1940

Fauna of the Three Forks Formation in Montana

Will Mitchel Jr.

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MITCHELL, W.

FAUNA OF THE THREE FORKS FORMATION
IN MONTANA

by

WILL MITCHELL, JR.

A Thesis
Submitted to the Department of Geology
in Partial fulfillment of the
Requirements for the Degree of
Bachelor of Science in Geological Engineering

MONTANA SCHOOL OF MINES
BUTTE, MONTANA
1990.
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FAUNA OF THE THREE FORKS FORMATION

IN MONTANA

by

Will Mitchell

INTRODUCTION

The Problem

The Upper Devonian in Montana is represented by limestones, shales and sandstones. These were named by A.C. Peale 1) after the town of Three Forks in the southwestern part of the state where they were first studied. An abundance of invertebrate fauna may be observed nearly everywhere this formation crops out.

The purpose of this paper is to identify and describe the fauna, correlate it with that of the Upper Devonian of other states, to note the geographic distribution, lithologic variations of outcrops, and to compare measured cross sections.

The field work was done during the fall of 1939 and the spring of 1940. Specimens were collected from Logan, Whitehall, South Boulder, Morrison Cave and Helena. Collections by Sloss from the Big Snowy Mountains and Livingston were also studied.

Identifications were made during the spring semester of 1940 at the Montana School Of Mines.

Acknowledgements

Special thanks are due to Dr. E.S. Perry, head of the geology department, Montana School of Mines, for his many valuable suggestions, and to Dr. Laurence L. Sloss, also of the Montana School of Mines, under whose direct supervision this paper was written, for his assistance in photographing, checking fossil identifications and editing of the manuscript. Finally, the writer acknowledges the splendid aid given by Miss Elizabeth Price of the Grant School in Butte, in collecting the fossils, and Miss Guinevere Crouch, Librarian at the Montana School of Mines, for securing the desired literature.

Previous Work

When A.C. Peale described the Upper Devonian in Montana, naming it the Three Forks Shale, he listed twenty-two species. Percy Raymond¹) in 1908, published his article, "The Fauna of the Upper Devonian in Montana". In 1916, an article with the same title was written by W.P. Haynes.²) These publications were freely used by the author. Since that time noth-

ing outstanding has been noted on the subject from the literature available.

**OCCURRENCE**

Describing the Three Forks, Peale divided it into the lower and upper shales.

"They are separated by a band of limestone 15 to 20 feet thick which is grayish brown in color, generally very compact and close grained, and upon weathering gives a yellow debris."(1)

The lower shale, which would be found in ravine bottoms, is obscured by the breaking down of the superimposed beds in all localities visited except at Logan where excellent outcrops of the lower shales are present. Examination of the lower beds and perusal of the literature indicates that no fossils are present. Immediately above the band of limestone, the upper shale contains the characteristically Devonian faunal elements such as *S. whitneyi*, *C. contracta*, etc.

Haynes suggested that it might be possible to divide the Three Forks into seven members which have definite lithologic characteristics. This division was noted by the author in all exposures studied in the Three Forks quadrangle; but at Gallatin Gateway and also in the Big Snowy Mountains the formation is almost entirely a mass of limestone. This latter con-

dition prevails throughout the northern and eastern parts of the state.

The limestones, being resistant, form steep bluffs. Due to the fact that the shales in the southwestern part of the state occur between the two massively bedded limestones of the Jefferson and Madison formations the differential weathering has produced a characteristic valley. Because of this the exposures are generally hidden by talus and cannot be measured.

A resume of the section as measured by Haynes may be seen on plate 1.

"Members 1 and 2 together vary from 60 - 80 feet and have an average thickness of about 70 feet. Member 3 varies in thickness from about 19 feet, in the west Three Forks valley, to 6 inches at Logan. It has an average thickness of about 6 feet. Member 4 varies from 3 to 10 feet in thickness; member 5 from 50 to 120 feet, member 6 from 15 to 40 feet, and member 7 varies from 40 to 80 feet". (1)

"A comparison of all the sections shows a distinct increase to the southwest in the amount of limestone in the formation." (2)

Beds considered to belong to the Three Forks formation have a thickness approximately as follows:

Base of gray Madison Limestone.

1. Yellow sandy limestone ........ 40 feet
2. Pale yellow arenaceous shale .. 30 feet
3. Fissile purplish shale ........ 7 feet

2) Ibid
4. Gray limestone .................. 8 feet
5. Green fissile shale............. 50 feet
6. Yellow, orange and gray lime-
   stone with calcite veins ........ 27 feet
7. Reddish yellow and orange
   blocky shales
   blocky shales .............. 70 feet

Weed 1) measured some sections in the northwest corner of
Yellowstone Park and found them to be similar to the section
above. In the Absaroka folio of Central Wyoming, he identi-
fied the Three Forks and found it to be 250 feet thick. It
is described as consisting of basal beds of blue-gray lime-
stone followed by alternating beds of shales and fine clays.
This is capped with bright purple and blue bedded limestones.

In southwestern Wyoming Kindle 2) recognized the Three
Forks formation, noting 80 feet of drab shales and shaly,
thin-bedded magnesian and siliceous limestone which wasbar-
ren of fossils and occurred between the Jefferson and the
Madison.

The Randolph quadrangle in Utah shows the Upper Devon-
ian in a section near Bear Lake. Richardson 3) reports 200
feet of soft red shaly limestone which is poorly exposed.

Two hundred and fifty feet of alternating shales and
impure limestones are described in the Livingston folio. 4)
The lower shales are more earthy.

1). Weed, W.H., Mono., 32, pt. 2, pp. 7, 22, and 26, 1899
2). Kindle, E.M., Bull. Am. Pal., No. 20, p. 12, 1908
p. 406, 1913
The upper member of the Monarch formation in the Little Belt Mountains quadrangle\(^1\) is equivalent to the Three Forks. Thinly bedded blue-gray limestone-shales which weather yellow to pink are exposed for as much as 140 feet. This same formation is referred to in the Fort Benton quadrangle\(^2\) and is reported to give an abundance of Devonian fossils.

Knopf\(^3\) recognized the Three Forks at Helena and found them to be composed mainly of fossiliferous calcareous shales, earthy shales, with thin beds of quartzite. He gives to these a thickness of 285 feet.

According to Haynes this formation is absent from the Philipsburg quadrangle but the author has seen an exposure of several feet of soft earthy shale between the Madison and Jefferson about three miles south of the foot of the Philipsburg hill highway. Very little time was spent here but no fossils were found.

There is a marked similarity of the brachiopod fauna to that of the Ouray district described by Kindle.\(^4\)

The upper Mennewanka of Alberta also contains fossils similar to those found in the Upper Devonian of Montana.

---

1). Atlas Folio U.S.G.S., no.86
2). Atlas Folio U.S.G.S., No.55
Measured Sections and Localities

Lying unconformably upon the Jefferson limestone at a locality called Devonian gulch which is across the Jefferson river at Logan, a town 8 miles west of Three Forks, there are 40 feet of yellow sandstone followed by 30 feet of green, purplish or black argillaceous paper-shales which due to their softness are concealed by their own debris. Above these is 45 feet of drab yellow limestone containing fossils at several horizons. This is capped by 25 feet of yellow limestone. Peale gives to this section a thickness of 135 feet.

In South Boulder canyon, in the southern part of Jefferson county, only 5 feet of sandy limestone shale is exposed. A heavy mantle covers the rest of the formation. This band occurs about half way between the Jefferson and Madison and is composed of a very hard material which has weathered slowly in comparison to the others. The thickness here is approximately 266 feet. Very few specimens were collected from this area.

South of the mouth of Morrison Cave there is a small exposure of the green paper-shale. There were fragments of many species lying on the surface. Here, the uncovered bed measures only 25 feet.

Fifteen feet of fine-grained black carbonaceous shales,
and light-colored fossiliferous calcareous shales, grading downward into earthy shales with interbedded quartzite for a distance of 270 feet is the description of the outcrop in the Helena district given by Dr. Knopf.\textsuperscript{1) The material collected from Mount Ascension, south of Helena, indicates that the Three Forks is more calcareous and compacted than at these other localities.

Outcropping in the Big Snowy Mountains facies are thick massive limestones containing a coral reef facies. The fine paper-shale so typical in the districts in the southwestern part of the state have not been found here. At Gallatin Gateway, the Three Forks occurs as a big cliff of limestone. Fossils are reported from there but none are included in the collection studied.

Oil companies from the Kevin-Sunburst field on the Sweetgrass arch report thin paper-shales and many Upper Devonian fossils from their oil well drillings. These shales will burn if lighted with a match. The fossils were not available for this paper, but it seems likely that the shales may be correlated with the uppermost Devonian Exshaw shale of Alberta.

The section on the west side of the valley of the north fork of Boulder Creek (about 3 miles north of the Whitehall-Three Forks highway) yields abundant fossils. In fact, it was here that the bulk of this collection was obtained. Many

\textsuperscript{1}) Knopf, A., \textit{Bull. U.S.G.S.}, No.527, p.92, 1914
forms may be gathered in great number from the surface of the
easily weathered paper-shale. About half way up the exposure
there is a sill of decomposed andesite. On each side of this,
the rock is thoroughly indurated. At 1 to 2 foot intervals
throughout the shales thin beds of fossiliferous limestone
occur; from these many of the fossils have been released by
weathering. These beds of limestone range around 1 to 4
inches in thickness and have a chocolate brown color. The
whole is capped by yellow sandstone. The total thickness ex-
posed is about 150 feet.

RELATIONSHIP TO OVERLYING AND UNDERLYING FORMATIONS

In all places visited by the author the Three Forks
formation was found lying unconformably between the Jeffers-
son limestone, which is lower Devonian, and the Madison
which is lower Mississippian.

Sometimes the upper Devonian occurs as a shale and
sometimes as a limestone. In either case the upper part
of the formation grades gradually one into the other while
at the lower border the change is more abrupt for example,
immediately above the Jefferson limestone will be found a
yellowish sandstone or argillaceous shale. It is also in-
teresting to note that there is an abrupt faunal change at
the base of the formation but at the top, but at the top
upper Devonian fossils and lower Mississippian fossils are found intermingling.

Relationship of Fauna to the Shales

Ammonoids are reported as being almost entirely limited to the lower and middle part of the fissile-shale. The upper members (beds 1 and 2) contain a fauna which is very different from the lower members and becomes more like the overlying lower Mississippian member. Raymond reports the fossils of these yellow sandstones and shales to be transitional between the upper Devonian and the Madison. Schuchert is convinced that there was a physical and faunal break in deposition at the end of the Devonian.

The green paper-shale offers Pectins in a great abundance while from the upper limestone we get Brachiopods.

Platyclymentia is localized in the shale and may be said to be a typical "shale fossil."

The main faunal contributor at the north fork of the Boulder Creek is the thin beds of limestone which are spaced at short intervals through the paper-shale. The upper limestone shows evidence of marine life but the species are indeterminable.

It is evident that the bulk of the collection was derived from members 4 and 5 of Haynes' column of the upper Devonian.
INDEX OF MINING DISTRICTS

1. Cone Butte
2. North Moccasin (Kendall)
3. Warm Springs (Gilt Edge) (Maiden)

LEGEND

- Main Highways
- Unimproved Roads
- Railroads
- Power Lines
- Rivers and Creeks
INDEX OF MINING DISTRICTS

1. Eldridge
2. West Gallatin (Spring Hill)
Class BRACHIOPODA
Order TELOTREMATA Beecher
Family RHYNCHONELLIDAE Gray
Genus CAMAROTOECHIA Hall and Clarke

Camarotoechia contracta Hall

(Plate IV, figures 2-6)
(Plate V, figures 1-6)


Description:

"Subquadrate, abruptly and deeply sinuate. Pedicle valve very slightly convex often becoming almost flat near the front and marked by a broad angular sinus. Brachial valve somewhat gibbous in the middle and regularly convex transversely, marked by a mesial fold. Surface with 16-20 angular plications of which there are 4 on fold and 3 on sinus". (1)

Discussion:

This type is very abundant in all areas where the Upper Devonian crops out. In fact it may be used as an index fossil. Sizes vary greatly. All specimens have at least 16 plications on each valve while some have 1, 2, or 4 plications on the sinus and 2, 3, or 5 on the fold.

The pictures of this species on the plates have an en-

largement range of from two to ten times the diameter of the specimen. The young ones have the same characteristics as the mature - excepting that the fold and sinus are not quite so well developed, although they are definite.

Localities:

Three Forks, Logan, North fork of the Boulder Creek, South Boulder, Helena, Morrison Cave, etc. Reported from Colorado, New York, Pennsylvania, Ohio, Iowa, New Mexico, and Alberta.

Genus LEIORHYNCHUS Hall

Leiorhynchus mesacostale Hall

(Plate VII, figures 3-4)

(Plate VIII, figures 1 and 4)


Original description:

"Shell oval or ovate, more or less gibbous, sinuate towards the front. Ventral valve usually moderately convex, gibbous on the umbo, gently curving or flattened on the sides, depressed in the middle into a wide shallow sinus; apex closely
incurved.

Dorsal valve convex, more or less gibbous, with the mesial fold prominent below the middle of the shell.

Surface of mesial fold and sinus marked by four, five or six well-defined rounded plications, which reach nearly or entirely to the apex, and are dichotomus in their upper part. Sides of the shell smooth, or obscurely marked by low obsolete folds; concentrically marked by fine striae.

In the larger number of specimens, the lateral portions of the follii are essentially free from plications, but they are sometimes visible, and in a single small specimen there are two plications on either side of the sinus; and one larger specimen shows a similar character. In others, there are inequalities of surface, indicating the plications. It should be recollected, however, that the specimens are usually in the condition of partial or entire casts, and these features may have been more strongly developed in the shell.

The cast of the dorsal valve presents the usual features of all the species in the longitudinal septum, which is distinctly divided on itsupper inner face."(1)

Localities:

Morrison Cave, North Fork of Boulder. Reported from New York.

Leiorhynchus madisonense var. gibbosum Haynes

(Plate VII, figures 1-2)


Original description:

Shell more gibbous and usually larger than

Leiorhynchus madisonense. An average specimen has a width of 23 mm. and a height of 20 mm., with a ratio of width to height of 1: :87.  

The valve of the pedicle is gibbous a little below the umbo, and curves evenly to the sides. It becomes flattened in the middle and is deeply sinuate toward the front of the shell. The beak is closely incurved over the umbo of the brachial valve.

The brachial valve is more convex than the pedicle and curves to the sides, with a broad, flattened mesial fold, well-developed from the upper third of the shell.

*From three to seven low, rounded plications occur in the sinus, and from four to eight in the fold. The specimens usually have from one to three low, rounded plications on the sides of the valves, which diminish in relief toward the lateral margins. All of the plications radiate from the beaks and they are almost invariably clearly defined from the beaks to the margin of the shell. This new variety differs from Leiorhynchus madisonense in the greater convexity of the valves; and normally greater number of plications in the fold and sinus, and in the height and width being more nearly equal.* (1)

Discussion:

This species resembles *L. Kellogi* but the plications on either side of the sinus and fold are broader and there are fewer of them. They are quite common in the limestones. The dimension ratios given above are typical of this specimen.

Localities:

Three Forks, Logan, North Fork of Boulder River.

Leiorhynchus *Jeffersonense* Haynes

(Plate VII, figures 5-6)


Original description:

"Shell large, sub-ovate and moderately convex on the brachial side; flattened on the pedicle side. Width of an average specimen, 44 mm. ratio: .625. Width of a smaller individual 38 mm.; height 23 mm.; ratio 1.6.

Valve of pedicle flattened toward the sides, with a moderately deep sinus, which starts from the beak. Sinus flat, and bordered by a single, usually prominent, rounded plication on each side. Four or five distinct, evenly spaced, rounded plications on the sides of the valve.

Brachial valve convex with a prominent flat-topped fold, which starts from the beak, and is composed of five or six rounded plications. One or two very low plications are visible on the sides of the valve in a few specimens." (1)

Discussion:

There is considerable variation in these specimens with regard to the plications on the fold and sinus. Probably some of them would approach the description of L. mesacostatae only for the fact that the width is so great in comparison to the height and that the folds are weak but limited to sinus and fold.

Localities:

Three Forks, Logan, North Fork of Boulder, Reported from Indiana.

Family SPIRIFERIDAE King
Genus SPIRIFER Sowerby

Spirifer raymondi Haynes
(Plate VI, figures 1-6)

Spirifer pionensis Meek, King, 40th. Parl. Surv., p.45, Pl.1, figs. 9 a, b.


Spirifer argentarius Kindle, Bull. Am.Pal., No.20, 1908, p.32, Pl.2, fig.4.


Original description:

"This form is apparently identical with the specimen figured by Dr. Raymond from the red shale as Spirifer pionensis". The differences are as follows:

"The shape of the shell is not semicircular in outline, but is triangular, and much like that of S. micronotus Conrad. The cardinal margin terminates in acute and not rectangular or obtuse extremities. The proportions of height to width are different." (1)

"Spirifer raymondi has from nine to twelve radiating plications observed. No minute striations were seen on the plications of any of the specimens. All of the well preserved specimens of S. raymondi show a slight fold in the middle of the sinus, and the surfaces of both valves are marked with fine undulating lines of growth." (2)

"On account of all of these differences from any described forms, it seems advisable to place these specimens from the Three Forks formation under the new specific name Spirifer raymondi." (3)

Discussion:

This species closely resembles *S. notabilis* from the Ouray of Colorado as described by Kindle. It is abundant and follows the description above closely. The only variations noted is that of size. Many of these specimens are found weathering from the limestones between the shale.

Localities:

North fork of the Boulder Creek, Morrison Cave, Reported from Three Forks and Princeton, as *S. Notabilis* in the Ouray of Colorado.

*Spirifer whitneyi* Hall

(Plate I, figures 1-6)

(Plate II, figures 1-6)

(Plate III, figures 1-3)

*Spirifer whitneyi* Hall, Surv. Iowa, pt. 2, 1858, p.502, Pl. 4, fig. 2.


Original description:

"Shell of medium size, transverse, semi-elliptical or pentagonal; height and width about as three to four, ventral valve gibbous towards
the beak and curving abruptly to the base; beak elevated above that of the opposite valve, and incurved over the area; mesial sinus well defined at its margin by stronger plications, curvilinear or subangular, beginning at the beak and regularly deepening towards the base, where it is often produced in a rounded or angular projection. Dorsal valve gibbous in the center, and sloping abruptly to the sides; mesial fold elevated, prominent, rounded and well defined, sometimes subangular; beak incurved; hinge line equal to or exceeding the width of the shell; area moderately large, concave vertically striated; a narrow defined area on the dorsal valve, foramen broad at base and open to the summit; a narrow defined groove marks the junction of the dental lamellae with the area."

"............Entire surface marked by extremely fine radiating striae, which cover alike the plications and the spaces between them; these sometimes give the plications a grooved appearance under a lens. Equally slender concentric undulating striae mark the whole surface; and along these are arranged minute granulations, which are only visible under a lens; a few more distinct imbricating lines of growth are sometimes seen."(2)

Discussion:

Specimens pictured on plate I resemble closely S. Whitneyi var. monticola Haynes in every respect but those on plate II and III are a different variety. No separation of the varieties has been attempted in this paper but the differences have been noted by the author.

Next to Camarotoechia contracta this is the most abundant.

There are great variations. Apparently the only thing distinctive about this species is the presence of plications on the fold and sinus. Usually Devonian Spirifers do not have these

plications here. That is why this species is often indistinguishable from *S. disjunctus*. There is possibly a duplication in descriptions of *S. whitneyi* from Iowa and *S. disjunctus* from Boulonnais, France. The hinge line shows great variation and may range from half the width to the whole width of the specimen.

"In cases where the striations are preserved in the specimens from western America it is easy to refer them to the species *whitneyi*, but the majority of the specimens are exfoliated, and they therefore come within the limits of the species *disjunctus*. This is undoubtedly the reason why so many of the western American species of this general type have been identified as *S. disjunctus*.(1)

Although several of the specimens are extremely well preserved the author was unable to find the striations which are reported to be so characteristic of *S. whitneyi*. There are as many as twelve plications on the fold and twenty-six on a side.

Localities:

All localities where the Upper Devonian outcrop in Montana. Reported from New Mexico, Colorado, Lyme Creek, Iowa, and New York.

*Spirifera disjunctus* Sowerby

(Plate III, figures 1-3)

(Plate IV, figures 1)

*Spirifera disjunctus* Sowerby, 1840, "Transactions of

the Geological Society", 2nd series, Vol.V, Pl.53, fig.8; Pl.54, figs. 12, 13.


Description:

"Very variable in shape from semicircular to attenuate winged. Pedicly valve but slightly incurved at beak, its mold gives a triangular area in part marked by the muscular impression disjoined from the sides of the shell by narrow fissures formerly occupied by the dental lamellae. Surface of both valves, including sinus and fold covered with very low, even plications. Sinus and fold are sharply defined from the rest of the shell," (1)

Discussion:

This species is extremely abundant. From the description of S. whitneyi I conclude that there is very little difference between the two. It is possible that the S. whitneyi is the adult of S. disjunctus. S. whitneyi is reported as having minute striations on the plications while in S. disjunctus they are absent. These could be a stage in the development of the species.

Localities:

North fork of the Boulder Creek, South Boulder, Helena, and Logan. Reported from New York, throughout North America

Genus *ATYPAL* Dalman

*Atrypa reticularis* Hall

(Plate XI, figures 1, 2 and 3)

*Atrypa reticularis* Hall, 1852. Pal. N.Y.,

**Original description:**

"Shell depressed suborbicular in its young state, becoming gibbous and sinuate in its mature condition; hinge line often nearly straight, and almost equally the width of the shell; valves nearly equally convex in the young state, the dorsal valve becoming more gibbous as the shell advances in age and sometimes acquiring an undefined mesial lobe down the centre. The ventral, in the young state, has the beak nearly straight and perforated at the apex, becoming incurved and finally closely bent over the beak of the opposite valve; a narrow false area is sometimes observable. Shell broadly and deeply sinuate in front." (1)

**Discussion:**

This is one of the abundant species. It follows the above description with the exception of its not being gibbous. Possibly this is because those forms studied are incipient. Possibly this is because those forms studied are not mature.

**Localities:**

They are found everywhere that the Three Forks outcrops. Reported from Iowa, New York, Ohio, Tennessee.

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Genus AMBOCOELIA Hall

Ambocoelida gregaria Hall

(Plate IX, figures, 1, 2, 4, and 5)


Description:
"Small spirifer-like pedicle valve greatly elevated, with a conspicuous, strongly incurved umbo; cardinal area arched and delthyrium open. Brachial valve with long, narrow cardinal process, crural plates long, parallel, erect; four well defined abductor scars present near the anterior margin." (1)

Discussion:
This is probably the most abundant of all the fossils in the Three Forks paper-shale. Some of the specimens are very well preserved but all follow the general description given above. There is a well marked sinus on the brachial valve. This characterizes the species.

Localities:
All outcrops of the Three Forks formation in Montana which have been studied report an abundance of these. They are reported from Iowa, and New York.

Family ATHYRIDAE Phillips

Genus CLEIOTHYRIDINA Buckman

Cleiothyridina devonica Raymond

(Plate X, figures 1-6)


Original description:

"The adult shell varies in outline from subcircular to transversely elliptical. The sides and front of the shell are usually somewhat straight, which gives the shell a rather quadrate form. The valves are nearly equally convex, the pedicle valve being slightly the deeper. The pedicle valve shows a narrow sinus or a flattened area in nearly all specimens, but in a few this valve is uniformly convex. On the brachial valve there is a low fold which is not defined at the sides and can be seen only when looking at the front of the shell. The beak of the pedicle valve is small and closely, incurved, but the pedicle opening remains clear throughout life, the pedicle continuing the encroachment upon the umbo as the beak becomes more incurved.

The surface markings on the better preserved specimens are those characteristic of the genus. The concentric lamellae are very numerous and the spiniform extensions of their free margins are long and slender. Partly exfoliated specimens show fine interrupted radial striae, and costs of the interior or show very numerous radiating vascular markings.

The spirals of a single specimen have been developed. They were replaced by hematite, while the interior of the shell was filled with calcite, thus permitting the use of acid. Each of the cones was found to taper rather rapidly outward and consisted of eleven turns of the flat lamella. The lamellae were not fimbriated as Davidson from those of Athyris pectinifera Sowerby to be unfortunately the
loop of this specimen was so distorted that its form could not be made out.

No other species of this genus are known from the Devonian, but several species have been described from the Mississippian and Pennsylvanian. The shell known as Cleiothris raissyi L'Evaille is the most common of the Mississippian forms. Girty states that the shell as figured by L'Evaille is 34.5 mm. wide and 22.5 mm. long, deeply folded, with the two depressions which define the fold so deep as to give the shell a trilobate appearance. The beak is not incurved so that the round open foramen is a noticeable characteristic of the typical specimen. ........

In young stages the shell is subcircular in outline, becoming quite transverse and somewhat quadrate in the adult, while old shells show a tendency to regain the circular form. The history of the development of the sinus of the pedicle valves is similar. In young shells it is entirely absent. In the adult it is strongly developed, but in many old individuals it is practically obliterated. Individuals are found in which the development of one or both of these characters is retarded or accelerated ..........." (1)
Order PROTREMATA

Superfamily STROPHOMENACEA Schuchert

Family STROPHOMENIDAE King

Genus SCHUCHERTELLA

Schuchertella chemungensis Hall

(Plate VIII, figure II)

Streptorrhynchus chemungensis Hall, Pal. N.Y., Vol. IV, Pl. 9, fig. 1.

Hemipronites chemungensis Meek, 40th, Parl. Surv., p. 13, fig. 2.


Original description:

"Shell semicircular or semielliptical, frequently symmetrical, the proportions of length and breadth varying in different individuals: hinge-line straight, nearly or quite equal to or greater than the greatest width of the shell: sides nearly rectangular to the hinge line, or curving inwards. Ventral valve more or less convex towards the umbo and sometimes in the middle, curving downwards or flattened toward the front and sides of the shell: beak often distorted; area vertical or inclined forwards or backwards, usually unequal on the two sides of the foramen, which is closed by a strong convex deltoidal plate. Dorsal valve depressed convex, sometimes nearly flat and sometimes very convex, with a narrow linear area: socket-plates strong, and supporting the cardinal process, which is double and has sometimes a faint ridge between the two divisions, which are themselves very short. Surface marked by sharp, close radiating crenulated striae, which increase mainly
by interstitial additions."

Discussion:

These specimens show a considerable range in size but they all seem to belong to the same species and variety. The dimensions of an average specimen are: width on hinge 25 mm., height 18 mm. A rather small specimen has a width of 9 mm., and a height of 7.5 mm. All of the specimens show the characteristics of the variety as noted by Hall.\(^1\)

The representatives of this species are neither concave nor convex but rather flat. Otherwise they agree with the above description. They are very numerous and are found in all districts where the Three Forks has been studied.

Localities:

Logan, North fork of the Boulder Creek, South Boulder, Big Snowy Mountains. Reported from Princeton and Livingston, Montana, also from the Chemung of New York, Pennsylvania, Ohio, Nevada, Manitoba and Alberta.

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Family ORTHIDAE Dallman
Genus SCHIZOPYORIA King

Schizophoria striatula Schuchert


**Description:**

"The dorsal valve has much the same shape as the ventral but is more gibbous. Larger individuals,......show a broad, faint elevation of the anterior portion. The striae are subequal, and number about 10 in the space of 5 mm." (1)

Brachial valve sinuate in front. Pedicle valve with abroad, undefined sinus, sometimes uncurving the margin of the shell. Surface very finely and evenly striated." (2)

**Discussion:**

Only one complete fossil of this type was obtained but several broken ones have been looked at. Specimens apparently vary widely among themselves with reference to the sinus, but this variation probably a developmental feature.

**Localities:**

North fork of the Boulder Creek, Logan. Reported from Three Forks, New Mexico, Gowa, New York.

Genus RHIPIDOMELLA Cehlert


Rhipidomella vanuxemi (?) Hall

(Plate IX, figures 3 and 5)

Orthisvanuxwmi Hall, 1858, Geol. Surv. Iowa, I, pt.2, p.487, Pl.2, figs.2 and 3.


Original description:

"Shell depressed orbicular, varying from circular to transversely broad oval, and rarely a little longer than wide, resupinate. Ventral valve most convex near the beak, gradually depressed below and flattened towards the front; beak elevated, scarcely incurved. Dorsal valve most convex a little above the centre, an undefined depression down the middle, which expands into a broad flattened space, sometimes giving the base a straight appearance; beak scarcely defined; length of area about one-third the width of the shell: foramen broad, partially filled with the strong cardinal process.

Surface marked by fine closely arranged radiating tubular striae, which increase by bifurcation and implantation, and are crossed by very fine concentric lines, and towards the margins by imbricating lines of growth; striae with frequent tubular openings upon the surface.

Interior surface finely punctate. Interior of ventral valve marked by a large foliate or flabelliform vascular impression, and in older shells a strongly defined impression of the adductor muscles a little above the centre of this, and a prominent cardinal process which is continued below in a ridge along the centre of the valve. Margins crenulate with the radiating striae, which are sometimes visible more than half way to the beak of the shell."

1). Hall, James, 1858, Geol. Surv. of Iowa, I, pt.2 p.487, Pl.2, figs. 2 and 3.
Discussion:

These species are very common although quite broken. They occur in the limestone rather than the shale. The sizes vary but otherwise follow the description given above. They correspond with the description and figures of those in the Ouray limestone of Colorado.

Localities:

Big Snowy Mountains, North Fork of the Boulder Creek, Reported from Logan and Three Forks, New Mexico and Colorado.

**Productella coloradensis** Kindle

(Plate XII, figures 1 and 4)

**Productella coloradensis** Kindle, Bull. U.S. Geol. Surv., No. 391, p. IV, Pl. IV, figs 208


Original description:

"Mature specimens of *P. Coloradensis* generally show a slight tendency toward a sinus in the ventral valve; generally this amounts only to a flattening across the middle of shell, but in some shells a distinct sinus is present, as shown in Plate IV, figure 5. In *P. semiglobosa* there is no such flattening, the shell presenting a regularly circular outline in front. The Colorado form is slightly more arched, the beak being rather more strongly incurved and the shell descending more abruptly in front. However, the Colorado and the Louisville species are very closely allied, particularly in the scattered irregular spine bases of circular
outline. Prominent ears similar to those of the Colorado are preserved on one of the Louisville shells.

Round spine bases mark the anterior two-thirds of the shell; on well-preserved specimens small round tubercles which do not seem to have spines take the place of these in the umbonal region. In exfoliated shells small round pits mark the mold of the shell under the spine bases, indicating a thickening of the shell on the inner side at the base of the spines. Fine concentric lines of growth mark the surface of well-preserved shells. Prominent concentric wrinkles mark the ears and less distinctly the umbonal region. They are absent or indistinct on the anterior two-thirds of the shell.

The dorsal valve is distinctly geniculate in front and moderately concave in the middle and posterior portion. The surface is marked by small shallow pits about corresponding in number to the spine-bases of the opposite valve. The cardinal process has two short slightly diverging prongs." (1)

Discussion:

This species is very common in the Upper Devonian of Montana: The sizes vary greatly. The description follows that given above very closely.

Localities:

They are very abundant in the Ouray of Colorado from where the original description comes. They are found in Montana in most of the outcrops of the Three Forks shale.

Family PRODUCTIDAE Gray
Genus PRODUCTELLA Hall
Productella spinigera kindle
(Plate XIII, figures 2 and 5)


Original description:

"Shell rather small, subhemispheric in outline.

Ventral valve moderately concave; beak small and slightly over arching the hinge line. Entire surface covered by closely set short slender spines or by small tubercles marking their bases. Some specimens are marked by strong lamellae of growth; in others these are indistinct or absent. In the former class the lamellae have given rise to a more or less regular concentric arrangement of the spines; in the latter no very definite concentric alignment is apparent.

Dorsal valve slightly concave. The entire surface is covered with fine short spines like those of the opposite valve. The spines on both valves are pressed close against the shell and point toward the front and lateral margins.

The interior of the dorsal valve is shown in a specimen believed to belong to this species. The inner surface is rugose or finely granulated. A fine thread-like septum beginning about 1 mm. from the cardinal process extends one-third the distance to the front. The two lobes of the cardinal process coalesce in front, giving a horse-shoe-like outline opening in front. --------- The minute character and general distribution of the spines distinguish this species from any with which it may be compared except P. Laminatus, which is distinguished from it as stated in the description of that species." (1)

Subkingdom MOLLUSCA
Class PELECYPODA
Order PRIONODERMACA Dall
Family PTERINEIDAE Dall
Genus LOXOPTERIA Fresch
Loxopteria holzapfeli Raymond
(Plate XIV, figures 1 and 4)

Loxopteria dispar Clarke, 1903. "The Naples Fauna Western New York; Memoir of new York State Museum, No. 6, p272, Pl.13, figs. 6-17.


Original description:

"Shell somewhat triangular in outline, in equi-valve, the right valve nearly flat, the left valve capuliform.

The right valve is slightly convex, sometimes quite flat. A narrow sulcus extends from the beak to a notch in the posterior margin of the shell, and delimits a wing-like portion of the valve. There is no posterior gape observable in any of the shells in the collection, but the thin margins of the "ears" are frequently broken.

The left valve is strongly elevated and acute in the umbonal region, but the beak is incurved almost to the hinge. The anterior end of the valve is smoothly rounded, the length of the hinge being less than the length of the shell. From the highest point on the valve to the anterior margin the slope is gradual, but the posterior slope is abrupt and slightly concave. This concavity is broken by a ridge which extends from the posterior side of the beak to a rounded, ear-like extension of the posterior margin of the valve.

The surface of both valves is marked by numerous fine, radiating striae. The right valve also
shows a few rather strong concentric undulations. No muscle scars have been observed on the left valves, but some of the better preserved casts of the interiors of right valves show a small but strong oval posterior scar and an apparently entire pallial line. An anterior muscle was undoubt-
edly present, but its scar has not been detected on any of the specimens at hand.

The prodissoconch is retained on both valves, and is set off from the remainder of the beak by a shallow groove. Its position shows a clock-wise torsion of the shell during growth.

The ligament was external. The ligamental area on the left valve is triangular, with the apex of the triangle directly beneath the beak. On the right valve the greater part of the ligamental area is posterior to the beak, and its plane is at an angle of about 45° to the remainder of the valve.

No striations were observed on the ligamental area."

Discussion:

Only one specimen of this type has been found although Raymond says they are very common at Three Forks. It seems to be localized in the fissile shale, according to him, but the one pictured comes from the limestone.

Localities:

Three Forks, Montana, North fork of the Boulder Creek.

Genus NUCULITES Conrad

Nuculites oblongatus Conrad

(Plate XIV, figure 6)

Description:

Elongate - ovate, widest anteriorly. Beak appressed and low. Surface marked by very fine concentric striae.

Discussion:
Only one specimen of this type was found. It was collected from the green shale at Logan. The hinge line cannot be seen. The concentric striations are clear.

Localities:

Genus AVICULOPECTEN McCoy
Aviculopecten sp?
(Plate XIII, figures 1 and 4)

Description:
"Pectiniform, inequilateral, in equivalve, with right valve usually less convex than the left. Hinge line straight with both anterior and posterior ears. Surface usually radially sculptured. Ligament internal, extending to both sides of the beak in many shallow grooves roughly parallel to the long hinge line. Resiliifer present. Teeth absent. Pallial line simple."(1)

Discussion:
Fragments of this type may be found in great abundance in the shale of the Logan deposit. This shale de-

crepitates soon after it is exposed to the atmosphere so it is difficult to get an identifiable specimen.

Locality:

Logan. Reported from Colorado, Iowa, Montana.
Phylum MOLLUSCOIDEA

Class BRYOZOA

Genus FENESTELLA Lonsdale

Description:

"Fan or funnel-shaped reticulated expansion of straight or flexuous rigid branches, apertures united by non-celluliferous cross-bars or dissepiments at regular intervals; two rows of apertures on the inside of branches, separated by a plain or tuberculated median keel." (1)

Discussion:

These specimens are so poorly preserved that the species cannot be given.

Location:

Upper Devonian in Montana.

Class CONULARIDA Miller and Gurley

Family CONULARIDAE Walcott

Genus CONULARIA Miller

Conularia sp?

Description:

"Shell elongated pyramidal with transverse section varying from quadrangular to octagonal. Each lateral face marked by a median or longitudinal groove. Surface transversely striated

Grabau, A.W., "North American Index Fossils", Vol.II.
Discussion:

This form is very abundant in the shale facies of the Three Forks at Logan. There seem to be none in the limestone. Only fragments have been found. The author has spent no time trying to identify these.

Locations:

Logan, Reported from New York, Ohio, Nevada and New Mexico.

Note: There is an abundance of Bryozoa of the order TREPOSTOMATA Ulrich as may be seen in plate XVIII, figures 3 and 6, and on plate XVII, figure 5, and on plate XIII, figures 3 and 6. The author has made no attempt to separate these any further. These forms are extremely abundant and their importance of their further classification cannot be over-emphasized.
Class CRUSTACEA Lamarck
Subclass OSTRACODA Latreille

Discussion:
One specimen of a very large ornate ostracod was collected from the shales at Logan. They may be viewed on plate XV, figures 1 through 6. The dimensions are about 1 centimeter. The author has made no attempt to classify this specimen.
Class CEPHALOPODA
Subclass TETRABRANCHIATA
Order NAUTILOIDA Hyatt
Family ORTHOCERATIDAE Hyatt
Genus ORTHOCERAS Breyn emend. Hyatt
Orthoceras montanense Raymond

(Plate XII, figures 3 and 6)


Original description:

"This species is known only from fragments none of which are large. The shell is circular in section and tapers very gradually. The cameras are shallow there being seven in a length of 16 mm. The sutures are nearly straight, the septa strongly convex. The eiphon tube is 1.5 mm. in diameter and by the same measurement at the smaller end of another specimen where the shell is 7 mm. in diameter. The eiphuncle is slightly off the center of the shell, but whether dorsad or ventrad cannot be determined. No specimen in the collection shows any part of a living chamber that can be referred to this species.

" ............. One of the specimens sectioned shows the short siphonal funnels very well as the siphuncle contained only a very soft clay which was easily removed. ............." (1)

Discussion:

This is another of the abundant fossils of the Upper Devonian in Montana. The size ranges are extremely great but the general description given above satisfies each.

Localities:
This species is common to the Upper Devonian of Montana and is observed in all areas where the formation crops out.

Order AMMONODEA
Suborder GASTROCAMPAULI Hyatt
Family CYMENIDAE Gumbel
Genus PLATYCYNEMEN Hydra Hyatt
Platyclymenia americana Raymond

Clymenia [Platyclymenia] americana Raymond 1907.

[Plate 16, figures 1-4]

Original description:
"Shell of medium size for the genus, compactly coiled, but not involute. The whorls are depressed in section, the venter of the inner whorls flattened, that of the living chamber more convex. The living chamber is large, consisting of over half a valuation. The chambers are rather shallow on the inner whorls, become deep in the adult, and then suddenly become so shallow that the septa are twice as numerous as before. The sides of the whorls are crossed by strong ridges which have a slightly diagonal trend and which die out on the umbilical margin and on the venter. Some of these ribs point forward, others a little backward. The ribs become further apart on each whorl, until on the body whorl they are quite distant from each other. They do not bear any fixed relationship to the chambers, for, as may be seen on the figures, a rib may be between the septa, or may be cut in any direction by a septum. The
dorsum is slightly concave and is frequently marked by a revolving line showing the position of the siphuncle. As shown by the figures, the suture is very simple." (1)

Discussion:

In Montana this is an index fossil. It is very abundant in all outcrops but whole fossils are almost impossible to get. The species is localized in the paper-shale. Its occurrence is not noted from anywhere else. It is never found in limestone. It is a typical shale fossil.

Localities:

In all areas in southwestern Montana where the shale is visible.

Suborder MICROCAMPHYLI Hyatt
Family NAUTILINIDAE Hyatt
Genus PROLOBITES Karpinsky
Prolobites simplex Raymond

(Plate XVI, figures 2, 3, 5 and 6)


Original description:

"Shell plump, involute, the umbilicus becoming very narrow in fully grown shells. Adult shells are only slightly compressed and the young specimens are almost globular. None of the specimens are entire, but from the shells at hand it

is evident that the living chamber occupies over half a valuation. The surface markings which consist of very faint ridges, run slightly fore and from the umbilicus and turn back in the venter, forming a shallow hyponomic sinus. The cameras are deep in young specimens, a specimen 10 mm. in diameter showing only three sutures in full valuation. The suture is almost straight from the umbilicus to the ventral lobe, but shows a shallow saddle near the umbilicus. This suture is much simpler than that of the adult Prolobites delphinus (Sandberger), but is somewhat like that of the variety atava described by French." (1)

Discussion:

Photographs were taken of this species by use of the microscope. The two shown closely resemble the description above.

Localities:

Logan and Helena.

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Weed, W.H.
Explanation of Plate I

Fig. 1. Spirifer whitneyi Hall, (Ventral valve) X 1.

Fig. 2. Spirifer whitneyi Hall, (Side view) X 1.

Fig. 3. Spirifer whitneyi Hall, X 1.

Fig. 4. Spirifer whitneyi Hall, X 1.

Fig. 5. Spirifer whitneyi Hall, (Top view showing shape of area) X 1.

Fig. 6. Spirifer whitneyi Hall, X 1.
Explanation of Plate II

Fig. 1. Spirifer whitneyi Hall, X 3/2

Fig. 2. Spirifer whitneyi Hall, (Top view showing shape of area) X 1

Fig. 3. Spirifer whitneyi Hall, X 1.

Fig. 4. Spirifer whitneyi Hall, (Top view showing shape of area) X 3/2

Fig. 5. Spirifer whitneyi Hall, (Partially released rock) X 1

Fig. 6. Spirifer whitneyi Hall, (Showing shape of area) X 1.
Explanation of Plate III

Fig. 1. Spirifer whitneyi Hall, X 1.
Fig. 2. Spirifer whitneyi Hall, X 1.
Fig. 3. Spirifer whitneyi Hall, (Top view showing shape of area) X 1.
Fig. 4. Spirifer disjunctus Sowerby, (Ventral valve) X 1.
Fig. 5. Spirifer disjunctus Sowerby, X 1.
Fig. 6. Spirifer disjunctus Sowerby, (Showing shape of area) X 1.
Explanation of Plate IV

Fig. 1. *Spirifer disjunctus* Sowerby; (view of both valves) X 1.

Fig. 2. *Camarotoechia contracta* Hall, (Enlarged by microscope) X 20.

Fig. 3. *Camarotoechia contracta* Hall, X 20

Fig. 4. *Camarotoechia contracta* Hall, X 20.

Fig. 5. *Camarotoechia contracta* Hall, X 20.

Fig. 6. *Camarotoechia contracta* Hall, X 20.
Explanation of Plate V

Fig. 1. Camarotoechia contracta Hall, (Ventral valve) X 3/2.

Fig. 2. Camarotoechia contracta Hall, X 3/2

Fig. 3. Camarotoechia contracta Hall, (Side view) X 3/2.

Fig. 4. Camaratooechia contracta Hall, X I.

Fig. 5. Camarotoechia contracta Hall, X I.

Fig. 6. Camarotoechia contracta Hall, (Side view) X I.
Explanation of Plate VI

Fig. 1. Spirifer raymondi Haynes, X I.

Fig. 2. Spirifer raymondi Haynes; X I.

Fig. 3. Spirifer raymondi Haynes, X I.

Fig. 4. Spirifer raymondi Haynes, X I.

Fig. 5. Spirifer raymondi Haynes, X I.

Fig. 6. Spirifer raymondi Haynes, (Top view showing shape of area) X I.
Explanation of Plate VII.

Fig. 1. Leiorhynchus madisonense var. gibbosum Haynes, X I.

Fig. 2. Leiorhynchus madisonense var. gibbosum Haynes, X I.

Fig. 3. Leiorhynchus mesacostale Hall, X I.

Fig. 4. Leiorhynchus mesacostale Hall, X I.

Fig. 5. Leiorhynchus jeffersonense Haynes, X I.

Fig. 6. Leiorhynchus jeffersonense Haynes, X I.
Explanation of Plate VII

Fig. 1. Leiorhynchus mesacostale Hall, XI.

Fig. 2. Schuchertella chemungensis Hall, XI.

Fig. 3. Schizophoria striatula Kindle, X I.

Fig. 4. Leiorhynchus mesacostale Hall, XI.

Fig. 5.

Fig. 6. Schizophoria striatula Kindle, XII.
Explanation of Plate IX

Fig. 1. *Ambocoelis gregaria* Hall, X 4.

Fig. 2. *Ambocoelis gregaria* Hall, (Side view showing beak) X 4.

Fig. 3. *Rhipidomella vanuxemi* (?) Hall (Enlarged by microscope) X 6.

Fig. 4. *Ambocoelis gregaria* Hall, X 4.

Fig. 5. *Ambocoelis gregaria* Hall, (Brachial valve, showing sinus) X 4.

Fig. 6. *Rhipidomella vanuxemi* Hall, X 1.
Explanation of Plate X

Fig. 1. Cleiothyridina devonica Raymond, X 3/2.

Fig. 2. Cleiothyridina devonica Raymond, X 3/2.

Fig. 3. Cleiothyridina devonica Raymond, X 3/2.

Fig. 4. Cleiothyridina devonica Raymond, X 3/2.

Fig. 5. Cleiothyridina devonica Raymond, (Enlarged by microscope) X 6.

Fig. 6. Cleiothyridina devonica Raymond, ((Showing spirals, the valve having been removed) X 3/2.)
Explanation of Plate XI

Fig. 1. Atrypa reticularis Hall, X 1
Fig. 2. Atrypa reticularis Hall, X 1
Fig. 3. Atrypa reticularis Hall, (side view) X 1
Fig. 4. Gastropod
Fig. 5. Gastropod X 5
Fig. 6. Crinoid stem X 1
Explanation of Plate XII

Fig. 1. *Productella coloradensis* Kindle, X 3/2

Fig. 2. *Productella coloradensis* Kindle, and *Orthoceros montanense* Raymond, X I

Fig. 3. *Orthoceros montanenses* Raymond, X I

Fig. 4. *Productelle coloradenses* Kindle, X 3/2

Fig. 5. *Productelle coloradenses* Kindle, X I

Fig. 6. *Orthoceros montanense* Raymond, X L
Explanation of Plate XIII

Fig. 1. Aviculopecten sp? X 3

Fig. 2. Productella spinigera Kindle, X I

Fig. 3. Bryozoz X I

Fig. 4. Aviculopectin, sp? X 3

Fig. 5. Productella spinigera Kindle X I

Fig. 6. Bryozoa X I
Explanation of Plate XIV

Fig. 1. Loxopteria holzapfeli Raymond
   X I

Fig. 2. Unidentified X I

Fig. 3. Conularia X I

Fig. 4. Loxopteria holzapfeli Raymond,
   X I

Fig. 5. Fenestella X I

Fig. 6. Nuculites oblongatus Conrad,
   X I
Explanation of Plate XV

Fig. 1. Ostracod Latreille X 5
Fig. 2. Ostracod Latreille X 5
Fig. 3. Ostracod Latreille X 5
Fig. 4. Ostracod Latreille X 5
Fig. 5. Ostracod Latreille X 5
Explanation of Plate XVI

Fig. 1. Plotyclymenia americana Raymond, X 1
Fig. 2. Prolobites simplex Raymond, X 10
Fig. 3. Prolobites simplex Raymond, X 10
Fig. 4. Protyclymenia americana Raymond, X 10
Fig. 5. Prolobites simplex Raymond, X 10
Fig. 6. Prolobites simplex Raymond, X 10
Explanation of Plate XVII

Fig. 1. Slab of fossiliferous rock X \( \frac{1}{2} \)
Fig. 2. Slab of fossiliferous rock X \( \frac{1}{2} \)
Fig. 3. Coral X I
Fig. 4. Slab of fossiliferous rock X \( \frac{1}{2} \)
Fig. 5. Bryozoa X I
Fig. 6. Coral X I
Explanation of Plate XVIII

Fig. 1. Razor Clam (?) X 3/2

Fig. 2. Crinoid stem X 2/2

Fig. 3. Bryozoa X I.

Fig. 4. Unidentified X I.

Fig. 5. Unidentified X I.

Fig. 6. Bryozoa X I.
#3

#6 (Same as #3)

#2

#4

#1