Fauna of the Wewoka Formation of Oklahoma," U. S. G. S., B. 544.
3. Condra, G. E. "The Coal Measure Bryozoa of Nebraska," Nebr. Geol. Survey, Vol. 2, pt. 2.

abundant in number of individuals. The pelecypods, Nuculopsis ventricosa Hall and Allorisma subcuneata Meek and Hayden are reported by Girty from the Wewoka formation of Oklahoma. Schizostoma catilloides Conrad is the only gastropod which I have found and is a common one in the Pennsylvanian.

In my study of the ostracodes I have extended the range of certain species, first collected and described by Knight,[1] from the Henrietta formation in Missouri. The two species of Hollina and Jonesina found in my material appear to be typical of the Lower Permian as they have not been reported from lower formations.

In conclusion, the fauna of the Garrison formation shows no marked differences from the fauna of the Pennsylvanian. Conditions of environment and forms of life inhabiting the seas continued much the same from Upper Pennsylvanian into Lower Permian.

1. Knight, J. B. "Some Pennsylvanian Ostracodes from the Henrietta Formation of Eastern Missouri". Journ. Pal. Vol. 2, No. 3; Vol. 2, No. 4.

SYSTEMATIC PALEONTOLOGY

PROTOZOA

Family Fusulinidae Moller

Subfamily Fusulininae Staff-Wedekind

Genus Fusulina Fischer

Fusulina emaciata Beede

The shell of this species is rather long and slender, elliptical in outline, with the ends somewhat blunt. An axial section shows the septa highly fluted throughout. The walls are thin in the first two whorls. The aperture is narrow and the tunnel angle small. The proloculum is fairly large, measuring about 0.1 mm. in diameter.

There is considerable variation as to size among my specimens. Some of the smaller specimens measured about 4.5 mm. in length while several of the larger ones measured over 7.5 mm. In some of the larger forms the relative thickness extends for a greater distance toward the ends than in the smaller forms.

[1]"This species is strikingly like F. longissimoides, but is smaller, of somewhat different form, showing a different development not due to dimorphism, and is from a higher horizon."

Range and distribution--Common in the Florena shale at Mannattan and Cottonwood Falls.

1. Beede, J. W., Ind. Univ. Studies, Vol. 3, Study 29, p. 14.

Genus Triticites Girty

Triticites ventricosus (Meek and Hayden)

The shell is extremely large, being about 10 mm. in length in an average specimen. A few specimens which I measured exceeded this by about five tenths of a mm. Outline of the shell is spindle-shaped with rather bluntly and evenly rounded ends. While nearly all of my specimens are of the elongate type, I have observed some which are comparatively short and rather thick. Many of the specimens are so well preserved that they show very distinctly the fluting of the antetheca.

In axial sections of a few specimens which I made, I counted nine volutions. All showed very large proloculums, which is quite characteristic of this species. The marked degree of septal fluting is very conspicuous.

Range and distribution--Upper Garrison shales at Manhattan and Strong City.

Family Textulariidae

Genus Cribrostomum Moller

Cribrostomum bradyi Moller

The test is composed of several chambers, biserially arranged throughout the length of the individual. The wall is finely arenaceous and perforated. Apertures in the early portion are similar to those of Textularia, an arched slit at the inner margin of the chamber, later becoming multiple.

My specimens differ from the type form in being slightly smaller in size. Also, the chambers in some are not quite so inflated. They all show, however, the characteristic biserial arrangement of the chambers.

This genus is distinguished from Climacammina in being biserial throughout, but is similar in body outline to the biserial part of Climmacamina. The chambers are more full and rounded and not compressed.

Measurements of three specimens from the Garrison at Manhattan: Length, 1 mm.; 1.2 mm.; 0.9 mm.; with the average at 1.03 mm.

Range and distribution--Rare in the Florena shale at Manhattan.

Genus Climacammina H. B. Brady

Climacammina antiqua H. B. Brady

Plate III, figures 4, 5.

The test is elongate and subcylindrical with the early chambers biserial and the later ones uniserial. Segments are numerous, with the sutures externally marked by depressed lines. An aperture or several irregular orifices occur on the face of the terminal segment.

Specimens in my collection show a wide range in size. Some of the largest ones measured about 2 mm. in length but the majority are about half this size. A few specimens show the small orifices occurring on the face of the terminal segments but in nearly every case the small openings are obscured by matrix.

The compressed or spatulate, unsymmetrical shape of the test is very pronounced.

Range and distribution--Abundant in the Florena shale at Manhattan and Cottonwood Falls.

Family Trochamminidae

Genus Globivalvulina Schubert

Globivalvulina bulloides (H. B. Brady)

The test is trochoid, subglobular or plano-convex. A depression occurs at the umbilicus on the flat ventral side, the dorsal side being strongly convex. The chambers are inflated and few, with the walls containing considerable cement. The aperture is low and arched at the umbilical margin of the last-formed chamber.

Nearly all of the specimens in my collection are smaller than the type form. They appear to be made up of three chambers, a large one with two smaller ones of equal size, giving a globular shape to the dorsal side.

This species is similar to the more modern type, Globigerina. The test is made up of a few globose segments and the excavation of the ventral surface is similar to the umbilical vestibule of Globigerina.

Range and distribution--Common throughout the Garrison formation.

Family Orbitolinidae

Genus Tetrataxis Ehrenberg

Tetrataxis maxima Schellwien

Plate III, figures 1, 2.

The test is conical in shape, consisting of a proloculum and elongate second chamber, later broken up into elongate, cresentic chambers. The aperture is elongate, located at the margin of the umbilical border of the chamber.

None of my specimens show any marked differences from the type form. They differ from T. palaeotrochus in being a little larger in diameter and the apex of the test not so sharply defined. The convex side appears to have been slightly compressed.

Range and distribution--Common throughout the Garrison formation.

Tetrataxis palaeotrochus (Ehrenberg)

The test is composed of several convolutions, each consisting of segments all more or less visible on the exterior. Septation is marked by slightly depressed or excavated lines.

Some of my specimens both large and small have a height nearly equal to the diameter of the shell at the base. The rather sharp apex is not so prominent in some as it is in others but, nevertheless, it is this character which readily distinguishes it from T. maxima.

Range and distribution--This species occurs at the same horizons as T. maxima but is less abundant.

ECHINODERMATA

Subphyllum Pelmatozoa Leuckart

Class Crinoidea Miller

Segments of crinoid stems are very abundant in all of the shale layers of this formation. I did not find any crinoid calyces so that it is impossible to make identification of genera and species. According to Zittel's[1] classification, the only crinoids found in the Permian are those belonging to the family Poteriocrinidae. Undoubtedly these stem fragments belong to some of the species of this family.

Range and distribution--Abundant in both the Florena and Neosho members at Manhattan, Cottonwood Falls and Strong City.

Subphyllum Echinozoa Leuckart

Class Echinoidea Bronn

Order Perischoechinoidea McCoy

Family Archaeocidaridae McCoy

Genus Archaeocidaridis McCoy

Archaeocidaris megastylus Shumard

Plate I, figures 14-20.

I have in my collection several plates of various sizes and fragments of numerous spines. The plates are hexagonal in outline, wider than long and some are unusually thick. The shafts of the spines which I have are broken away, so that I

1. Von Zittel, Karl A., Textbook of Paleontology, vol. I, pp. 173.

am unable to determine the length of them or the presence of lateral spines. The socket is deep, wide and smooth. The neck is marked with a slightly raised ring, which is finely striated longitudinally.

This species resembles Echinocrinus Agassiz in general outline and the presence of granules around the rim of the plate. Some of my plates are considerably larger than those described by Girty[1] and differ in being from .5 mm. to 2.5 mm. wider than long.

Measurements of three plates: Length, 13 mm., 13.5 mm., 12.5 mm.; width, 14 mm., 16 mm., 13 mm.

Range and distribution--Common at all horizons in the Garrison formation.

MOLLUSCOIDEA

Class Bryozoa Ehrenberg

Order Gymnolaemata Allman

Suborder Cyclostomata Busk

Family Fistuliporidae Ulrich

Genus Fistulipora McCoy

Fistulipora carbonaria Ulrich

Plate I, figure 7.

This bryozoan is common in both the lower and upper Garrison. It is a typical incrusting form and usually very thin. In one of my specimens the apertures are quite large and the

1. Girty, G. H. "Fauna of the Wewoka Formation of Oklahoma": U. S. G. S., B. 544, p. 37.

peristomes stand out as prominent ridges about two-thirds of the way around the openings.

A cross section of a part of this particular specimen shows large vesicles between the apertures, one row between each opening. Tabulae pass across the tube, about a tube's diameter apart.

This species is distinguished from F. nodulifera Meek in having larger apertures, fewer and larger vesicles and numerous diapnragms across the tubes. It differs from F. minor McCoy in having one instead of two series of vesicles surrounding each zooecium.

Range and distribution--Common in the Lower and Upper Garrison at Manhattan, Cottonwood Falls and Strong City.

Suborder Trepostomata Ulrich

Family Batostomellidae Ulrich

Genus Batostomella Ulrich

Batostomella leia Condra

The zoarium of this species is a ramose form with slender irregular branching stems, supported by basal expansion. B. leia is represented in my collections by a few stem fragments, somewhat weathered with almost smooth surfaces. Mature and well preserved specimens show numerous small acanthopores and a few large ones occurring at some cell angles.

A vertical section through one of my specimens shows long zooecia bending from the center to the surface, with a thickening of the walls near the apertures. Diaphragms occur in a few zooecia but are not common.

This species is often confused with R. lepidodendroides Meek on account of the presence of a few large acanthopores.[1] It is distinguished from the latter by the even cylindrical surface, small apertures, wide interspaces, and thin mature regions.

Range and distribution--A few stem fragments were found in the Florena shale at Manhattan, and in the lower Neosho at Strong City.

Genus Tabulipora Young

Tabulipora distans (Condra)

While the zoarium of T. distans is normally an incrusting expansion, a few specimens have been found of the ramose form. I have a few specimens in my collection which I am referring to this type. The apertures are subcircular and of varying sizes, with the interspaces thick and unequal in width. I have observed a few large acanthopores at some of the cell angles but they are not common, while numerous small ones surround the zooecia.

This species resembles T. spinulosa Rogers in having similar though larger and less numerous large acanthopores which are not placed along the walls between the zooecia as

1. Condra, G. E. "Coal Measure Bryozoa of Nebraska". Nebr. Geol. Survey, vol. 2, pt. 1.

well as in the cell angles. The presence of diaphragms also distinguishes it from this species. The ramose forms collected by Condra are about the size of the old growth of R. lepidodendroides, but can be distinguished by the number of diaphragms.

Range and distribution--A few specimens were found in the Florena shale at Manhattan and in the upper shale beds at Strong City.

Tabulipora heteropora? (Condra)

I am provisionally referring a few stem fragments to this species. Condra's original description of this species is that of a massive or incrusting zoarium. My specimens are of the incrusting form on small stem fragments of R. lepidodendroides. The distinguishing feature on which I am basing my identification is the variation in size of the zooecial apertures. There appears to be no definite arrangement of the openings. On some I have observed slight elevations occurring over the surfaces, but they are very inconspicuous.

The distinguishing characters of this species are the varying sizes of the zooecial apertures and in the form of the zoarium. It is similar to T. rudis Ulrich but differs mainly in being a massive or incrusting form and not irregular branches.

Range and distribution--Rare in the Neosho member.

Tabulipora carbonaria (Ulrich)

This is the most common species of this genus to be found in the Garrison formation, and is about as abundant as any of the other bryozoans collected. None of the specimens in my collections show any marked differences from those described by Ulrich.[1] Several of my specimens show larger and more numerous acanthopores than others, especially the larger forms. This difference in size is probably due to immature growth and possibly some of the specimens have been more weathered.

Several cross sections of some of the specimens, which I made, show the same distinguishing characteristics. Diaphragms are very numerous in the mature zooecia and occur about a tube's diameter apart. The divisional lines between the thickened portion of the walls of the zooecia is marked by a series of minute dark spots.

Range and distribution--Abundant throughout the Garrison formation.

Tabulipora spinulosa (Rogers)

In all of my specimens the large acanthopores occurring at the so-called cell angles project from the surface as prominent spines. Smaller acanthopores are placed along the walls between the angles but do not show any definite arrangement.

1. Ulrich, E. O., Geol. Surv. Ill., VIII, p. 443, pl. LXXIII.

In some of my specimens I have not observed any mesopores, while a few have some very small ones. All of the specimens in my collection are well preserved and show prominently the spine-like acanthopores. Some of the acanthopores are so conspicuous that they can be detected without the aid of a lens.

[1]"This species is similar to T. ohioensis Foerste. The acanthopores are more numerous and there is a greater contrast between the large and small acanthopores. There are six instead of ten apertures in a space of two mm."

Range and distribution--A few specimens were found in the Florena shale at Manhattan and Cottonwood Falls.

Suborder Cryptostomata

Family Fenestellidae King

Genus Fenestella Lonsdale

Fenestella mimica Ulrich

This fenestellid species is very common in the Neosho member of the Garrison formation. All of my specimens are straight-branched with few bifurcations. The carina appears as a faint line on most of them but is fairly distinct in a few. All, nowever, show the row of small spines on the carina 0.12 mm. apart. The dissepiments do not appear quite as wide as those described by Ulrich.[2]

1. Stenopora spinulosa Rogers, Kan. Univ. Quart., IX, No. 1, pp. 1-2, pl. IV, 5.
2. Ulrich, E. O., Geol. Surv. Ill., VIII, p. 552.

In nearly every specimen the apertures occur, one at each end of the dissepiment and one about equi-distant from each dissepiment along the fenestrule. This does not always hold true on some branches just above a bifurcation.

Closely related forms are F. tenax Ulrich, F. limbata Foerste and F. spinulosa. F. tenax has larger cell apertures, larger and more elliptical fenestrules, and a distinct, prominent keel. F. spinulosa is more robust and with fewer zooecia. F. limbata has narrower fenestrules, a wider keel with blunt spines about .20 mm. apart.

Numerous fragments were found in the middle Garrison at Strong City and in the upper Garrison south of Manhattan.

Fenestella limbata Foerste

This species so closely resembles F. mimica that some of my specimens appear to be nothing more than varieties of the latter. They show, however, a straight and more definite carina with a row of spines about .2 mm. apart. The spines are as wide as the carina but on some specimens they have been worn down, appearing low and broad. The apertures are not quite as large as those in F. mimica but all have prominent peristomes.

The branches on the reverse face are prominently striated and in some specimens the dissepiments show faint

striations. The fenestrules on the reverse are more nearly rectangular than with either F. tenax or F. mimica. On the obverse face they are about twice as long as wide, modified by the slightly expanded dissepiments and zooecial apertures. The carina, slightly encroaching apertures, and prominent striae serve to separate the species from typical F. mimica Ulrich.

Range and distribution--Rare in the Florena shale at Manhattan.

Fenestella tenax Ulrich

Plate III, figure 3.

None of my specimens show any marked differences from those described by Ulrich.[1] The striations on the reverse face of some of them are more prominent than on others. The dissepiments are short but wide, making the fenestrules elliptical on the reverse. Zooecia generally occur at the ends of the dissepiments and one between. The apertures are not as large as those of F. mimica. The spines on the carina of some of the specimens are very obscure, having probably been worn off.

This species resembles the form F. cyclofenestrata to some extent, but has a more pronounced keel with few spines and not quite as large dissepiments.

1. Fenestella tenax Ulrich, Geol. Surv. Ill., VIII, p. 546.

Range and distribution--Common in the Florena shale.

Fenestella spinulosa Condra

This species is represented in my collections by several fragments. All of the specimens show the characteristic large spines on a definite carina, and the small zooecia. The spines are arranged so that one occurs near the end of each dissepiment with another between.

Condra[1] in his original description recognizes two forms of growth. "One of which has strong branches (about their own diameter apart), stout dissepiments, and rectangular fenestrules; the other form is more lax in growth, having wider fenestrules, as well as thinner branches and dissepiments. Specimens belonging to the last named form were at first classified as F. sevillensis Ulrich on account of characters of the reverse face. As soon as the obverse was seen, they were correctly placed. F. perelegans (Meek), an associated species, resembles F. spinulosa in general measurements but has very thin, depressed dissepiments on the reverse; the obverse faces are quite dissimilar."

Range and distribution--Several specimens were found in the Florena shale.

Fenestella gracilis Condra

A few specimens belonging to this species were found in the Florena shale.

1. Fenestella spinulosa Condra, Am. Geol., XXX, No. 6, pp. 343, 344, pl. XXI, 4-6.

The distinguishing characters in F. gracilis are the straight branches and fairly long fenestrules. The obverse face has a wide carina, with rounded summit, bearing a row of small, sharp, conical spines placed about .22 mm. apart. The fenestrules are quite regular in form, subrectangular, varying some in dimensions with different conditions of growth.

The zooecia are placed in two alternating ranges with moderately prominent peristomes, set close in against the carina. In some of my specimens there are four zooecia to the fenestrule while in others there are five.

This species is similar to F. dentata Rogers, but is not so large or robust.

Range and distribution--Florena shale at Manhattan and Cottonwood Falls.

Fenestella binodata Condra

Plate III, figure 21.

My collection contains only a single specimen which I am identifying as this species. The chief distinction to be noted is the rather broad and rounded keel bearing an alternating double row of compressed but prominent nodes. The nodes on my specimen are not quite so large or as elevated as those figured by Condra.[1]

1. Fenestella binodata Condra, Nebr. Geol. Survey, vol. 2, pt. 2, pp. 66-67.

[1] "This species, though related to F. ovatipora Rogers, which has a raised area and no spines, is very distinct. This species is nearer F. conradicompactilis Condra, which may have a slightly binodate appearance, but is distinct on account of the character and number of apertures to the fenestrule, and the more definite binodate arrangement of larger nodes; the reverse faces are very dissimilar. The principal characters of this species are found in the double row of alternating nodes on a broad carina, and in the comparatively robust appearance."

Range and distribution--A single specimen was collected from the Florena shale at Manhattan.

Genus Thamniscus King

Thamniscus octonarius Ulrich

This palmate-form of bryozoan is a common fossil throughout the Garrison formation. All of my specimens show typically the characters assigned to this species.

The circular apertures are arranged in a longitudinal series between obscure raised lines, and in more or less regular diagonal series. The peristome rises about the aperture, incomplete at its lower margin, spreading again and becoming obsolete below the aperture so as to enclose a faintly margined circular suboval depression.

1. Fenestella binodata Condra, Nebr. Geol. Surv., vol. 2, pt. 2, pp.66-67.

[1]Ulrich detected in some of his specimens a small pore at the bottom of these depressions. I have not observed any such pores on my specimens as all of the depressions appear to be partially filled with matrix. In some of my specimens the peristomes are quite prominent while in others they are worn down and almost obscure.

Ulrich's type specimens were collected from the Upper Coal Measures of Greenwood County, Kansas.

Range and distribution--Abundant in all the shale layers of this formation.

Family Acanthocladiidae Zittel

Genus Pinnatopora Vine

Pinnatopora pyriformipora Rogers

Several specimens possessing the more or less distinctive characters of P. pyriformipora are contained in my collections. Some of my specimens have more prominent spines along the mesial carina than in some of the others. The smaller spines are found on the more weathered specimens and undoubtedly have been worn down. The spines occur about 0.4 mm. apart, the same as in those figured by Rogers.[2]

1. Ulrich, E. O., Ill. Geol. Surv. vol. 8, Text, p. 612.
2. Pinnatopora pyriformipora Rogers, Kans. Univ. Quar. IX, No. 1, p. 9, pl. 11, 6, 6a.

This species resembles P. trilineata Meek in general outline and size, but does not show a triliniate carina on the obverse face.

Range and distribution--Common in the Neosho member.

Pinnatopora trilineata Meek

The three mesial lines constitute the principal distinguishing character of this species. The size of the midrib as well as the number of pinnae in a given space are also important. The obverse face of all of my specimens show very distinctly the three fine straight lines along the center, the median one in all specimens being slightly the stronger.

According to Meek's[1] measurements, between eight and nine pinnae are given off on each side in 1 cm. Forms of the same species observed by Condra and Ulrich were found to have twelve pinnae given off on each side in the space of 1 cm., as do the specimens which I have examined. I have several specimens which tally with these measurements but the obverse faces are so obscured with matrix that it is impossible to determine if the three mesial lines, so characteristic of this species, are present.

Range and distribution--A few specimens were found in the shale at Cottonwood Falls and Strong City.

1. Glauconome trilineata Meek, 1872. Pal. East. Neb. p. 157, pl. 7, fig. 4a?4b-4d.

Pinnatopora youngi? Ulrich

I am provisionally referring a few specimens to this species. They are all of a more robust form than the two species previously described. The midrib is strong with the reverse side broadly convex and finely striated. The obverse face is rather flat with a keel bearing nodes about .8 mm. apart.

This species is closely associated with P. vinei but is distinguished by a thicker midrib, shorter lateral branches, and longer zooecia.

Range and distribution--Found in the lower Middle Garrison formation at Strong City.

Genus Septopora Prout

Septopora biserialis Swallow

This is one of the most common bryozoans found in the lower Permian. It is easily recognized by the small mesial carina on the obverse face carrying long and prominent nodes. Most of my specimens are so well preserved that they show these spine-like projections very plainly without the need of a lense. The branches are nearly parallel, increasing in number by interpolation or by lateral division, smooth or striated, with few accessory pores on the reverse face. In nearly all of my specimens the dissepiments are slightly arched but in a few they are straight.

The species is closely related to S. robusta but does not have as many accessory pores on the reverse faces and has only two rows of zooecia on the dissepiments while the former has three. It is distinguished from S. subquadrans Ulrich in developing new branches by interpolation and lateral division instead of bifurcation.

Range and distribution--Abundant in both members of the Garrison formation.

Septopora multipora (Rogers)

Several fragments of this species, distinguished by the reverse face covered with fine longitudinal striae and circular pores, with moderately well defined peristomes, are contained in my collection. All of my specimens conform to the original description given by Rogers[1]. Some, however, are a little more robust than others. The obverse face shows a rounded carina with small nodes placed at distances of 0.35 mm.

This species is closely related to Septopora decipiens Ulrich, but differs in having eight instead of twelve to thirteen lateral branches or pinnae on each side of the midrib in 1 cm. Specimens first studied by Rogers were placed under the genus Pinnatopora. He did not study the obverse face and failed to recognize the pinnae as being united by dissepiments.

1. Pinnatopora multipora Rogers, Kansas Univ. Quart., IX, No. 1, pl. III, 2, 2a.

Range and distribution--Common throughout the Garrison formation.

Septopora pinnata Ulrich

My specimens belonging to this species are almost like basal portions of S. biserialis (Swallow). This form is regarded by some authors as not representing a logical species distinct from S. biserialis. S. interporata is in all probability a synonym.

The zoarium is a pinnate frond consisting of one or more midribs and lateral branches. The obverse face bears a carinate ridge with a row of small nodes. The dissepiments are relatively large, and may be either arched or straight, with two to nine zooecial apertures on each one. Small pores are often found between the zooecial apertures but the same feature often occurs on other species of the same genus.

Range and distribution--A few specimens were found in the lower and middle Garrison at Strong City and Cottonwood Falls.

Septopora robusta Ulrich

This species is represented in my collection by a few well preserved fragments. In general appearance this form is similar to S. biserialis, in having a distinct keel on the obverse face bearing a row of prominent nodes, but the branches and dissepiments are more robust.

The distinguishing characters of the species are its robust appearance, the presence of three ranges of zooecia on each dissepiment, and by the large number of accessory pores on the reverse face. In some of my specimens these pores are more numerous than on others but all show this feature very plainly as well as the three ranges of zooecia on the dissepiments.

Range and distribution--Rare in the Garrison formation.

Family Rhabdomesontidae Vine

Genus Rhombopora Meek

Rhombopora lepidodendroides Meek

Plate I, figures 11, 12.

Possibly with the exception of S. biserialis this species is the most common and widely distributed bryozoan in the Neosho member of the Garrison formation.

Meek's[1] description was based on the young growth. Condra[2] collected many specimens from the Coal Measures of Nebraska and placed them under the following ramose growths: 1. young condition; 2, old condition with monticules; 3, old condition with monticules. To the ramose growths may be added

1. Rhombopora lepidodendroides Meek, Pal. East. Neb., p. 141, pl. VII, 2a-f.

2. Condra, G. E., Coal Measure Bryozoa of Nebraska, Nebr. Geol. Surv., Vol. 2, pt. 1, p. 100.

the incrusting form, which is rarely found.

I have specimens in my collection typical of these types of growth, the young forms and old forms without the monticules being the more common. The apertures in the young growth are arranged in vertical and diagonally intersecting series which open into rhombic or subelliptical vestibules. The intersecting series and vestibules are not plainly shown in old growths.

Range and distribution--Abundant in the Neosho member.

Genus Streblotrypa Ulrich

Streblotrypa prisca (Gabb and Horn)

Several fragments of this branching form are contained in my collection. This species is readily distinguished by the surface modified by slightly wavy longitudinal ridges between which occur shallow depressions into which the apertures and mesopores open. These small pits or mesopores occur below the apertures, usually in two rows, placed at regular intervals, generally with six in each depression. The small pits on my specimens are nearly all partially filled with matrix but under a microscope are easily detected.

The species is somewhat similar to S. nicklesi Ulrich but has considerably larger cells.

Range and distribution--Common in the lower and middle Garrison at Cottonwood Falls and Strong City. A few specimens were found in the upper Neosho member at Strong City.

Class Bracniopoda Dumeril

Order Neotremata Beecner

Superfamily Discinacea Waagen

Family Discinidae Gray

Genus Orbiculoidea d'Orbigny

Orbiculoidea mannattanensis Meek & Hayden

This species is represented in my collection by a single brachial valve which is somewhat crushed. The shell is subcircular in outline, of moderate size, with the apex moderately prominent. The surface is ornamented with concentric growth lines, wider at the anterior margin. The foramen is situated just beneath the beak of the valve, but is filled with matrix. The diameter measured 13.5 mm. which is small for this species.

[1]"This species differs from O. missouriensis in being more compressed, thicker shelled, shorter sulcus, and in having more distinct concentric lines; from O. convexa in being much less convex and much smaller."

Range and distribution--This single specimen was found in the Upper Garrison at Strong City.

Order Protremata Beecher

Superfamily Strophomenacea Schuchert

Family Strophomenidae King

Subfamily Orthotetinae Waagen

Genus Derbya Waagen

1. Beede, J. W., Kan. Univ. Geo. Survey, Vol. VI, p. 56.

Derbya crassa Meek and Hayden

Plate II, figure 3.

This species is represented in my collection by one complete specimen and the fragments of several others.

This single specimen is subcircular in outline, contracting somewhat at the hinge line. The ventral valve is gently convex with the beak somewhat projecting. The dorsal valve is moderately convex, the beak being small and depressed.

The fragments of this species which I have have all been crushed, giving a crinkled appearance to the surface of the valves, and to the edges.

The one well preserved specimen which I have agrees very closely with Meek's[1] description of the surface markings. The surface is marked by thin, elevated lirae, separated by relatively broad flat interspaces. The lirae are more or less regularly alternating or unequal. Across the surface occur regular, fine, crenulating lamellae which produce scale-like projections.

D. crassa is similar to D. robusta but is of a much smaller size. Some of the fragments which I collected indicate a size larger than D. crassa and may be possibly D. robusta.

Range and distribution--Upper and Lower members of the formation at Mannattan, Strong City and Cottonwood Falls.

1. Meek and Hayden, Acad. Nat. Sci. Phila. Proc., p. 261.

Derbya cymbula Hall and Clarke

The specimen in my collection, although part of the anterior portion of both valves are missing, conforms closely to the original description.[1]

This species is characterized by the large size of the shell and straight hinge line about two-thirds the greatest diameter of the shell. It is easily recognized and separated from D. bennetti by its larger size, relatively lower beak and its non-bilobate brachial valve. Another species, D. affinis described by Hall and Clarke is very similar to D. cymbula but differs in the location of the point of greatest convexity in the pedicle valve and smaller size. Beede[2] collected similar specimens from the Upper Coal Measures, but while they fitted the description of D. affinis, he considered them as young or stunted forms of D. cymbula.

The surface of my specimen is covered with numerous fine striae, increasing by implanation, being of about equal size over the umbonal region but increasing in size nearer the margin.

Range and distribution--A single specimen was found in the Middle Garrison at Strong City.

Derbya robusta Hall

Several incomplete specimens were found in the Florena

1. Derbya cymbula Hall and Clarke, Pal. N. Y., VIII, pt. 1, p. 348, pl. XI-B, ff. 2, 3, (1892).
2. Derbya cymbula Beede, Kan. Univ. Geol. Sur., VI, p. 61.

shales, but most of them well enough preserved for identification.

This species agrees in many respects with the description of D. keokuk and it is quite probable that the two are synonymous. D. keokuk was first found and described from the Keokuk beds of the Mississippian but many specimens have been collected from the Upper Pennsylvanian and Lower Permian which are almost identical with this species. The outline and interior of the pedicle valve of both species are identical. Some specimens differ from D. keokuk in a slightly longer hinge as ascribed to that species. The length of the hinge is not a constant character in any of the species of this genus.

Professor Clarke[1] regards D. robusta as a continuation of the other specific type, perhaps with some slight variation, and that the genus attained its culminant variability of expression in the Coal Measures.

Two of my specimens show the interior of the pedicle valve marked by a large, deep, semicircular impression, which is marked by irregular radiating ridges and furrows of variable size.

Range and distribution--Common in the Florena shales at Manhattan.

Genus Meekella White and St. John

Meekella striatacostata Cox

Plate I, figures 1, 3.

1. Kan. Univ. Geol. Surv., Vol. VI., p. 67.

The specimens which I have are all somewhat crushed. There is considerable individual variation to be found in this species. In most of the larger specimens the width is considerably greater than the length. The distinctness of the plications varies with age. In young specimens the plications are very narrow and faint, in older ones they are more distinct and sharp. Young specimens are much less convex and comparatively longer than old ones. The height of the cardinal area varies greatly, some specimens having the beak only moderately elevated.

One of my specimens shows particularly well the radiating plications, which are marked by fine radiating striae. Across these toward the front and lateral margins occur a few growth lines.

Measurements of a specimen--Length, 20 mm.; width, 27 mm.; convexity,

Range and distribution--Florena shales, Manhattan and Cottonwood Falls.

Family Productidae Gray

Subfamily Chonetinae Waagen

Genus Chonetes Fischer

Chonetes granulifer Owen

Plate I, figures 4,5,6,8,9.

This bracniopod is the most common one found in the Garrison formation. It has both a wide vertical and horizontal range.

C. granulifer is closely related to C. flemingi and probably should not be regarded as distinct species but as distinct varieties of the same species. Both species are marked by radiating lirae of about the same degree of fineness. C. granulifer is generally distinguished by a larger, flatter and longer hinge, a narrower cardinal area, and less prominent beak. C. flemingi is covered with numerous small spines, a feature which is less conspicuous in C. granulifer but is none the less present.

[1] "Meek and Hayden described the large mucronate type as Chonetes mucronatus but later placed that species in the synonymy of C. granulifer Owen and consequently are responsible for the general application of the name C. granulifer to the spreading mucronate type of shell." For this reason Girty is disposed to associate the name C. granulifer rather with the type of shell which Norwood and Pratten called C. flemingi.

A large number of the shells which I have collected are more of this mucronate type, while many others are more blunt and covered with numerous small spines, typical of C. flemingi. It is evident that there is considerable variation between these two types and it is possible that I have two different species in my collection. I will, however, refer all of them to the species C. granulifer as first described by Owen.

1. Girty, G. H. Fauna of the Wewoka Formation of Oklahoma, U. S. G. S., B. 544, p. 60.

It is possible that all of these forms will be recognized as C. variolatus D'Orbigny of which C. flemingi has been considered a synonym. The interlira pores have been described as distinguishing characters of both species.

Measurements of five specimens:

Length	Width	Convexity
16.5 mm.	29 mm.	4.5 mm.
14.0 mm.	27 mm.	3.5 mm.
13.0 mm.	24 mm.	2.5 mm.
15.0 mm.	28 mm.	4.0 mm.
14.0 mm.	21 mm.	2.5 mm.

Range and distribution--Both members of the Garrison formation. More common in the Florena shales.

Subfamily Productinae Waagen

Genus Productus Sowerby

Productus cora d'Orbigny

Plate II, figure 4.

This species is distinguished from the other productids by the fine, crenulated striae and the scarcity of spines. It is similar in outline form to P. pertenuis but considerably larger. Most P. coras have few spines, while some have a large number, which is quite characteristic of P. pertenuis. I have counted forty spines on my specimen and there may be possibly a few more. I base my identification of this specimen on the shallow mesial sinus of the ventral valve, which may or may not be found on all of this species, but is never found on P. pertenuis.

P. cora is closely related to P. insinuatus and in young specimens of either species it is almost impossible to distinguish them apart. Relative lack of spines and a ventral sinus is a basis of separation, but even these variations are not constant for either species.

I can not determine the measurements of my specimen because the anterior and side portions of valve have been broken away.

Range and distribution--This single specimen was found in the Upper Garrison at Strong City.

Productus semireticulatus Martin

Plate II, figures 1, 2.

Next to Chonetes granulifer this brachiopod is the most common one occurring in this formation. Several specimens were collected from all three horizons at different localities.

This species is distinguished by its large size, subquadrate outline, broadly distinct sinus and moderately sized sub-equal striations bearing a few scattered spines. Girty[1] describes a new variety of a western form, "hermosanus," which in general resembles P. semireticulatus but is somewhat smaller, more inflated and incurved, with fewer spines, and ears which are at the same time more extended and inrolled.

1. Girty, G. H., Carboniferous Formations and Faunas of Colorado, U. S. G. S., Prof. Paper 16, p. 359.

Several of my specimens show considerable variation in size but are all undoubtedly the same species. A few of them have small, short pustules on the front part of the curving valve.

Measurements of a single specimen: Length, hinge to front, 39 mm.; width, 58 mm.; convexity, 30 mm.

Range and distribution--Specimens were collected from both the Upper and Lower members of this formation at Manhattan, Cottonwood Falls, and Strong City.

Genus Pustula Thomas

Pustula nebraskensis Owen

Plate I, figure 2.

I have one small specimen measuring 19 mm. in length and 22 mm. in width, and three larger ones somewhat crushed and cemented together.

All of the shells are a little wider than long, with the hinge line less than the greatest width of either valve. A moderately distinct mesial sinus extends from the beak to the anterior margin of the valve. The surface of the ventral valve is covered with more or less defined, broad concentric undulations, and obscure striae of growth, over which are arranged two sets of spines, connected at their bases with short interrupted ribs or elongated tubercles. One set consists of small short appressed spines, and the other of stout, more erect long ones.

This species is distinguished from others of the same genus by its relative small size, and the presence of the concentric grooves or undulations, which form a rather characteristic feature of the species. Some specimens show two different sets of spines, in some the larger spines are sparingly developed, while in other specimens the small spines are less abundant.

Range and distribution--This species was found in the Middle and Upper Garrison at Strong City.

Order Telotremata

Superfamily Spirideracea Waagen

Family Spiriferidae King

Genus Spiriferina King

Spiriferina kentuckyensis Meek

Plate I, figure 13.

Only one specimen belonging to this species was found in the Upper Garrison at Strong City. The width of my specimen is considerably greater than the length, producing very sharp mucronate ears. The plications on either side of the mesial sinus are high and somewhat sharp. Both the fold and the sinus are larger than the ribs. The surface of both valves is ornamented with evenly arranged lamellae of growth.

This species has been regarded as the same as S. spinosa which is an entirely different species. Hall and Clarke[1]

1. Hall and Clarke, N. Y. Geol. Surv., Vol. 8, pt. 2, p. 54.

describe a form as being S. kentuckyensis which is larger, a shorter hinge line, and with low and broad plications, which is possibly S. subelliptica.

Measurements of the specimen: Entire length, 7 mm., width, 16 mm.; convexity, 5mm.

Range and distribution--This single specimen was found in the Upper member of the Garrison formation at Strong City.

Family Athyridae Phillips

Subfamily Athyrinae Waagen

Genus Composita Brown

Composita subtilita d'Orbigny

Plate II, figures 6, 7.

Tnis species is represented in my collection by two fairly large specimens slightly crushed and several fragments of smaller sized shells.

Individual variations make this species an interesting one to study. Some forms have a nearly circular outline, while others are more elongate. In some the sinus is shallow and broad; in others narrow and deep; and in certain smaller types it is little more than a depressed line.[1] Girty regards the latter as young examples of the larger, more strongly characterized shells.

All of the shells in my collection are probably those of old specimens, being quite large, and having the characteristic

1. Girty, G. H. Carboniferous Formations and Faunas of Colorado, U. S. G. S., Prof. Paper 16, p. 406.

broad shallow sinus. The surfaces of the valves are practically smooth, with imbricating growth lines more conspicuous on the anterior halves of the valves.

Measurements of two specimens: Length, 43 mm., 36 mm.; width, 34 mm., 40 mm.; convexity,

Range and distribution--Common throughout the Garrison at Cottonwood Falls, Manhattan, and Strong City.

MOLLUSCA

Class Pelecypoda Goldfuss

Order Prionodesmacea

Superfamily Nuculacea

Family Nuculidae Adams

Genus Nuculopsis Girty

Nuculopsis ventricosa Hall

This species is represented in my collection by the casts of two small specimens. The beaks are rather widely separated and the top of the cast in front of them is slightly concave. The casts are thick, sub-ovate, and very convex, with the greatest convexity in advance of the middle of the valve.

Girty[1] distinguishes this species from a true Nucula and places it in a new genus, on the following characters--the ligamental grooves, the usually almost smooth surface,

1. Girty, G. H., Fauna of the Wewoka Formation of Oklahoma. U. S. G. S., B. 544, p. 119.

the projecting and sharply rounding anterior extremity, the little constriction at the anterior end, and the strongly convex border back of the middle.

Measurements of the two specimens: Length, 22 mm., 19 mm.; width, 14 mm., 15 mm.

Range and distribution--Two specimens were collected from the shales below the base of the Wreford limestone, five and one-half miles south of Manhattan.

Order Anomalodesmacea Dall

Superfamily Anatinacea Dall

Family Pholadellidae Miller

Genus Allorisma King

Allorisma subcuneata Meek and Hayden

I have in my collection the fragment of a single specimen. Most of the dorsal part of both valves has been broken away and a small part of the basal margin. The beaks of both valves are quite pronounced. The well defined concentric undulations usually more distinct on the beaks and umbonal region are very prominent. The shell is longitudinally elongated, the general outline of the fragment indicating a size about three times as long as high.

This species is similar to A. granosum and A. geinitzi but is readily distinguished from either of them by its larger size and more slender form. A. subcuneata differs from A. costatum in the absence of the large, even, sharply elevated ribs which is typical of the latter.

Range and distribution--This single specimen was collected from the shales below the Wreford limestone, five and one-half miles south of Manhattan.

Class Gastropoda

Subclass Stretoneura Spengel

Order Aspidobranchia Schweigger

Suborder Rhipidoglossa Troschel

Family Euomphalidae de Koninck

Genus Schizostoma Bronn

Schizostoma catilloides Conrad

Plate I, figure 10.

This species was originally described by Conrad under the genus Inachus as I. catilloides. The following is Conrad's[1] original description:

Inachus catilloides.-"Discoidal; both sides concave from the outer margin to the center; all the volutions exposed, transversely wrinkled; large volution carinated on the margins; back obtusely carinated in the middle."

I have a single specimen in my collection, which has been somewhat crushed, the upper surface being concave while the lower surface is nearly flat.

Range and distribution--This specimen was found in the Middle Garrison at Strong City.

1. Conrad, Acad. Nat. Sci. Phila. Jour., 1st ser., vol. 8, pt. 2, p. 273, pl. 15, fig. 3.

ARTHROPODA

Subphyllum Branchiata

Class Crustacea

Subclass Trilobita Walch

Order Opisthoparia Beecher

Family Proetidae Corda

Genus Phillipsia Portlock

Phillipsia sangamonensis Meek & Worthen

Plate II, figure 5.

I am provisionally referring several small pygidia to members of this species. The pygidia of this species are quite common and occur throughout the shales of the Garrison formation.

The pygidium is somewhat triangular in outline, slightly wider than long, narrowing to the posterior end. The border is wider at the posterior end and narrows toward the anterior. Most of my specimens are worn and obscured with matrix, so that it is impossible to count the number of segments. Girty[1] in his description of this species counts about 20 segments to the axis and about 11 segments to each of the pleural lobes. The segments of the axis are naturally narrower than the lateral ones.

Closely related species are P. major and P. missouriensis. The former has 23 axial and 12 pleural segments and the latter has 18 axial and 11 pleural segments on the pygidium. Girty[1] regards all three species as possibly being the same. The

1. Girty, G. H., Fauna of the Wewoka Formation of Oklahoma, U. S. G. S., B. 544, p. 268.

differences which he points out between P. sangamonensis and the other two are that the cephalon contracts a little more distinctly from the genal angles forward. The axis of the thorax appears to be broader in some specimens, and the border at the end of the pygidium slightly narrower.

Range and distribution--Common throughout the Garrison formation.

Subclass Eucrustacea Kingsley

Suborder Ostracoda Latreille

Superfamily Beyrichiacea Ulrich and Bassler

Family Beyrichiidae Jones, emend Ulrich and Bassler

Genus Hollina Ulrich and Bassler

Hollina radiata Ulrich and Bassler

Plate III, figures 10, 12.

This species is very abundant in the shales of the Garrison formation, numerous specimens were collected from all of the localities visited.

In this species the general outline of the shell, minus the frill, is similar to that of H. emaciata. The principal difference is the much wider frill in H. radiata. The width of the frill varies considerably with individuals. In most of my specimens it is from two to two and one-half times wider than in H. emaciata. A few show very distinct radial plications--the plications often appearing as rather heavy, dark lines on the frill.

The surface markings on my specimens are the same. The granules on the surface of the valves are more conspicuous in some and less so on others, but none, however, are as prominent as the granules on H. emaciata.

This form is different from H. emaciata Ulrich and Bassler by having a much wider frill and faint plications.

Range and distribution--Common in all horizons of the Garrison.

Hollina emaciata Ulrich and Bassler

Plate III, figures 8, 9.

In size, shape, and general expression this species is about the same as H. radiata, but has an emaciated look, the surface of the valves between the nodes being more sunken and the ventral portion less tumid though ridged. A short, vertical curved ridge in the post-dorsal angle and a rim-like border along the straight back and anterior end, are other distinguishing features. The flange in this species is very narrow and even, rising from a point on the anterior near the margin and extends around the valve above the margin, dying away close to the postero-dorsal angle. In some specimens the spines located on the anterior margin of the valve are more numerous and larger than on others.

This species is similar to H. buenleri Knight but is distinguished by the presence of the curved ridge in the post-dorsal angle and the rim-like border along the dorsum and

anterior end. It differs from H. radiata in a narrower and flatter frill and the absence of plications.

Measurement of two specimens: length, 1 mm., 0.98 mm.; width, 62 mm., 0.57 mm.

Range and distribution--Abundant in the Garrison formation.

Genus Hollinella Coryell

Hollinella bassleri (Knight)

The outline of this species is entirely similar to H. buehleri Knight.[1] The anterior node is less prominent and the frill consists of a linear row of short spines, uneven in length. A second row of spines extends around the ventral and end margins close to the margin of the valve and reaches almost to the hinge-line at both ends.

Many of the specimens in my collection vary as to size. A few of the smallest ones average about 0.38 mm. in length and 0.21 mm. in height. The larger specimens average 0.81 mm. in length and 0.45 mm. in height. These smaller specimens are undoubtedly young forms of the same species for I have not been able to find any differences other than size.

This species is clearly differentiated from H. dentata[2] Coryell by having two rows of spines instead of one. In H. dentata the spines are larger and more tubucular in shape. It is similar in general outline to H. ovata Coryell. H.

1. H. buehleri Knight, Journ. Pal., vol. 2, No. 3, p. 236.
2. H. dentata Harlton, Journ. Pal., vol. 1, No. 3, p. 203.

grahamensis Hariton has two rows of submarginal spines but they are larger and are described as bordering a small marginal frill which lies between them.

Range and distribution--Numerous specimens were collected from the middle and upper Garrison.

Family Kloedenellidae Ulrich and Bassler

Genus Jonesina Ulrich and Bassler

Jonesina bolliaformis Ulrich and Bassler

This is a very common species in the Garrison shales. Several of my specimens are from the same horizon and locality as those first collected and described by Ulrich and Bassler.[1]

The distinguishing features of this species are the rather elongate subovate form, surface of the valves with two rounded and not very prominent nodes, subcentrally situated, one on either side of the deep median sulcus, and generally connected by a more or less obscure loop.

The two nodes with the connecting loop are in appearance suggestive of some species of Bollia. In some of my specimens the "loop" is well defined, while in others it is almost indistinct. This form is similar in outline to J. craterigera (Jones and Kirkby) but differs in having smooth surfaces, while the latter has reticulated surfaces. It differs from Beyrichia fodicata Jones and Kirkby and B. fastigata Jones and Kirkby by its relative shorter valves and margined by a distinct rim.

1. New paleozoic Ostracoda-Ulrich and Bassler, U. S. N. M. Pr. vol. 30, No. 144, pp. 158-159.

Range and distribution--Many specimens were collected from all of the shale members of this formation.

Jonesina bolliaformis tumida Ulrich and Bassler

Plate III, figures 13-16.

This form differs from the typical variety of the species in two particulars,[1] "(1) the outline is somewhat rhomboidal, the anterior border being oblique, beginning to curve backward just beneath the antero-dorsal angle, and (2) the anterior third of the valve within the rim is much more tumid, this portion of the carapace being indeed decidedly thicker than the posterior part and generally exceeds even the middle thickness. Occasionally the antero-median node is obsolete.

"It is thought possible that this variety may indicate merely a sexual phase of J. bolliaformis. Supposed female individuals of a number of Silurian and Devonian species of Jonesina are known, but in these the tumidity is larger and much more sharply defined, and it occurs, not on one of the ends, but always on the ventral side of the valves."

In some of my specimens the overlapping of the left valve onto the right is quite pronounced. The surface of nearly all of the specimens are smooth, a few, however, are finely granulated. Some of the more mature forms have a slightly wider flange than the younger specimens.

1. J. bolliaformis tumida, Ulrich and Bassler,, U. S. N. M. Pr., vol. 30, No. 1446, pp. 159.

Range and distribution--Specimens were collected from the lower, middle and upper Garrison.

Family Kirkbyidae Jones

Genus Ulrichia Jones

Ulrichia montosa Knight

Plate III, figure 11.

This species is represented in my collection by two single specimens collected from the upper Garrison formation.

The distinguishing characteristics of this form are the two prominent nodes separated from each other by a valley-like depression and the pronounced reticulation of the surface of the valves. In both of my specimens the pits are quite large, the largest ones being in a row next to the inner flange. The relief on the anterior node appears to be lowest ventrally while on the posterior node it is the reverse, both being about the same in size. The hinge is straight and almost equal to the greatest length of the shell. The ventral outline is nearly straight to gently convex. The antero-dorsal angle is acute and sharp while the postero-dorsal angle is more obtuse and less sharp.

This species most nearly resembles Ulrichia bituberculata McCoy but is distinguished from it by sharper and more elevated nodes, relative greater length and sharper antero-dorsal angle.

The dimensions of my two specimens are:

Length	1.20 mm.	1.11 mm.
Height	0.60 mm.	0.50 mm.

Range and distribution--The two specimens were found in the upper Garrison at Strong City.

Genus Kirkbya Jones

Kirkbya voluta Knight

This species is represented in my collection by two single valves--one right and one left. Both specimens conform closely to Knight's[1] description. The anterior part of the right valve is broken away so that it is impossible to determine the exact size of the antero-dorsal angle or the complete length of the hinge-line. The general curvature of the antero-ventral margin indicates an angle of about ninety degrees with its juncture at the hinge-line.

A smooth, narrow margin extends from angle to angle. The inner flange is carinated and extends from angle to angle, the widest area between the inner and outer flange being located ventrally and tapering to the angles. The noding on my specimens is very obscure. Two indistinct nodes rise near the dorsal line and are more or less connected by a broad rounded ridge curving down ventrally. There is a very shallow depression between these nodes along the dorsal hinge area.

In general shape and outline this form is similar to U. montosa Knight. Surface markings are quite close to some of the species belonging to the genus Ampnissites. It differs from K. permiana Jones in its concentrically wrinkled surface and plateau-like area within the corrugations.

1. Journ. Pal., vol. 2, No. 3, p. 253, pl. 32, fig. 3a-b.

Measurements of two specimens: length, 1 mm., 0.90 mm.; height, 0.46 mm., 0.50 mm.

Range and distribution--Two specimens were found in the Florena shales at Manhattan.

Kirkbya scaphula? Knight

There are several specimens in my collection which I am provisionally referring to this species. None of my specimens measured are quite as large as those figured by Knight,[1] the two largest ones being 0.78 mm. and 0.80 mm. in length and 0.39 mm. and 0.40 mm. in height, respectively.

The main points of differences which I am able to detect in my specimens from Knight's are a slightly higher elevation of the anterior portion of the valve and a slightly less height between the ventral and dorsal margins in the anterior portion of the valves. There is very little variation in these respects and may be none at all, for the specimens studied by Knight were all somewhat obscured by matrix. Nearly all of the specimens examined show a distinct Kirkbyan pit on the ventral slope of the shell a little back of the middle.

Many of my specimens, in outline form, closely resemble specimens of K. permiana Jones,[2] especially those first figured

1. Journ. Pal., vol. 2, No. 3, p. 256, pl. 32, fig. 4a-b.
2. J. W. Kirkby and T. R. Jones. "On Permian Entomostraca from the Shell-Limestone of Durham." Tr. Ty. Nat. Field Club., vol. 4, pp. 122-171, pls. 8 A, 9, 10, 11. (1858-1860).

from the "Shell-Limestone of Durham." Except for smaller size, my specimens bear several marks of similarity. This species resembles K. clarocarinata Knight but is distinguished by the inner flange extending outward and downward so as to hide the outer flange while in K. clarocarinata the inner flange is short and does not hide the outer flange.

Range and distribution--Specimens were collected from the middle and upper Garrison formation.

Genus Amphissites Girty

Amphissites centronotus Ulrich and Bassler

Plate III, figure 18.

This is perhaps one of the most abundant ostracodes in the lower Garrison shales at Manhattan and Cottonwood Falls. Some of my specimens are topo-types, having been collected from the same horizon and locality as those first collected and described by Ulrich and Bassler.[1]

The distinguishing features of this species are: the three prominent nodes, the anterior and posterior being ridge-like and the median nearly hemispherical in shape, a conspicuous Kirkbyan pit located just a little below the median node, and the neat reticulation of the surface of the valves.

1. A. centronotus Ulrich and Bassler, U. S. N. M. Pr., vol. 30, No. 1446, pp. 160.

A. centronotus is similar to A. girtyi Knight from which it may be distinguished by the absence of a bar connecting the median with the lower end of the posterior node in that species. It resembles Kirkby tricollina Jones and Kirkby, but in the latter the median node is smaller and the lateral ones are not ridged.

Range and distribution--Very common in the lower and upper Garrison at Manhattan, Cottonwood Falls and Strong City.

Amphissites pinguis Ulrich and Bassler

Plate III, figure 19.

This species occurs along with A. centronotus and is hardly less abundant. Unlike the latter the anterior node is less prominent and in some specimens rather difficult to detect, but is always present. The posterior node is quite prominent on both valves, appearing from a dorsal view as small ears extending out from the postero-dorsal area. Knight[1] has reversed the original orientation of the species in his description and regards the posterior node as obsolete and describes the anterior as low, broad and rounded. In some this holds true but I have observed in others that the anterior node is not so broad but somewhat elevated.

This small ostracod resembles A. oblonga Jones and Kirkby but in the former the valves are considerably larger and without either nodes or a sulcus. It is distinguished from

1. Journ. Pal. vol. 2, no. 3, p. 264.

A. roundyi Knight which it resembles somewhat by its more obscure ridging and noding and by its greater relative height and convexity.

The dimensions of a mature specimen are:

Length	0.68 mm.
Height	0.38 mm.

Range and distribution--Numerous specimens were collected from the Florena shales at Manhattan and Cottonwood Falls and from the upper at Strong City.

Amphissites allerismoides Knight

Plate III, figure 17.

This form is well represented in my collection. Many specimens were found throughout the shale of this formation.

None of my specimens are as large as those originally deseribed by Knight. They do not differ, however, in any other respect and hardly warrant the establishment of a variety based on size alone. All of the specimens examined show the inner and outer flange distinctly with the three intervening rows of reticulation pits. I did not observe much variation as to size of these pits.

The anterior node is more clearly defined than the posterior and may show some variation in size with different specimens. The flat band of three rows of reticulation pits between the inner flange and the central nodiferous area is distinct ventrally and anteriorly but dies out on the posterior end.

A rather distinguishing feature of this species is the conspicuous reticulation with large open meshes, over all of the surface except the two flanges.

In outline it suggests certain young forms of Kirkbya permiana Jones but differs in both cardinal angles being strongly obtuse. The reticulation is not so fine as in the former. There is a marked similarity in the noding of A. allerismoides and A. roundyi Knight. They are differentiated by size and the two prominent flanges of the former.

Range and distribution--Common throughout the Garrison formation.

Ampnissites simplicissmus Knight

Plate III, figure 20.

This species is represented in my collection by a few perfect specimens.

The anterior and posterior ends of the valve are so evenly rounded that correct orientation is difficult. The only evidence of noding is a slight widening of the antero-dorsal region and a flattening of the post-dorsal area. The surface of the valves are obscurely reticulated and in a few the surface is practically smooth. The characteristic Kirkbyan pit occurs almost in the center of each valve and is in nearly every case a little darker in color than the rest of the valve. Not all of the specimens examined have the spinelets rising from the points of juncture of the meshes

of the reticulations. It is safe to assume that they were present but have been worn off.

The simplicity of outline and shape with the obscure reticulations, "pit" and small spines distinguishes this species from any other.

The dimensions of a mature specimen are:

Length 0.62 mm.

Height 0.38 mm.

Range and distribution--Rare in the upper Neosho member.

Superfamily Cypridacea

Family Bairdiidae

Genus Bairdia McCoy

Bairdia beedei Ulrich and Bassler

Plate III, figures 6, 7.

This species and the following are the most common ones found in the Garrison formation. Many perfect specimens were found in the lower, middle and upper shales.

It is characterized by its rather large size, great convexity of both valves, the larger (left) valve prominently overlapping the right along the dorsal edge, and smooth surfaces of valves.

This form is differentiated from B. cestriensis Ulrich in the shape of the posterior end, this being longer and the upper half of its outline straighter. They also differ in a greater dorsal overlap in the former, in the more curved

ventral edge, and in the greater and more uniformly curved (lanceolate) outline in edge views. This species is less extended anteriorly and a less prominent angular overlap in the ventral sinuosity of the right valve, as observed in Bairdia moorei Knight.

Dimensions of an average size specimen are:

Length 1.18 mm. Height 0.74 mm. Convexity 0.50 mm.

Range and distribution--Abundant throughout the Florena and Neosho members.

Bairdia beedei abrupta Ulrich and Bassler

One of the chief differences between this form and the more typical form of the species is the relative greater length, less height and convexity. The dorsal and ventral parts in the two varieties are about the same but the outlines of their smaller (right) valves are slightly different, the height at the post-cardinal angle being greater in the variety abrupta than in the other. This difference may possibly be due to the amount of dorsal overlap in the individual.

A similar form is B. plebeia McCoy but the main differences between the two is a greater length and more pointed extremities in the former. It differs from B. cestriensis Ulrich in the same respects and from B. moorei Knight in greater length, less height and convexity.

Some of my specimens, particularly those collected from the Florena shales two miles east of Cottonwood Falls, are

unusually well preserved. Many of them have a more or less vitreous to pearly luster and are almost translucent.

Several of the specimens in my collection are from the same locality as those first collected and described by Ulrich and Bassler.[1]

Range and distribution--The same as for Bairdia beedei Ulrich and Bassler.

Bairdia citriformis Knight

This is somewhat of a variable species, the convexity being great in some and less so in others. The overlap of the left valve is slight but continuous along the dorsal edge from beak to beak. The overlap along the ventral line is confined principally to the middle. Owing to the convexity of both valves the line of overlap is deeply impressed.

The distinguishing characters of this species are the prominent and impressed overlap of the left valve onto the right, the sharply pointed posterior beak and less sharp anterior beak and the tendency to considerable convexity in both valves.

My specimens conform closely to the original description.[2] No differences were observed in the specimens examined except a slight variation in size. In a few the posterior beak was

1. Bairdia beedei abrupta Ulrich and Bassler: U. S. Nat'l. Museum, Vol. 30, No. 1446, pp. 162.
2. Bairdia citriformis Knight: Journ. Pal., Vol. 2, No. 4, pp. 321-322, pl. 43, figs. 4a-c.

a little more blunt than in the majority but this difference I assumed to be due to the wearing away of it.

This species is distinguished from B. brevis Jones by its more oval outline and slender beaks.

Measurements of two large specimens are:

Length 0.94 mm. Height 0.60 mm. Convexity 0.41 mm.

Length 0.85 mm. Height 0.47 mm. Convexity 0.42 mm.

Range and distribution--Abundant in the lower shales at Manhattan.

Bairdia altifrons Knight

There are a few specimens in my collection which I am referring to this species. They all appear to be slightly more convex than those figured by Knight,[1] but show no other marked differences. In some the anterior margin curves more evenly into the ventral margin than in others.

The overlap of the left valve is very small, the greatest amount being along the dorsum and the least near the anterior end. The hinge-line is over half of the greatest length of the shell and gently curved. Normally the greatest thickness occurs a little behind the middle but in some I have observed the greatest convexity in the middle and slightly in front of the middle.

The general contour of the shell, minus the sharp beak, suggests B. texana Harlton but in the latter the posterior beak

1. B. altifrons Knight: Journ. Pal. Vol. 2, No. 4, pp. 324-325, pl. 43, figs. 6a-b.

is sharply pointed and upturned. A similar form is B. subelongata var. major Jones and Kirkby but they are distinguished by the relative greater length and size in the latter.

Measurements of two specimens are:

Length	Height
1.05 mm.	0.60 mm.
1.03 mm.	0.59 mm.

Range and distribution--Common in the Florena shales at Manhattan and Cottonwood Falls, also found in the upper Neosho at Strong City.

Bairdia haworthi Knight

[1] "Outline as viewed from the side roughly subelliptical. Dorsal outline gently curved and low, the highest point posterior to the middle, and passing from that point to the ends in nearly straight lines. The beak of my one otherwise perfect specimen is broken but one may infer that it is bluntly pointed. The anterior end is narrowly but not acutely rounded. The ventral margin is gently convex near the ends and gently concave medianly. The right valve is shaped much like the left as the overlap is slight. As viewed from above the outline is narrow lanceolate, the sides being gently convex from end to end.

1. Bairdia haworthi Knight: Journ. Pal., Vol. 2, No. 4, p. 325, pl. 43, figs. 7a-b.

"This form differs from B. glennensis in its lesser relative length, more nearly straight dorsal outline and less attenuated anterior end. From B. altifrons it is easily distinguished by its greater length and rounder lower anterior end."

The chief difference which I have noted in my specimens is a slightly greater height, the length being about the same.

The dimensions of two specimens are:

Length	1.15 mm.	1.20 mm.
Height	0.40 mm.	0.50 mm.

Range and distribution--This form is rare in the lower and upper shales.

Bairdia glennensis Harlton

This species is represented by a single specimen, with a very small portion of the beaks broken away. The long, slender outline distinguishes this form from any others of the same genus. The ventral outline curves gently down from the ends and is almost straight for the greater part of its length. The dorsal outline is a gentle curve from end to end with the greatest amount of curvature in about the middle.

The anterior end is elongated but is not so pointed as the posterior beak. The greatest amount of overlap along the ventral margins occurs about equi-distant from each end and is not very pronounced.

This form is differentiated from B. naworthi Knight by its relative greater length, more strongly curved dorsal out-

line and more elongated anterior end. It differs from B. subelongata Jones and Kirkby by having the dorsal line more curved and the posterior end more drawn out.

Dimensions of the only specimen are:

Length	1.45 mm.
Height	0.56 mm.

Range and distribution--A single specimen was found in the Florena shales at Cottonwood Falls.

Genus Healdia Roundy

Healdia longa? Knight

I have two doubtful specimens in my collection which I am assigning to this species, basing my identification of them as such on the size and lack of spines or surface ornamentation of any kind.

The two valves are almost the same size with the left one slightly the larger of the two. There is a very slight overlap of this one onto the right. In a dorsal view the outline of the shell is wedge-shaped with the greatest convexity in the posterior area and tapering down towards the anterior portion. The hinge-line is nearly straight with a little concavity at about the middle. The concentric ridge, characteristic of this genus, bordering the posterior area is so indistinct that only a faint trace of it can be discerned.

This form resembles H. ampla Roundy, from which it may be distinguished by its lack of posterior spines and appreciably smaller size. In a dorsal view it is similar to H. boggyensis Harlton but differs in that there is a more gentle curvature and rounding of the posterior margin into the ventral margin.

The dimensions of the two specimens are:

Length	0.72 mm.	0.71 mm.
Height	0.39 mm.	0.40 mm.
Width	0.32 mm.	0.34 mm.

Range and distribution--The two specimens were found in the upper Neosho member at Manhattan.

Family Cytherellidae Sars

Genus Cytherella Jones

Cytherella missouriensis Knight

All of my specimens measured approximately the same in size. The right valves are considerably the larger and in some specimens show very distinctly a thin narrow flange extending slightly over the edges of the right. The anterior end is more broadly rounded than the posterior which is only slightly less so.

This species bears marked resemblances to some forms of the genus Cavellina Coryell.[1] The general outline of both are almost identical, particularly Cavellina subovata Coryell.

1. H. N. Coryell: Journ. Pal., Vol. 2, No. 2, p. 89.

The main point of distinction between members of this genus and those of Cytherella is the presence, in the former, within the interior of each valve a partition that extends inward and partially separates the posterior one-third of the body cavity from the rest, and on the inner surface of each valve, lying between the center and the dorsal margin, is a small rounded tubercle.

Measurements of two specimens are:

Length	1.13 mm.	1.1 mm.
Height	0.72 mm.	0.70 mm.

Range and distribution--A few specimens were collected in the upper Garrison at Strong City.

	Lower				Middle				Upper		
	2	6	9	10	1	3	4	7	5	8	11
PROTOZOA											
Fusulina emaciata	X	X		X							
Triticites ventricosus									X	X	X
Cribrostomum bradyi	X			X							
Climacammina antiqua	X			X							
Globivalvulina bulloides	X			X	X		X		X	X	X
Tetrataxis maxima	X			X	X	X	X		X	X	X
Tetrataxis palaeotrochus	X			X	X	X	X		X	X	X
ECHINODERMATA											
Archaeocidaris megastylus	X	X	X	X	X		X	X	X	X	X
Crinoid stems	X	X	X	X	X	X	X	X	X	X	X
BRYOZOA											
Fistulipora carbonaria	X			X					X		X
Batostomella leia	X?			X							
Tabulipora distans				X					X		X
Tabulipora heteropora?				X							X
Tabulipora carbonaria	X	X		X			X		X	X	X
Tabulipora spinulosa	X			X							
Fenestella mimica	X			X		X			X		
Fenestella limbata	X			X							
Fenestella tenax	X			X					X		
Fenestella spinulosa	X			X							X
Fenestella gracilis	X			X							
Fenestella binodata	X			X							
Thamniscus octonarius	X	X	X	X	X		X		X	X	X
Pinnatopora pyriformipora					X	X					

	Lower				Middle				Upper		
	2	6	9	10	1	3	4	7	5	8	11
Rinnatopora trilineata	X			X		X			X	X	X
Rinnatopora youngi					X						
Septopora biserialis	X	X	X	X	X		X		X	X	X
Septopora multipora	X	X	X	X	X		X		X	X	X
Septopora pinnata				X	X	X					
Septopora robusta	X			X	X		X		X		X
Rhombopora lepidodendroides	X			X	X	X	X	X	X	X	X
Streblotrypa prisca				X	X		X		X		X
BRACHIOPODA											
Orbiculoidea mannattanensis											X
Derbya crassa	X			X					X		X
Derbya cymbula					X		X				
Derbya robusta				X							
Meekella striatacostata	X			X							
Chonetes granulifer	X	X	X	X	X	X	X		X	X	X
Productus cora											X
Productus semireticulatus	X			X	X		X		X		X
Pustula nebraskensis	X			X	X	X					X
Spiriferina kentuckyensis											X
Composita subtilata	X			X	X				X		X
PELECYPODA											
Nuculopsis ventricosa										X	
Allorisma subcuneata										X	
GASTROPODA											
Schizostoma catilloides						X					

	Lower				Middle				Upper		
	2	6	9	10	1	3	4	7	5	8	11
TRILOBITA											
Phillipsia sangamonensis	X	X		X	X		X		X	X	X
OSTRACODA											
Hollina radiata	X	X		X	X	X	X		X	X	X
Hollina emaciata	X	X		X	X	X	X		X	X	X
Hollinella bassleri					X	X	X		X		X
Jonesina bolliaformis	X			X		X				X	
Jonesina bolliaformis tumida	X			X		X				X	
Ulrichia montosa											X
Kirkbya voluta				X							
Kirkbya scapnula?					X	X	X				X
Amphissites centronotus	X	X	X	X	X		X		X		X
Amphissites pinguis	X			X							X
Amphissites allerismoides	X			X		X			X	X	
Amphissites simplicissmus									X		X
Bairdia beedei	X	X		X	X	X	X	X	X	X	X
Bairdia beedei abrupta	X	X		X	X	X	X	X	X	X	X
Bairdia citriformis				X		X?					
Bairdia altifrons	X			X		X			X		X
Bairdia naworthi				X					X	X	
Bairdia glennensis	X										
Healdia longa?										X	
Cytherella missouriensis											X

Locality Table

No. 10.--Lower member: Florena shales, Stagg Hill, one and one-half miles southwest of Manhattan, Kansas.

5.--Shale layer in the lower part of the upper Garrison, exposed in a road cut five and one-half miles south of Manhattan, Kansas.

4.--Lower middle; exposed along the road one mile northwest of Strong City, Kansas.

3.--Shale layer in the Lower middle, exposed in a road cut, five and one-half miles south of Manhattan, Kansas.

1.--Lower middle; exposed in a road cut one mile northwest of Strong City, Kansas. Material was collected from a shale layer a few feet above that in No. 4.

8.--Shale layer directly below the base of the Wreford limestone, five and one-half miles south of Manhattan, Kansas.

11.--Upper Garrison, exposed in a road cut one and one-fourth miles northwest of Strong City, Kansas.

6.--Lower Garrison, exposed in a road cut, three miles northeast of Garrison, Kansas.

2.--Lower member: Florena shales, exposed in a rock quarry above the top of the Cottonwood limestone, two miles southeast of Cottonwood Falls, Kansas.

7.--Upper part of the Florena shales, exposed in a road cut, five and one-half miles south of Manhattan, Kansas.

8.--Middle Garrison, exposed in a road cut, twelve miles northeast of Manhattan, Kansas.

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EXPLANATION OF PLATES

Plate I

All figures x1

Figs. 1, 3.--Meekella striatacostata Cox.
2.--Pustula nebraskensis Owen. Ventral valve.
4,5,6,8, 9.--Chonetes granulifer Owen. 4, 5, 8, ventral views; 6, 9, interior views of the ventral valves.
7.--Fistulipora carbonaria Ulrich. Zoarium incrusting a brachiopod shell.
10.--Schizostoma catilloides Conrad.
11 ,12.--Rhombopora lepidodendroides Meek.
13.--Spiriferina kentuckyensis Meek.
14-20.--Archaeocidaris megastylus Snumard. 14,15, 16,20, ambulacral plates; 17, 18, 19, spines.

Plate 2

All figures x1

Figs. 1, 2.--Productus semireticulates Martin. Ventral views, imperfect specimens.
3.--Derbya crassa Meek and Hayden. Ventral view.
4.--Productus cora d'Orbigny. Ventral valve with spines.
5.--Phillipsia sangamonensis Meek and Worthen. Pygidium.
6 ,7.--Composita subtilita d'Orbigny. 6, dorsal view; 7, ventral view.

Plate 3.

All figures x30.

Figs. 1, 2.--Tetrataxis maxima Schellwien. Peripneral views.
3.--Fenestella tenax Ulrich. Obverse view.
4, 5.--Climacammina antiqua H. B. Brady.
6, 7.--Bairdia beedei Ulrich and Bassler. Right side.
8, 9.--Hollina emaciata Ulrich and Bassler. 8, left valve; 9, right valve.

10,12.--Hollina radiata Ulrich and Bassler. 10, right valve; 12, left valve.

11.--Ulrichia montosa Knight. Right valve of a large individual.

13-16.--Jonesina bolliaformis tumida Ulrich and Bassler. 14, 15, right valves; 13, 16, left valves.

17.--Amphissites allerismoides Knight. Right valve of small specimen.

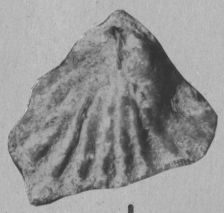
18.--Amphissites centronotus Ulrich and Bassler. Right valve.

19.--Amphissites pinguis Ulrich and Bassler. Left valve.

20.--Amphissites simplicissmus Knight. Right valve.

21.--Fenestella binodata Condra. Obverse view.

PLATE I



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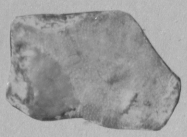

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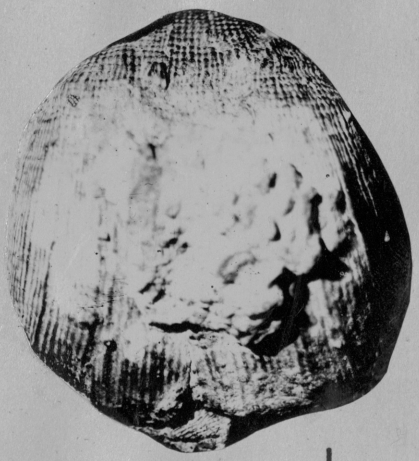
PLATE II



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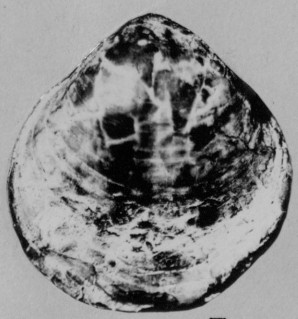

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PLATE III