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Brachiopoda from the Madison limestone in Montana

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BRACHIOPODA FROM THE MADISON LIMESTONE IN MONTANA.

by

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INTRODUCTION

Brachiopods are important fossils in a study of the stratigraphy of the Madison limestone because they are abundant and relatively well preserved. The writer originally intended to figure and describe all the available brachiopods from the Madison formation in Montana, and to make correlations between localities in the State where the exact stratigraphi position of the fossils could be determined, Because the collections wer found too large to be described completely only the new species are figured and described at this time. However, in order to identify the new species every specimen in the collections was carefully studied. The previously known species, as well as new species, are presented in the form of a faunal chart. See page 85.

A discussion of the anatomy of the Brachiopoda is unnecessary in this paper, because the class is well known to paleontologists.[1] For this reason descriptions of the families of the class Brachiopoda have also been omitted. Generic descriptions are given only of the genera to which the new species belong.

The fossils studied by the writer were collected from eighteen localities in the State. The principal collections were made by C. F . Deiss in northwestern Montana for the State Bureau of Mines and Geology. The specimens catalogued and deposited in the Museum of Paleontology of the State University were collected by J. P. Rowe, R. C. Rowe, J. H. Bradley Jr., and Earl Douglass. Edward L. Broadwater made a collection from the Yakinikak limestone in Flathead County. The writer made collections from the Madison limestone in the Pryor Mountains.

HISTORICAL REVIEW

The Madison formation is of lower Mississippian age, consists predominantly of blue or grey massive limestones, and occurs over a large portion of the state. Those papers which discuss only extent and lithology of the Madison formation without contributing specifically to the paleontology of its fauna have been omitted in the following historical review.

The first description of the brachiopod fauna from the Madison limestone in Montana was by Meek[2] in 1873. He collected fossils from the formation at the outlet of Mystic Lake; on the east side of Madison River

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[1] An adequate discussion of Brachiopod morphology may be found in, Carl von Zittel, "Textbook of Paleontology," 2nd. ed. pp. 355-69, 1913.

[2] F. B. Meek, "Paleontological Report:" Sixth Ann. Report of the U. S. Geol. Survey of the Territories, pp. 432-434; 465-471. 1873.

Canyon; on Bridger Peak; near Fort Ellis; near Black-Tail Deer Creek; on the north side of Gros Ventees Butte; on Flathead Pass; on the north side of Henry's Lake; and in the canyon west of Gallatin River. Concerning this material Meek stated,[3]

> "In looking over the collections from these localities, I have been impressed with the similarity of their general facies, without being quite sure that any of them are identical, to the fauna of the Waverly Group of Ohio, now known to belong to the Carboniferous. At the same time that I would refer the beds from which these fossils were obtained to the Carboniferous, it should be remarked that we have every reason to believe that they belong to a lower horizon in the series than those from which nearly all of the collections from 'Old Baldy';* Montana were obtained; also, than the fossiliferous beds on the divide between Ross Fork and Lincoln, Montana."

Meek recognized the existence of Upper and Lower Carboniferous horizons, and attempted to place exactly the age relationship of the Lower Carboniferous strata. He also gave faunal lists and inadequate descriptions of two new species of brachiopods.

In 1893 Peale[4] applied the formational name Madison to the Lower Carboniferous strata exposed in the Three Forks region. C. D. Walcott identified the collected fossils and called them Lower Carboniferous though the basal collections had a distinct Devonian affinity. After Peale named the Madison formation, the name was applied to Lower Mississippian rocks throughout the greater portion of Montana, Wyoming,

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[3] Idem. p. 433

[4] A. C. Peale, "The Paleozoic section in the vicinity of Three Forks, Montana:" U. S. Geol. Survey, Bull. 110, pp. 32-43. 1893.

*Old Baldy Mountain is situated seven miles S. 10° W. of Virginia City, Madison County, Three Forks quadrangle, Montana.

southeastern Idaho, and northern Utah. No new forms were described in Peale's report but faunal lists were given.

In 1899 Girty[5] contributed an excellent description of the fauna of the Madison limestone as represented in the collections made by the Arnold Hague survey of Yellowstone National Park. Girty regarded the Madison as representing the Kinderhook and Osage epochs. He also gave a thorough discussion of the age relationships, part of which follows,[6]

> "We may therefore conclude that the Madison limestone does not probably represent the period of the Genevieve group, but, while showing distinct affinities with the Kinderhook, may have persisted through the period of the Osage as well."

Girty figured and discussed a large number of known species of brachiopods and described 11 new species and varieties.

In 1905[7] Earl Douglass made several collections in southwestern Montana. Part of these collections are in the Museum of Natural Science of the State University. The fossils are practically valueless because they were not catalogued, and many of the locality labels have been lost. With the exception of the collections, faunal lists of Madison brachiopods were Douglass' only contribution to the problem.

In 1917 Clark[8] collected Madison fossils from Old Baldy Mountain near

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[5]G. H. Girty, "Devonian and Carboniferous Fossils:" U. S. Geol. Survey, Monograph, 32, pt. 2, pp. 483-496; 507-577. 1899.

[6]Idem p. 494.

[7]Earl Douglass, "Some Notes on the geology of southwestern Montana:" Annals of the Carnegie Museum, vol. III, no. 2, pp. 416-425. Pittsburg, 1905.

[8]T. H. Clark, "New blastoids and brachiopods from the Rocky Mountains:" Harvard College, Mus. Comp. Zoology, Bull. 61, pp. 361-380. 1917.

ginia City, and described one new genus and four new species of brachio-
s.

No other writers have contributed to the paleontology of the Madison
estone except for those who have given faunal lists in various publica-
ns of the U. S. Geological Survey and other reports.

Recent work in neighboring regions deserves mention here. In 1927
ren[9] described two new species of brachiopods from the Rundle limestone,
ch is tentatively correlated with the Madison of Montana. In 1932 the
s writer[10] described four species from the Banff shale.

In 1927 Girty[11] described nine new species of brachiopods from the
sissippian limestones of southeastern Idaho. In the same paper he gave
excellent discussion concerning the relation of the Madison formation
the type section of the Mississippian formations.

TECHNIQUE OF OBSERVATION AND STUDY

Many of the specimens studied were embedded in hard crystalline lime-
ne. The best method of removing the matrix and exposing the specimen
by the use of a fine chisel and light hammer. Chisels were made by
ding large phonograph needles to an edge; then mounting them in a stylus
pped with a chuck.

S. Warren, "Banff Area, Alberta:" Memoir No. 153, Canadian Geological Survey, pp. 58-59. 1927.

, A. Allan, P. S. Warren, and R. L. Rutherford, "A preliminary study of the eastern ranges of the Rocky Mts. in Jasper Park, Alberta;" Trans. of the Royal Soc. Canada, 3d ser. vol. 26, sec. 4, pp. 244-48. 1932.

, H. Girty, "Description of new species of Carboniferous and Triassic fossils:" U. S. Geol. Survey Professional Paper, No. 152, pp. 411-417. 1927.

The material was examined under a binocular microscope in order to observe minute structures. Brushing with a stiff short haired brush was helpful in cleaning some surfaces. A very thin film of oil smudged on some of the specimens and then briskly brushed made some minute details more readily observable.

ARTIFICIAL KEYS FOR THE IDENTIFICATION OF GENERA AND SPECIES

The following keys form an important part of the technique of studying a large number of fossils species. The generic and specific characters were taken from the original description, if available, or from other sources and tabulated on charts. By analyzing these charts for distinctive characters keys were constructed which eliminated inaccuracies in determining the differences between closely related forms. The construction of these keys formed a large part of the work necessary for accurate specific determinations. The large variety of forms handled required the use of a rapid method of identifying species. These keys provided such a method. Genera which contained five or fewer species were not keyed because a comparison of the specimen with the original descriptions and figures could be made readily. Practically all the descriptions of North American Mississippian brachiopoda were made available by the cooperation of the library staff. The following keys are given in this paper in order to place them on record for future use. Omissions of genera or species are noted at the end of each key.

Key to North American genera of Mississippian Brachiopoda

I. SHELL ENCRUSTING

#. Conforming to shape of object to which attached ——— CRANIA
##. Not conforming; shape subconical ——— ORBICULOIDEA
OEHLERTELLA

II. SHELL CONCAVO-CONVEX TO PLANO-CONVEX

C. Cardinal area present
d. valves spinose
k. spines limited to a single row along cardinal margin
t. double set of concentric oblique markings present- CHONETINA
tt. double set of concentric oblique markings absent
h. pedicle valves strongly convex; with narrow sinus CHONETINA
hh. pedicle valve not strongly convex; sinus generally absent ——— CHONETES
kk. spines irregularly distributed over surface of valves
e. with cicatrix on pedicle valve ——— STROPHOLOSIA
ee. without cicatrix on pedicle valve
*. plano-convex; psuedoresupinate ——— SCHIZOPHORIA
**. concavo-convex; moderately convex ——— PRODUCTELLA

dd. valves aspinose
f. shell smooth
ea. high cardinal area; linguloid ——— BARROISELLA
eal. low cardinal area; rounded ——— AMBOCOELIA
fff. shell striate; lamellae present or absent
e. strong wrinkles concentric to anterior margin —— LEPTAENA
ee. no strong wrinkles concentric to anterior margin
r. resupinate; nonseptate pedicle valve ——— SCHELLWIENELLA
rr. not resupinate
tr. triangular rostral cavity in pedicle valve — ORTHOTETES
trr. no triangular rostral cavity in pedicle valve DERBYIA

CC. Cardinal area absent
d. valves spinose
kk. spines irregularly distributed over surface of valves
q. with long tubular extension of pedicle valve ——— PROBOSCIDELLA
qq. without long tubular extension of pedicle valve —
O. strong flexuous growth lines on both valves —— ETHERIDGINA
OO. no strong, flexuous growth lines
n. with diaphram arising from brachial valve ——— DIAPHRAGMUS
nn. without diaphram arising from brachial valve — PRODUCTUS
—— PUSTULA
kkk. spines situated on concentric bands ——— ECHINOCHONCHUS
dd. valves aspinose
f. shell smooth

j. dorsal valve linguloid ---------- LINGULA
jj. dorsal valve linguloid, subtrigonal in outline ------ GLOSSINA
jjj. dorsal valve depressed conical, or patelliform ------ ORBICULOIDEA
---- PHOLIDOPS

III. SHELL BICONVEX
i. hinge line short; posterior part of shell pointed
a. fold and sinus absent
f. shell smooth, terebratuloid,
sl. short loop formed direct, united in median line forming a broad plate ---------- SELENELLA
---- ROMINGERINA
ssl. long crura; with ascending branches or fringes ------ CRYPTONELLA
---- HARTTINA
sssl. short loops, cruralia often present ---------- CRANAENA*
---- HAMBURGIA*
---- ROWLEYELLA*
---- DIELASMA*
fff. shell striate; lamellae present or absent ---------- RHIPIDOMELLA
ffff. shell strongly plicated; lamellae present or absent
pa. very coarse subangular plications (5-6)
i. punctate ---------- RHYNCHOSPIRINA
---- HUSTEDIA
ii. impunctate, (strongly serrate edge but not a true fold and sinus) ---------- PTYCHOSPIRA
pr. plications numerous, rounded, non-bifurcating ---------- EUMETRIA
---- ACAMBONA
---- TETRACAMERA
---- MOOREFIELDELLA
aa. fold and sinus present
f. shell smooth
g. terebratuliform
ax. fold and sinus simple
s. with median septum ---------- CIRTYELLA*
ss. without median septum
i. punctate ---------- CRANAENA*
---- DIELASMA*
---- DIELASMELLA*
ii. impunctate ---------- COMPOSITA
axx. fold or sinus, or both of biplicate character
i. punctate ---------- DIELASMA*
---- DIELASMOIDES*
---- GIRTYELLA*
ii. impunctate ---------- CAMAROPHORELLA
---- COMPOSITA

gg. rhynchonelliform, (plications obsolete or broadly rounded) ---------- CAMAROPHORIA
---- SEMINULA
ggg. subquadrate; sharply rostrate ---------- CENTRONELLA
---- CENTRONELLOIDEA

*See key to genera of family Dielasmatidae.

fff. shell striate; lamellae present or absent ---------- RHIPIDOMELLA
ffff. shell plicate; lamellae present or absent
i. punctate
pa. coarse, subangular plications ---------- RHYNCHOPORA
pr. numerous rounded simple plications ---------- EUMETRIA
ii. impunctate
ps. plications bearing fine radiating striae ---------- AXIODEANEIA
---- PARAPHORHYNCHUS
---- RHYNCHOTETRA
pss. plications not bearing fine radiating striae
b. plications not extending to beaks; obsolete in posterior portion ---------- CAMAROPHORIA
---- PUGNAX
---- PUGNOIDES
bb. plications extending to beaks.
pr. numerous, simple, rounded plications ---------- MOOREFIELDELLA
po. few, broad, rounded, obsolete plications ---------- SHUMARDELLA
pa. angular to subangular plications
s. with median septum in brachial valve ---------- CAMAROTOECHIA
---- TETRACAMERA
ss. without median septum in brachial valve ---------- ALLORHYNCHUS

2. Hinge line medium; length of hinge line less than, but occasionally subequal to greatest width of shell
a. fold and sinus absent
d. shell spinose
kk. spines irregularly distributed over surface of valves ---------- SCHIZOPHORIA
kkk. spines on concentric bands ---------- CLIOTHYRIDINA
dd. shell aspinose
f. shell smooth
w. fine concentric lines parallel to anterior margin— CAMAROPHORELLA
ww. shell with strong lamellar expansions at each growth line ---------- ATHYRIS
---- COMPOSITA
fff. shell striate; lamellae present or absent
e. with strong wrinkles concentric to anterior margin — STREPTORHYNCHUS
ee. without strong wrinkles concentric to anterior margin
s. with median septum ---------- ORTHOTETES
---- DERBYIA
ss. without median septum ---------- SCHELLWIENELLA
---- SCHUCHERTELLA
ffff. shell strongly plicate; lamellae present or absent
j. lamellae present ---------- ATHYPA

aa. fold and sinus present
d. shell spinose
kk. spines irregularly distributed over surface of valves ---------- NUCLEOSPIRA

kkk. spines on concentric bands
n. double tubed spines ---------- RETICULARIA
nn. flat imbricating spines ---------- CLIOTHYRIDINA
nnn. fine hollow tubulose costae, produced into spines - SCHIZOPHORIA
dd. shell aspinose
f. shell smooth
w. shell with fine concentric growth lines
c. cardinal area present ---------- MARTINIA
cc. cardinal area absent or obsolete ---------- COMPOSITA
---- SEMINULA
---- CAMAROPHORELLA
ww. shell with broad lamellar extensions at each growth line ---------- ATHYRIS
ffff. shell strongly plicate; lamellae present or absent
g. rhynchonelliform ---------- LIORHYNCHUS
---- CAMAROPHORIA
gbx. spiriferoid
i. punctate ---------- SPIRIFERELLA
ii. impunctate
clr. cardinal extremities rounded ---------- BRACHYTHYRIS
cla. cardinal extremities angular ---------- SPIRIFER

3. Hinge line long; length of hinge line equal or subequal to the greatest width of shell
a. fold and sinus absent ---------- SCHELLWIENELLA
---- SCHUCHERTELLA
aa. fold and sinus present
i. punctate
sx. with syrinx ---------- SYRINGOTHYRIS
sxx. without syrinx
ya. cardinal area differentiated into three areas ---- PSUEDOSYRINX
yaa. cardinal area not differentiated into three areas
ca. cardinal area high ---------- CYRTINA
cal. cardinal area low ---------- SPIRIFERINA
ii. impunctate
kp. spines on plications ---------- ACANTHOSPIRA
kpp. without spines on plications
ca. cardinal area high ---------- CYRTIA
cal. cardinal area low to moderately high
fold and sinus nonplicate, or single one ---------- DELTHYRIS
fold and sinus plicate---------- SPIRIFER

Key to Genera of family Dielasmatidae

I. Without fold or sinus in either valve
  A. with median septum supporting hinge plate ---------- ROWLEYELLA
  AA. without median septum supporting hinge plate
    d. dental plates present in pedicle valve
      x. hinge plate in brachial valve not attached along median line ---------- HAMBURGIA
      xx. hinge plate in brachial valve attached directly to valve along median line ---------- DIELASMA
      ---- CRANAENA
    dd. without dental plates in pedicle valve ---------- BEECHERIA

II. Sinus present in both pedicle and brachial valves
  A. with median septum supporting hinge plate ---------- GIRTYELLA

  (Composita laevis Weller characterized by same condition of fold and sinus) ---------- COMPOSITA

III. Sinus present in pedicle valve; neither fold nor sinus present in brachial valve ---------- DIELASMA
  ---- CRANAENA

IIII. Fold and sinus present
  a. fold in brachial valve of bisinuate character; low median fold in broad shallow sinus ---------- GIRTYELLA
  (Dielasma inflata Weller has same character) ---------- DIELASMA

V. Sinus in pedicle valve of bisinuate character; developed only in anterior portion of shell, and there weakly ------ DIELASMOIDES

VI. Fold and sinus of simple (single) character, lying in brachial and pedicle valves respectively
  k. beak straight, erect, slightly incurved; valves much compressed ---------- DIELASMELLA
  kk. beak strongly incurved; large foramen encroaching on umbonal region; valves moderately compressed to tumid ---------- DIELASMA

Key to Mississippian species of genus Brachythyris

X. Size of shell small
  a. sinus bears plications
    p. plications continuous from beak to anterior margin
      1. single fine median plication ---------- n. sp. 1
      3. three plications in sinus
        1p. 6 lateral plications on each slope ---------- n. sp. 2
        1p. 11 lateral plications on each slope ---------- n. sp. 3
      4. four plications in sinus ---------- altonensis
    pp. plications not continuous from beak to anterior margin obsolete past midlength ---------- semiplicata
  aa. sinus does not bear plications
    c. with well defined false cardinal area ---------- peculiaris

cc. without well defined false cardinal area	
L. lateral slopes strongly convex at anterior margin (90° to plane of valve)	fernglenensis
LL. lateral slopes less convex at anterior margin	
lp. 5-6 lateral plications on each slope of valve	simulans
lp. 8-10 lateral plications on each lateral slope	burlingtonensis
XX. Size of shell medium	
c. well defined false cardinal area	subcardiformis
cc. without false cardinal area	
p. plications continuous from beak to anterior margin	
1. single plication in sinus	burlingtonensis
4. four plications in sinus originating from bounding ones	choteauensis
7. seven plications in sinus	gurleyi
XXX. Size of shell large	
y. plications essentially obsolete on fold and sinus	suborbicularis
yy. plications rounded (3), well defined on fold and sinus	subcardiformis

Key to some Mississippian species of genus Camarotoechia

A. Angle at beak, formed by lateral margins less than 90°	
L. Length of shell less than width	tuta
LL. Length of shell greater than width	
u. with prominent umbonal cap	n. sp. 2
uu. without prominent umbonal cap	
p. 2 plications in sinus	n. sp. 1
p. 3 plications in sinus	camarifera
p. 4 plications in sinus	
pl. 7-8 lateral plications on each slope	grosvenori
pl. 5 lateral plications on each slope	n. sp. 3
AA. Angle at beak 90° or less	
L. length of shell less than width	tuta
LL. length of shell greater than width	grosvenori
LLL. shell strongly globose in outline	subglobosa
AAA. Angle at beak, formed by lateral margins, 90° or more.	
n. shell flat or subplanate	
m. deep groove in umbonal region of brachial	marshallensis
mm. without deep groove in umbonal region	sappho
nn. shell subglobose	
r. fold marked by a longitudinal median depression extending ¼ distance from beak to anterior margin	
pa. with angular plications	choteauensis
pr. with rounded plications	tuta
rr. fold not marked by a median depression	
L. length of shell less than width	
at. anterior margin truncate	mutata

ar. anterior margin rounded
pa. angular plications ---------- elegantula
---- metallica
pr. rounded plications ---------- grosvenori
---- purduei
LL. length of shell greater than width
p. 2 plications in sinus ---------- herrickana
p. 3 plications in sinus ---------- subglobosa
p. 4-5 plications in sinus ---------- grosvenori

Note: Following species omitted from key: allani, sageriana, 3 varieties of purduei, contracta, endlichi.

Key to Mississippian species of genus Camarophoria

N. Strong numerous plications
s. sinus bearing 2-3 very broad, depressed plications ---- ringens
ss. sinus bearing 7-8 depressed, rounded plications ------- hamburgensis

NN. Few, broad, rounded to obsolete plications
w. with plications on lateral slopes
L. length of shell less than width
(wide sinus) ---------- explanata
LL. Length of shell greater than width
(narrow sinus; prominent beak) ---------- obesa
ww. without plications on lateral slopes ---------- bisinuata

NNN. Non-plicate; concentric growth lines ---------- thera
(figure and description make form seem more probably an Athyris or Composita.)

Key to some Mississippian species of genus Chonetes

A. Greatest width of shell lying along hinge line
s. sinus present
c. cardinal extremities acutely angular
i. costae bear spine bases (punctations) ---------- batesvillensis
ii. costae not bearing spine bases (impunctate) ------- logamensis
cc. cardinal extremities rectangular or obtusely angular - multicosta
ss. sinus absent
c. cardinal extremities acutely angular
p. radiating costae essentially obsolete; subordinate to concentric ornamentation ---------- planumbona var.
---- choctawensis

pp. radiating costae broad, depressed, not originating at beak ---------- logani

ppp. costae extending to beak

i. costae bear spine bases ---------- sericeus

---- batesvillensis

ii. costae not bearing spine bases

e. strongly depressed, extended, auriculations

m. shell minute ---------- ornatus var.

---- arkansanum

mm. shell small; not minute ---------- glenparkensis

ee. auriculations small; not extended ---------- ornatus

cc. cardinal extremities rectangular to obtusely angular

k. fine radiating costae not extended to beak ----------

p. 100 costae at anterior margin ---------- burlingtonensis

p. 35-40 costae at anterior margin ---------- geniculatus

---- logani

kk. fine radiating costae extended to beak

i. costae bearing spine bases

p. 5-9 costae per mm. ---------- shumardanus

p. 3-4 costae per mm. ---------- batesvillensis

ii. costae not bearing spine bases

p. 5-9 per mm. ---------- chesterensis

p. 2-4 per mm. ---------- miseri

---- ornatus

---- setigerus

AA. Greatest width of shell not along hinge line

s. sinus present

p. 3-4 costae per mm. ---------- missouriensis

p. 6 costae per mm. ---------- illinoisensis

ss. sinus absent

i. costae bear spine bases

o. pits in intercostal furrows ---------- shumardanus

oo. no pits in intercostal furrows ---------- illinoisensis

ii. costae do not bear spine bases

p. 35-40 costae at anterior margin ---------- geniculatus

p. 75-100 costae at anterior margin ---------- gregarius

p. 170 plus costae at anterior margin ---------- missouriensis

Note: Following species omitted; pulchellus, tumidus.

Key to some Mississippian species of the genus Cliothyridina

X. Size small
  L. length greater than width ---------- sublamellosa
  LL. length less than width
    dd. sinus very shallow, not prominent ---------- elegans
  LLL. width and length subequal
    v. valves subequally convex
      c. outline distinctly sub-pentagonal ---------- parvirostris
      cc. outline tending from subpentagonal to circular ---- hirsuta
        (possibly synonymous) ---- temilineata
    vv. not subequally convex; brachial valve more convex ---- sublamellosa

XX. Size medium
  LL. length less than width
    d. sinus deep anteriorly ---------- prouti
    dd. sinus shallow ill defined anteriorly ---------- glenparkensis

XXX. Size large
  L. length greater than width ---------- incrassata
  LL. length less than width ---------- obmaxima

Following species omitted: squamosa, roysii.

Key to Mississippian species of genus Composita

X. Size small
  L. length greater than width
    s. with fold and sinus
      g. distinct groove along the median line in sinus ---- trinuclea
      gg. without median groove in sinus
        f. fold in brachial valve replaced by sinus ---------- laevis
        ff. fold in brachial valve obsolete ---------- lewisensis
    ss. without fold and sinus
      (very poorly developed or obsolete though may be present)---------- corpulenta
      u. extenuate, pointed umbonal region ---------- n. sp. 4
      uu. umbo not extenuate; high rounded prominent --- n. sp. 3

  LL. length less than width
    s. with fold and sinus
      t. sinus strong, tripartite in pedicle valve ---------- opposita
      tt. sinus simple
        a. with fine concentric growth lines ---------- globosa
        aa. with coarse heavy concentric growth lines ---------- pentagonia
    ss. without fold and sinus ---------- n. sp. 1

LLL. length and width subequal ---------- n. sp. 2

XX. Size medium
d. sinus deep anteriorly ---------- sulcata
dd. sinus shallow anteriorly ---------- subquadrata

Key to some Mississippian species of genus Dielasma

X. Size small
s. with fold and sinus
f. fold and sinus of tripartite character ---------- inflata
ff. fold and sinus narrow and single
e. greatest convexity in brachial valve ---------- illinoisensis
ee. greatest convexity in pedicle valve ---------- occidentalis
ss. without fold and sinus
o. triangular in outline ---------- subspatulatum
oo. elongate oval in outline ---------- formosum

XX. Size medium
s. with fold and sinus
l. sinus originating at beak, extending anteriorly ------- shumardanus
ll. sinus originating at midlength
u. umbo prominent projecting conspicuously beyond beak of opposite valve ---------- sinuata
uu. umbo prominent but not projecting ---------- arkansanum
lll. sinus originating close to anterior margin ---------- n. sp. 1
ss. without fold and sinus
p. fine depressed radiating costae ---------- choteauensis
pp. without fine radiating costae ---------- utah
---- formosum

XXX. Size large
i. shell punctate
o. subtriangular in outline ---------- fernglenensis
oo. subelliptical in outline ---------- gorbyi
ii. impunctate ---------- burlingtonensis

Note: The following species are omitted: hastata, osceolensis, sacculus.

Key to some Mississippian species of genus Eumetria

X. Size small
- pa. angular plications ---------- acuticosta
- pr. rounded plications
  - v. shell ventricose ---------- verneuiliana
  - vv. not ventricose ---------- perstrialis

XX. Size medium
- p. plications broad and rounded ---------- altirostris
- pp. plications narrow rounded; subangular at times
  - c. 30-40 costae on each valve ---------- costata
  - e. 42-48 costae on each valve ---------- vera
- ppp. plications lacking ---------- osagensis
  (may be E. vera if lack is not constant feature)

Note: The following species are omitted: marcyi, woosteri.

Key to Mississippian species of genus Girtyella

I. Sinus originating in umbonal region
- f. fold and sinus of tripartite character ---------- brevilobata
  ---- turgida
  ---- intermedia
- ff. fold and sinus not of tripartite character ---------- n. sp. 1

II. Sinus originating approximately at midlength, or posterior to middle of valve
- fff. without fold on brachial valve ---------- cedarensis
- f. fold and sinus of tripartite character ---------- intermedia
  ---- indianensis
  ---- woodworthi

Key to some Mississippian species of genus Productus

I. WIDTH OF SHELL GREATER THAN LENGTH
- x. size of shell small
  - A. hinge line equal to greatest width of shell
    - a. mesial sinus present
      - r. costae essentially absent ---------- adairensis
      - rr. costae not continuous; interrupted or elongate pustules ---------- dolorosus
      - rrr. coarse, continuous radiating costae ---------- richardsi
        ---- mesialis
      - rrrr. fine, continuous, radiating costae ---------- inflatus var.
        ---- coloradoensis

aa. mesial sinus absent
i. finely pubctate (in slightly exfoliated cond.) --- altonensis
ii. impunctate
r. costae essentially absent[12] ---------- subsulcatus
---- subsulcatusvar
---- moorefieldanus
---- moorefieldanus var. pusillus

rrrr. fine, continuous, radiating costae
c. 6 costae per mm. ---------- scitulus
cc. 3 costae per mm., also enrolled margin -------- wortheni
two following species belong in this group ---- parviformiis
---- gallatinensis

C. hinge line less than greatest width of shell
a. mesial sinus present ---------- dolorosus
aa. mesial sinus absent
p. with conspicuous mesial costa ---------- mesicostalis
pp. without conspicuous mesial costa
m. pronounced, inflated enrolled margin ---------- martinicinctus
mm. without enrolled margin[12] ---------- subsulcatus
---- subsulcatus var. janus
---- moorefieldanus
---- moorefieldanus var. pusillus

xx. Size of shell small
A. hinge line equal to greatest width of shell
a. mesial sinus present
z. costae absent on lateral and anterior slopes of valve ---------- semistriatus
zz. costae present on lateral and anterior slopes of valve
ww. concentric wrinkles absent ---------- lowei
---- multistriatus
w. concentric wrinkles present
e. auriculations small, not extended
b. strongly incurved beak ---------- burlingtonensis
bb. moderately incurved beak
rrrr. costae fine ---------- inflatus
---- inflatus var.
---- ? coloradoensis
rrr. costae coarse ---------- semireticulatus
---- mississippiensis
ee. auriculations large, extended ---------- depressus
---- mosialis

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[12]For discussion of these four species see: U. S. G. S. Bull. 439, pp. 47-50.

aa. mesial sinus absent
m. enrolled margin on pedicle valve ---------- wortheni
mm. without enrolled margin ---------- scabriculus

C. Hinge line less than the greatest width of shell
a. mesial sinus present
n. elongate nodes ---------- blairi
nn. fasciculate nodes anterior to spine bases ---------- fernglenensis
---- subsulcatus
---- subsulcatus var. janus
aa. mesial sinus absent ---------- sedaliensis

xxx. Size of shell large
A. hinge line equal to greatest width of shell
ww. concentric wrinkles absent ---------- multistriatus
w. concentric wrinkles present
b. strong band of spines around valve joining cardinal extremities ---------- crawfordsvillensis
bb. group of spines in oblique rows along cardinal extremities ---------- magnus
bbb. spines irregularly disposed ---------- semireticulatus
position uncertain ---------- giganteus

II. LENGTH OF SHELL GREATER THAN WIDTH
x. Size of shell small
A. hinge line equal to greatest width of shell
a. sinus present ---------- subhorridus
aa. sinus absent ---------- parvulus
C. hinge line less than greatest width of shell
c. costae regular and radiating ---------- arcuatus
---- sampsoni
cc. costae not regular and radiating ---------- indianensis
---- subhorridus

xx. size of shell medium
A. hinge line equal to greatest width of shell ---------- inflatus
---- depressus
C. hinge line less than greatest width of the shell
g. concentric wrinkles confined to portion of valve near cardinal extremities ---------- ovatus
gg. concentric wrinkles distributed over entire valve- arkansanum

III. WIDTH AND LENGTH SUBEQUAL
x. Size of shell small
A. hinge line equal to greatest width of shell
a. sinus present ---------- dolorosus
---- multistriatus
aa. sinus absent ---------- moorefieldanus
---- moorefieldanus var. pusillus
---- parvus

C. hinge line less than greatest width of shell ---------- galeanus
xx. size of shell medium
A. hinge line equal to greatest width---------- curtirostris
---- lowei
C. hinge line less than greatest width of shell ---------- tenuicostus
xxx. size of shell large
A. hinge line equal to greatest width of the shell -------- setigerus
C. hinge line less than greatest width of the shell -------- viminalis
---- newberryi

Note: The following species of Productus have been omitted from the key because the literature in which they are described is not available: carbonarius, confragosus, compressus, duplicostata, giganteus, gracilis, granulosus, incurvus, ivesi, latissimus, leuchtenbergensis, lineolatus, margaritaceous, martini, nodocostatus, occidentalis, pectenoides, phillipsi, raricostatus, rushvillensis, subserratus, spinosus, swallovi, villiersi.

Key to Mississippian species of genus Rhipidomella

X. Size of shell small
a. sinus absent
f. with a broad low fold (brachial valve has sinus) --- jerseyensis
ff. without broad low fold ---------- tenuicostata
incertae sedis ---------- pulchella
aa. fold and sinus present
c. cardinal area present, well developed
m. minute shell, (5-6 mm.); gibbous ---------- perminuta
mm. not minute (10-25 mm.); lenticular
t. subquadrate
s. sinus ill defined ---------- diminutiva
ss. sinus strong, mod. deep ---------- thiemi
cc. cardinal area absent ---------- dubia

XX. Size of shell medium
k. pedicle valve with sinus
c. with fine costae, 9-13 per mm. ---------- arkansana
cc. with moderately coarse costae, 2-3 per mm. ---------- burlingtonensis
kk. pedicle valve without sinus ---------- missouriensis

XXX. Size of shell large
O. subcircular in outline
ks. with sinus in brachial valve ---------- oweni
kss. without sinus in brachial valve ---------- burlingtonensis
OO. not subcircular in outline; subquadrangular ---------- nevadensis

Key to Mississippian species of genus Rhynchotetra

XX. Size of shell medium
  ss. simus absent; or obsolete
    b. plications extending to beak (4-5 in number) ——— missouriensis
    bb. plications essentially obsolete on beak and in umbonal region ——— elongatum
  s. simus present ——— gibbosum

XXX. Size of shell large
  p. plications simple ——— ovatum
  pp. plications not simple; but dividing
    k. plications generally simple, only 2-3 divide ——— caputtestudinis
    kk. plications with frequent bifurcations ——— gibbosum

Key to Mississippian species of genus Rhynchopora

X. size of shell small
  i. punctate
    p. 2-3 plications in simus ——— perryensis
    pp. 3-6 plications in sinus
      0. plications in simus marked by a median groove extending some distance from the anterior margin- pustulosa
      00. plications is simus not marked by a median groove
        t. punctate probably confined to the tops of plications ——— beecheri
        tt. punctae usually in single row on each side of plications ——— hamburgensis
    ppp. 8-10 plications on simus ——— pinguis
    pppp. 7 plications on simus ——— persimuata
  ii. impunctate ——— cooperensis

XX. Size of shell medium ——— rowleyi

Key to Mississippian species of genus Schellwienella

XX. Size of shell medium
  k. costae coarse (2 per mm.) ——— choteauensis
  kk. costae fine (2-5 per mm.)
    lc. posterior margins of cardinal area lying almost in a straight line
      v. pedicle valve concave throughout entire length ——— cremulicostata
      vv. pedicle valve concave only at the anterior margin — inaequalis
    lcc. posterior margins of valve are not in a straight line ——— inflata

XXX. Size of shell large
  W. greatest width at hinge line ---------- burlingtonensis
  WW. greatest width not along hinge line
    KK. concentric markings crossing costae are stronger in the intercostal furrows than on the summits of the costae ---------- alternata
    KKK. concentric markings crossing the costae are stronger on the summits of costae than in intercostal furrows
      lc. posterior margins of cardinal area lying almost in a straight line ---------- inaequalis
      lcc. posterior margins not in a straight line --- inflata
    KKKK. without concentric markings crossing the costae — planumbona

Key to some Mississippian species of genus Spirifer

I. WIDTH GREATER THAN LENGTH

  x. Size of shell small
    l. sinus marked by a simple non bifurcating median plication
      A. Cardinal extremities rounded or obtusely angular
        r. cardinal area high ---------- jeffersonensis
        rr. cardinal area moderately high
          d. sinus deep ---------- bifurcatus
          dd. sinus shallow ---------- annectans
      B. Cardinal extremities sharply angular
        s. with fine radiating striae
          d. sinus deep (profound anteriorly) ---------- leydi
          dd. sinus shallow
            ca. cardinal area low and narrow
              lp. lateral plications not bifurcating ---- centronatus
              lp. lateral plications bifurcating ---------- albertensis
            cat. cardinal area triangulate and slightly arched ---------- louisianensis
            ---- osagensis
        ss. without fine radiating striae
          m. cardinal area vertically striate ---------- platynotus
          mm. cardinal area not vertically striate ---------- latior
            ---- agelaius
            ---- kellogi
      C. Cardinal extremities mucronate
        bs. fold and sinus distinctly biplicate ---------- biplicatus
        bbs. fold and sinus not biplicate; bears additional plications on lateral slopes of sinus
          kp. 1 plic. on lateral slope of sinus ---------- biplicoides
            ---- n. sp. 3
          kp. 2 plic. on lateral slope of sinus ---------- osagensis

D. Cardinal extremities right angled ---------- bifurcatus
---- latior

ll. Sinus marked by a bifurcating median plica
A. Cardinal extremities rounded or obtusely angular
rr. cardinal area moderately high ---------- marshallensis
rrr. cardinal area low, small ---------- tenuimarginatus
B. Cardinal extremities sharply angular
jzh. 16-20 rounded depressed plications on lateral slope ---------- platynotus
jzh. 8-10 depressed rounded plications ---------- albertensis
jzh. 28-34 depressed rounded plications ---------- n. sp. 4
lll. Sinus without median plication; or any lateral plications in sinus ---------- mundulus
---- n. sp. 8
---- n. sp. 9

XX. Size of shell medium
l. sinus marked by a simple non bifurcating median plication
A. Cardinal extremities rounded or obtusely angular ---- martiniformis
B. Cardinal extremities acutely angular
r. cardinal area high
jyh. 16-18 simple rounded plications on each lateral slope of valve ---------- legrandensis
jyh. 9-10 plicae on each lateral slope ---------- n. sp. 1
jyh. 12-14 plicae on each lateral slope ---------- calvini
rr. cardinal area moderately high
s. with fine radiating striae
cs. with fine concentric strias ---------- washingtonensis
---- increbescens
css. without fine concentric strias ---------- n. sp. 2
---- centronatus
ss. without fine radiating stries
ca. cardinal area long and narrow; lateral margins subparallel to hinge line ---------- marionensis
caa. cardinal area not long and narrow; broadly triangular
kl. plications extending to beak, well defined
1-2 plicae on each lateral slope of sinus ---- platynotus
2-3 plicae on each lateral slope of sinus ---- n. sp. 5
3-4 plicae on each lateral slope of sinus ---- vernonensis
2-4 plicae on each lateral slope of sinus ---- shepardi
kll. plicae extending to beak but poorly defined --- n. sp. 7
kkll. plicae in sinus not extending to beak -------- albapinensis
C. Cardinal extremities mucronate
jzh. 20-23 bifurcating rounded plicae on each lateral slope of valve ---------- shepardi
jzh. 12-15 nonbifurcating radiating plicae on lateral slopes of each valve ---------- mysticensis
D. Cardinal extremities right angled
jyh. 11-15 nonbifurcating rounded plicae on each lateral slope ---------- keokuk

jzh. 15-20 bifurcating, rounded plicae on each lateral slope of valve ---------- floydensis
jya. 5-8 simple angular plicae on each lateral slope --- bifurcatus
---- leydi

ll. sinus marked by a bifurcating median plication
A. Cardinal extremities rounded or obtusely angular
s. with fine radiating striae ---------- rutherfordi
ss. without fine radiating striae
jzh. 25 or more bifurcating, rounded plicae on each lateral slope of valve ---------- subrotundus
jyh. unequal, nonbifurcating plicae on each lateral slope of valve ---------- inaequalis
B. Cardinal extremities sharply angular
s. with fine radiating striae
jzh. 3-5 plications in each side of sinus divide into fascicles of 2 or 3 ---------- missouriensis
jzh. 2-3 plicae on each side of sinus divide but not into fascicles ---------- albertensis
jyh. plicae nonbifurcating on lateral slopes ---------- centronatus
ss. with fine concentric striae
O. outline imbrex type ---------- platynotus
OO. outline subsemicircular ---------- deltoideus
C. Cardinal extremities mucronate ---------- rutherfordi
D. Cardinal extremities right angled ---------- keokuk
---- pellaensis

lll. Sinus without median plication ---------- winchelli
llll. Sinus with evanescent plicae ---------- moorefieldanus
---- n. sp. 7

XXX. Size of shell large
l. sinus marked by a simple nonbifurcating median plica
A. Cardinal extremities rounded or obtusely angular ------ calvini
B. Cardinal extremities sharply angular
r. cardinal area high
jyh. 12-14 simple depressed convex plicae in sinus
kp. 4-5 flattened plicae in sinus in addition to median one ---------- calvini
jyh. 12-17 rounded plicae on each lateral slope of valve
kp. 7 plicae in sinus ---------- insculptus
jzh. 10-12 rounded, bifurcating, fasciculate plicae on each lateral slope ---------- mortonanus
rr. cardinal area moderately high
jyh. 25-30 simple depressed, rounded, plicae; separated by narrow angular plicae; on each lateral slope ---------- forbesi
jyh. 34-40 similar plicae ---------- casei
jyh. 25 rounded, subangular plicae, 5-8 next to sinus double, continuing to anterior margin in pairs ---------- mortonanus

rrr. cardinal area low; small
jzh. valve covered by bifurcating plicae, fasciculate in groups of three ---------- haydenianus
jzh. valve covered with nonbifurcating plicae ------- crawfordsvillensis
---- incertus
---- incertiformis
C. Cardinal areas mucronate ---------- desiderata
11. sinus marked by a bifurcating median plication
A. Cardinal extremities rounded or obtusely angular
r. cardinal area high ---------- brazerianus
rr. cardinal area moderately high
dd. sinus shallow; broad ---------- grimesi
d. sinus narrower, deeper, and more sharply defined rowleyi
d. smaller shell than grimesi, with more rotund form and narrower median sinus ---------- gregeri
rrr. cardinal area low and small ---------- sillanus
---- striatus
---- pikensis
---- n. sp. 14
B. Cardinal extremities acutely angular
r. cardinal area high
f. fold acuminate ---------- lateralis
ff. fold not acuminate
sp. sinus plicate ---------- n. sp. 11
ssp. sinus not plicated ---------- n. sp. 10
rr. cardinal area moderately high
kkzh. 20-25 bifurcating, rounded plications in sinus logani
---- arkansanum
---- n. sp. 6
kkzh. 16-20 bifurcating rounded plicae in sinus------ subaequalis
---- forbesi
---- n. sp. 13
kkza. 15 bifurcating angular plicae in sinus ------- imbrex
rrr. cardinal area low ---------- rundlensis
---- cascadensis
---- incertus
111. No median plication on sinus ---------- banffensis

II. WIDTH LESS THAN LENGTH
X. size of shell small
A. Cardinal extremities rounded or obtusely angular
d. sinus deep ---------- littoni
dd. sinus shallow ---------- indiamensis
XX. size of shell medium ---------- subrotundus
---- maplensis
XXX. size of shell large ---------- grimesi

III. WIDTH AND LENGTH SUBEQUAL
  X. size of shell small
    l. sinus marked by a simple nonbifurcating median plicae ---------- brekenridgensis
    ll. sinus marked by a median bifurcating plication ---------- rostellatus
  XX. size of shell medium ---------- albertensis
  ---- subrotundus
  XXX. size of shell large ---------- brazeriamus
  ---- scobina

Note: The following species have been omitted from the key: clavatula, duplicostus, heilhavii, kellogi, ovalis, waverlyensis, trigonalis.

Key to some Mississippian species of genus Spiriferina

X. Size of shell small
  I. width of shell greater than length
    p. with median plica in sinus ---------- solidirostris
    pp. without median plica in sinus
      d. diameter not exceeding 5.5 mm. ---------- norwoodana
      dd. diameter ranging from 5.5 mm. to 25 mm.
        e. 7-9 plicae on each lateral slope ---------- subtexta
        ee. less than 7 plicae on each lateral slope ----------
          t. surface of valve crowded with tubercles (spine bases) ---------- spinosa
          tt. surface of valve not bearing tubercles ---------- salemensis
  II. Width of shell equals twice the length ---------- transversa

XX. Size of shell medium ---------- subelliptica

Note: The following species have been omitted from this key: binacuta, cristata, depressa, octoplicata, pulchella, praetransversa.

Key to some Mississippian species of genus Syringothyris

X. Size of shell small
  p. 16 plicae on each lateral slope ---------- halli
  pp. less than 16 plicae on each lateral slope ---------- missouriensis
XXX. Size of shell large
  I. width of shell approximately 3 times the length ---------- extenuatus
  II. width of shell approximately 2 times the length
    es. cardinal area sloping posteriorly at an angle of 40° from the hinge line ---------- platypleurus
    ess. cardinal area sloping posteriorly at an angle greater than 40° from the hinge line

b. brachial valve moderately convex ---------- newarkensis
bb. brachial valve strongly convex ---------- textus
---- n. sp. 1

III. width and length approximately subequal
cs. cardinal area sloping posteriorly at an angle of 40° from the hinge line ---------- bushbergensis
css. cardinal area sloping posteriorly at an angle greater than 40° from the hinge line 50-60 degrees
k. with secondary cardinal area ---------- typus
kk. without secondary cardinal area ---------- hannibalensis

90 plus degrees
f. flat cardinal area ---------- subcuspidatus
ff. concave cardinal area ---------- solidirostris

Note: The following species have been omitted from the key: herricki, gigas.

DESCRIPTIONS OF GENERA

Genus ATRYPA Dalman

1767. Anomia, Linnaeus. Systema Naturae, ed. xii, p. 1152.

1820. Terebratulites, Schlotheim. Petrefactenkunde, p. 262, Nachtr., pl. xvii, fig. 2; pl. xviii, fig. 2; pl. xx, fig. 4.

1821. Anomites, Wahlenburg. Nov. Act. Reg. Soc, Scientif. Upsal., vol. viii, p. 65.

1822. Terebratula, Sowerby. Mineral Conchology, vol. iv, p. 324, fig. 2.

1828. Atrypa, Terebratula, Dalman. Kongl. Vetenskaps Akad. Handlingar, pp. 127, 128, 143; pl. iv, figs. 2, 3; pl. vi. fig. 6.

1914. Atrypa, Weller. Mississippian Brachiopoda, Illinois State Geological Survey, Monograph I, pp. 284-285. Generic description taken from this publication.

DESCRIPTION: Shell subcircular in outline, strongly inequivalved with the brachial valve gibbous or with the valves subequally convex, the hinge-line short and the cardinal extremities rounded, surface radially plicate and usually marked by more or less conspicuous, concentric, lamellose lines of growth. Pedicle valve with a small, incurved beak with the foramen and

delthyrium hidden except in young individuals; internally the hinge teeth are large and widely separated, and the muscular impressions are sharply defined. In the brachial valve the crura are long, narrow and widely divergent, the jugum consists of two processes situated posteriorly at the junction of the crura with the primary lamellae, directed towards the center of the shell and not joined at their inner extremities, the spirals have their bases subparallel with the inner surface of the pedicle valve, and their apices convergent towards the center of the brachial valve.

Genotype: Anomia reticularis Linnaeus. Systema Naturae, 12th edition, vol. 1, p. 1132.

Genus BRACHYTHYRIS McCoy

1844. Brachythyris, McCoy, Carboniferous Fossils of Ireland, pp. 128, 144, fig. 20.

1914. Brachythyris, Weller, Mississippian Brachiopoda, Illinois State Geologic Survey, Monograph I, pp. 370-371. Synonymy incomplete, generic description taken from Weller.

DESCRIPTION:" Shells varying in size from small to large, the length and breadth subequal, the outline ovate to subcircular; the hinge-line straight, much shorter than the greatest width of the shell, the cardinal extremities rounded. Mesial sinus of the pedicle valve and the fold of the brachial valve more or less well developed. Surface of both valves marked by radiating plications which are simple upon the lateral slopes of the valves, those of the fold and sinus increasing in number in passing from the beak to the front margin. The pedicle valve with the beak usually only moderately elevated above the hinge-line, and the cardinal area strongly arched. Internally, the dental lamellae supporting the hinge-teeth are short, commonly being only ridge-like thickenings of the inner surface of

the valve on each side of the delthyrium, the muscular scars ill-defined. The brachial valve commonly less convex than the pedicle, with a very narrow, inconspicuous cardinal area, the cardinal process low, with its anterior surface vertically striated: the form of the brachidium as in Spirifer."

Genotype: Spirifera ovalis Phyllips. Geology of Yorkshire, pt. 2, p. 219, pl. 10, fig. 5. 1894.

Genus CAMAROTOECHIA Hall and Clarke

1841. Atrypa, Conrad. Ann. Rept. Paleontologist. Dept. N. Y., p. 55.

1843. Atrypa, Hall, Geology of New York; Rept. Fourth Dist.; Tables of Organic Remains, No. 66, figs. 3, 4; No. 67, fig. 2.

1847. Atrypa, Hall. Paleontology of New York, vol. 1, pp. 21, 23, pl. iv (bis), figs. 7, 9.

1852. Atrypa, Hall. Paleontology of New York, vol. 2, p. 70, pl. 23, figs. 4, 5; p. 274, pl. 57, fig. 1; p. 279, pl. 58, figs. 3, 4.

1857. Rhynchonella, Hall. Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 78, figs. 1-7; p. 82, fig. 1-3; pp. 81, 86.

1860. Rhynchonella, Billings. Canadian Journal, vol. 5, pp. 271, 272.

1860. Rhynchonella, Hall. Thirteenth Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 87, 88.

1862. Rhynchonella, A. Winchell. Proc. Acad. Nat. Sci. Philadelphia, pp. 407-408.

1862. Rhynchonella, Billings. Paleozoic Fossils, vol. 1, pp. 141-143, figs. 118-120.

1863. Rhynchonella, Hall. Transactions of the Albany Institute, vol. 4, pp. 215, 216.

1867. Rhynchonella (Stenocisma). Hall. Paleontology of New York, vol. 4, pp. 335-345, 348-353, pl. 54, figs. 1-59; pl. 54a, figs. 1-23, 44-49; pl. 55, figs. 1-52.

1879. Rhynchonella, Hall. Twenty-eighth Rept. N. Y. State Mus. Nat. Hist., pp. 163, 164, pl. 26, figs. 12-33.

1882. Rhynchonella, Hall. Eleventh Ann. Rep. State Geologist of Indiana, pp. 305-307, pl. 26, figs. 12-33.

1884. Rhynchonella, Walcott. Monogr. U. S. Geol. Survey, vol. 8, p. 152, pl. 14, fig. 3; pl. 25, fig. 6; p. 155, pl. 14, fig. 8.

1887. Rhynchonella, Gosselet. Annales de la Societ Geologique du Nord, vol. 14, p. 188, pls. 1-3.

1888. Rhynchonella, Herrick. Bulletin Labor. Denison University, vol. 3, pp. 39, 40, pl. 5, fig. 1; pl. 7, fig. 25; pl. 10, fig. 9.

1893. Camarotoechia, Hall and Clarke. Pal. N. Y., vol. 8, pt. 2, p. 189.

DESCRIPTION:"By restricting the application of the term Stenoschisma to shells agreeing in hinge-structure with Rhynchonella formosa, the necessity is created for a new designation for the large group of shells to which that term was applied in 1867. While these shells are susceptible to considerable variation in exterior, they usually maintain a full trihedral contour with shallow pedicle, and convex brachial valves, evincing little, if any evidence at maturity, of a reversal of the relative convexity of early growth, a feature so apparent in some of the other groups of rhynchonellioda. Their distinctive characters, however, are internal; the median septum of the brachial valve is divided posteriorly in such a manner as to form an elongate cavity, which does not extend to the bottom of the valve. Each branch of the septum supports one of the lateral divisions of the hinge-plate, to which are attached the curved crural processes. In normal conditions of development the median interspace of the hinge-plate is not closed. The dental sockets, bordering the hinge-plate, are cremulated in the species which are assumed as representing the typical characters of the group. There is no cardinal process.

In the pedicle-valve slender vertical lamellae support the rather small teeth and extend well into the cavity of the valve, enclosing a deep and narrow pedicle-scar.

This is a group of shells highly developed in species, and eminently characteristic of the Devonian faunas, and hence Rhynchonella congregata, Conrad, is designated as the type of the genus."

Genotype: Rhynchonella congregata Conrad.

Genus COMPOSITA Brown

1849. Composita, Brown, Illustrated Fossil Conchology of Gt. Britain and Ireland, p. 131.

1914. Composita, Weller, Mississippian Brachiopoda, Illinois State Geological Survey, Monograph I, pp. 484-485. Synonymy incomplete, generic description from Weller.

DESCRIPTION: "Shells small or of medium size, subovate, subquadrangular to subpentagonal in outline, the valves biconvex, with the fold and sinus developed in the anterior portion of the shell or sometimes extending posteriorly to the umbonal region, both the fold and sinus may be marked by a rather sharp mesial sulcus. The surface of the valves smooth or marked only by concentric lines of growth which are never extended into lamellae. The beak of the pedicle valve incurved so as to conceal the delthyrium, but the foramen is usually exposed, encroaching upon the umbonal region of the valve. Internally the dental lamellae and muscular scars resemble those of Athyris, but with the diductor impressions usually more faintly developed. In the brachial valve the hinge-plate is similar to that of Athyris, but with its posterior margin extended posteriorly beyond the margin of the valve into the umbonal cavity of the opposite valve; the brachidium, including the jugum, with its accessory lamellae

similar to that of Athyris."

Genotype: Spirifer ambiguous Sowerby. Mineral Conchology, vol. 4, p. 105, pl. 376. 1823.

Genus DIELASMA King

1809. Conchyliolithus, anomites, Martin. Petrefacta Derbiensia, p. 11.

1816. Terebratulites, Sclotheim. Denkschr. der K. Akad. der Wissensch. zu München, vol. 6, p. 27.

1824. Terebratula, Sowerby. Mineral Conchology, vol. 5, p. 65.

1824. Terebratula, von Buch. Ueber Terebrateln, p. 90.

1836. Terebratula, Morton. American Journal of Science, vol. 29, p. 150, pl. 2, fig. 4.

1844. Atrypa, McCoy. Synopsis Carb. Foss. Ireland, p. 153.

1845. Terebratula, de Verneuil. Geol. de la Russie et des Mont. de l'Oural, vol. 2, pp. 63, 65, pl. 9, figs. 7, 8.

1848. Terebratula, Geinitz. Verstein. der deutsch. Zechst. Gebirg., p. 11, pl. 4, figs. 27-36.

1850. Epithyris, King. Monogr., Permian Foss. England, p. 146, pl. 6, figs. 40-45.

1854. Terebratula, Semenow. Die Foss. des schles. Kohlenk., p. 11, pl. 3, fig. 5.

1855. Semimula, Mc Coy. British Paleozoic Fossils, p. 408.

1856. Terebratula, Hall. Pacific R.R. Reports, vol. 3, p. 101, pl. 2, figs. 1-2.

1857. Terebratula, Davidson. British Permian Brachiopoda, pp. 3-11, pl. i, figs. 5 - 22; pl. ii, fig. 2.

1857. Terebratula, Davidson. British Carboniferous Brachiopoda, pp. 11-16, pl. i, figs. 1-16, 23-32; pl. ii, figs. 1-8.

1858. Terebratula, Hall. Transactions of the Albany Institute, vol. 4, pp. 6, 7, 35.

1858. Terebratula, Hall. Geology of Iowa, vol. 1, pt. 2, p. 711.

1859. Dielasma, King. Proc. Dublin Univ. Bot. Zool. Assoc., vol. 1, p. 260.

1893. Dielasma, Hall and Clarke. Pal. N. Y., vol. 8, pt. 2, pp. 293-296.
Description taken from Hall and Clarke.

DESCRIPTION: "The apex of the pedicle-valve is closely incurved, so that in adult shells but little remains of the deltidial plates. The foramen is large, quite generally encroaching upon the umbo and often becoming very oblique to the longitudinal axis; with the increase of this obliquity the dental plates are thickened in their inner surface, which thus becomes more or less protruded. The inverted sheath or collar within the foramen is highly developed and clearly shown on internal casts. On the interior the dental plates are conspicuous, as in Cryptonella, but they stand vertically upon the bottom of the valve, not showing the convergence and often actual union occurring in that genus.

In the brachial valve the dental-sockets are quite deep and narrow, the socket-walls rising abruptly, though not attaining the height of the dental plates of the opposite valve. They are distinctly separated from the crural plates or margins of the hinge-plate, and converge toward the apex where they merge into a slightly elevated cardinal process; the latter usually appearing as a crescentic submarginal wall, though when best preserved is seen to be composed of two lateral, somewhat rounded lobes. The crural plates are two divergent vertical lamellae, originating just below the cardinal process, and attaining a length equal to the distance between their extremities, which is about one-third the width of the valve at that point. Between these plates lies the long shallow hinge-plate, which is raised but little above the bottom of the valve, and is sometimes actually adherent to it. This plate attains its greatest width at the extremities of the vertical crural plates, its margins converging

thence anteriorly, its full length often equalling one-third that of the valve. To this plate are attached all the muscles of the brachial valve, the scars of both anterior and posterior adductors being frequently clearly defined upon its surface."

Genotype: Terebratulites elongatus Schlotheim. Denks. Acad. Munchen, vol. 6, p. 27, figs. 7-9, 13, 14. 1816.

Genus ECHINOCHONCHUS Weller

1809. Anomites punctatus Martin. Petrefacta Derbiensa, p. 8, pl. 37, fig. 6.

1836. Productus punctatus? Morton. Am. Journal Science, 29, p. 153, pl. 26, fig. 38.

1838. Productus semipunctatus Sheppard. Am. Journal Science, 34, p. 153, fig. 9.

1860. Productus tubulispinus McChesney. New Paleozoic Fossils, p. 37.

1914. Echinochonchus, Weller. Mississippian Byachiopoda, Illinois State Geological Survey, Monograph I, p. 138. Described as a new genus, synonymy not given.

1927. Echinochonchus, Chao, Geologic Survey of China, Paleontologica Sinica Ser. B. vol. 5, fascicle 2, 1927, p. 63, pl. 6, figs. 7, 8, 15, 16; Ibid., fascicle 3, 1928, p. 54.

1929. Echinochonchus, Schuchert and LeVene, Fossilium Catalogus, pars 42, p. 5. Weller does not give synonymy of the genus in the original description. It has been reconstructed here from the synonymy of the genotype.

DESCRIPTION: Original from Weller 1914, Description.- "Shell productoid in form and with internal characters as in the genus Productus. The external surface of the valves marked by more or less sharply differentiated concentric bands which commonly grow broader in passing from the beak to outer margins, each band bearing numerous, crowded, fine, appressed, imbricating spines, either subequal or unequal in size, which are produced from elongate, node-like bases.

Remarks.- This genus is proposed to include those shells which have heretofore been placed in the genus Productus in the group typified by P. punctatus. This whole group of species differs so fundamentally from the members of the genus Productus as typified by the genotype P. semireticulatus, in their surface markings, that it has long seemed to the writer that they should be separated under a different generic name, although their internal characters are essentially alike. The genus is represented in the Mississippian faunas under consideration by several species, none of which suggest any intergradation with those of the restricted Productus."

Genotype: Anomites punctatus Martin 1809, Petref. Derb., p. 8, pl. 37, fig. 6.

Genus GIRTYELLA Weller

1891. Terebratula turgida Whitfield. Ann. N. Y. Acad. Sci., vol. 5, p. 586, pl. 13, figs. 21-22.

1908. Harttina indianensis Girty. Proc. U. S. Nat. Mus., vol. 34, p. 293, pl. 19, figs. 6-15.

1911. Girtyella indianensis Weller. Journal of Geology, vol. 19, p. 442, figs. 2a-i. Complete synonymy is not given with the original description of the genus. Synonymy reconstructed here from the synonymy of the genotype.

DESCRIPTION: Original from Weller 1911, "Shell terebratuliform. The pedicle valve sinuate, with a large, subcircular or subovate, oblique foramen which encroaches upon the umbo; the brachial valve frequently sinuate and often with a slight median fold in the bottom of the sinus. Internally the dental lamellae are well developed in the pedicle valve. In the brachial valve the socket plates are joined by a concave hinge-plate which is imperforate at the apex and is supported by a median septum; the inner sides of the dental sockets retreat from the margins of the

valve anteriorly beyond the point of articulation, and become the bases of the crura which are still joined by the concave hinge-plate and are also supported by lamellae resting against the inner surface of the lateral slopes of the valve. The brachidium short, its free portion apparently being like that of Dielasma and not reaching to the middle of the shell.

Remarks.- Members of this genus have commonly been included in the genus Dielasma but they differ fundamentally from that genus in the presence of a median septum supporting the hinge-plate of the brachial valve, and in the origin of the bases of the crura from the socket-plates. In his description of the species which is selected as the genotype, Girty referred the form to the genus Harttina on account of the presence of a median septum in the brachial valve, but the brachidium of Harttina is elongate, like that of Cryptonella, reaching nearly to the front of the shell, while that of Girtyella is short, like the brachidium of Dielasma.

Genotype: Harttina indianensis Girty. Proc. U. S. Nat. Mus., vol. 34, p. 293, pl. 19, figs. 6-15. 1908.

Genus SPIRIFER Sowerby

1793. Conchyliolithus (striatus) Anomiae Martin. Figures and descriptions of petrifactions collected in Derbyshire, pl. 23. 1793.

1815. Spirifer striatus Sowerby. Trans. Linnaean Soc., vol. 12, p. 514.

1914. Spirifer, Weller. Mississippian Brachiopoda, Illinois State Geologic Survey, Monograph I, pp. 307-308.

The generic description is taken from two sources. The first quotation is the original description of the genotype as quoted in Marcou's

"Geology of North America".[13] The second quotation is from Weller's "Mississippian Brachiopoda".[14]

The complete description given by Marcou is as follows: "Description.- This species is well known and found wherever the Mountain Limestone exists. The following is the description of it given by William Martin in 1793. 'Conchyliolithus (striatus) Anomiae a fossil shell-valves convex, semi-orbicular, longitudinally striated; the striae strongly marked, close and numerous. Beak of the larger valve pointed, and curved over the hinge, which extends on a straight line, the whole breadth of the shell. Margin obsoletely waved. A convex fold down the middle of the smaller valve, proceeding from the valve of the margin to the beak-in the larger valve, a concave fold. The folds slight; that of the larger valve scarcely distinguishable. A triangular aperture under the beak of the larger valve.' (See: Figures and Descriptions of Petrifactions collected in Derbyshire, by William Martin, plate 23; Wigan, 1793.)"

The following description is taken from Weller, 1914. "Description.- Shells varying in size from small to very large, usually wider than long, rarely longer than wide, the hinge-line straight, shorter than the greatest width of the shell and the cardinal extremities rounded; or more frequently the greatest width of the shell along the hinge-line and the cardinal extremities angular and more or less extended, sometimes conspicuously acuminate. Mesial sinus in the pedicle valve and fold in the brachial

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[13]Jules Marcou, "Geology of North America; with two reports on the prairies of Arkansas and Texas, the Rocky Mountains of New Mexico, and the Sierra Nevada of California," Paleontology, Chap. III, p. 49., pl. 7, fig. 2. 1858.

[14]Stewart Weller, "Mississippian Brachiopoda," Illinois State Geological Survey, Monograph I, p. 307-308. 1914.

valve usually well developed, more rarely without fold or sinus. Surface of both valves marked by radiating plications which may be simple without division from the point of origin to the anterior margin, or may divide in various manners; the plications may be present upon the lateral slopes only or upon both the lateral slopes and the fold and sinus. Besides the plications the surface may also be marked by fine, radiating striae or by fine or coarse concentric growth lines, or by both radiating and concentric markings. The pedicle valve with the beak variously elevated above the hing-line and variously incurved, the cardinal area varying from very narrow to high, usually arched but sometimes nearly or quite flat, the delthyrium rather broadly triangular and open; the surface of the cardinal area is transversely striate and the inner layers bear a series of vertical canals at whose extremities along the hinge-line the shell tissue is sometimes produced in a row of denticles which articulate with a row of pits in the opposite valve. Internally the hinge teeth are strong and are supported by short dental lamellae; the muscular area is of moderate size and is often deeply impressed, ovate or subcordate in outline, occupied in large part by the diductor scars which are usually marked by radiating or branching furrows. The brachial valve with a very narrow cardinal area divided by a broadly triangular delthyrium; the cardinal process is a low, transverse, sessile apophysis with its surface vertically striated; the muscular impressions much less strongly marked than in the pedicle valve; the dental sockets narrow and of moderate depth, the socket plates well developed and at their extremities supporting the crural bases; the crura are long, straight, and slightly divergent, the spiral

cones are directed obliquely outward and posteriorly towards the cardinal extremities, the primary lamellae are not united by a jugum, but the position of the jugum is indicated by the presence of a pair of spine-like processes upon the primary lamellae a little in front of their junction with the crura.

Remarks.- This genus has the largest specific representation of any in our Mississippian faunas, and the species themselves are usually very characteristic of the horizon in which they occur. As a whole the Mississippian species are characterized by the presence of plications in the fold and sinus of the valves, and in a large number of species the plications upon the lateral slopes exhibit more or less bifurcation."

Genotype: Anomites striatus Martin. Petref. Derb., pl. 23, 1809.

Genus SYRINGOTHYRIS Winchell

1796. Anomites, Martin. Trans. Linnean Society, vol. 4, p. 44, pl. 3, figs. 1-6.

1809. Conchyliolithus anomites, Martin. Petrefacta Derbiensa, pl. 46, fig. 34; pl. 47, fig. 5.

1816. Spirifer, Sowerby. Mineral Conchology, pl. 120, figs. 1-3.

1840. Spirifer, Troost. Fifth Geol. Rept. of Tennessee, p. 17, 48.

1841. Cyrtia, Troost. Sixth Geol. Rept. of Tennessee, pp. 11, 12.

1847. Spirifer, Yandell and Shumard. Contribution to the Geology of Kentucky, pp. 19, 21.

1885. Cyrtia, McCoy. British Paleozoic Fossils, p. 426.

1857. Spirifer, Hall. Tenth Rept. N. Y. State Cab. Nat. Hist., pp. 169, 170.

1858. Spirifer, Hall. Geology of Iowa, vol. 1, part 2, pp. 520, 603, 646, 647, pl. 7, fig. 6; pl. 13, fig. 4; pl. 20, fig. 5.

1860. Spirifer (Cyrtia ?), Swallow. Trans. St. Louis Acad. Scil, vol. 1, p. 647.

1863. Syringothyris, A. Winchell. Proc. Acad. Nat. Sci. Philadelphia, vol. 15, second ser., pp. 6-8.

1914. Syringothyris, Weller. Mississippian Brachiopoda, Illinois State Geological Survey, Monograph I, pp. 384-385. Generic description taken from Weller, 1914.

"Shells varying in size from small to very large, spiriferoid in form, with a much elevated cardinal area, the hinge-line straight and elongate, representing the greatest width of the shell, the fold and sinus well developed and usually non-plicate. The pedicle valve subsemipyramidal in form, the high cardinal area either flat, concave or convex, differentiated into three regions, a central including the delthyrium, and two lateral, by a pair of lines originating at the apex and passing obliquely to the cardinal margin, which they intersect at equal distances from the basal angles of the delthyrium; the central region is distinctly marked by vertical striae, while the lateral regions are marked only by the horizontal lines of growth; internally the dental lamellae are moderately well developed, they rest upon the floor of the valve and are a little produced anteriorly along the lateral margins of the muscular scar; they are united transversely by a delthyrial plate whose position is subparallel with the cardinal area but somewhat depressed below it; this plate extends to various distances from the apex of the delthyrium towards the hinge-line and at the middle point of its cardinal margin it is produced still further towards the cardinal margin of the valve as a free spine-like process; on the inner side of the spine-like extension of the delthyrial plate, and continuing along the median line of the inner surface of the plate towards the apex of the valve, is a tube which is split longitudinally internally, this split tube, together with the extension of the delthyrial plate, being

termed the syrinx. In some cases the syrinx is solid. A pseudodeltidial covering of the delthyrium entirely separate from the delthyrial plate and syrinx is sometimes present. The muscular scars as in Spirifer. The brachial valve essentially as in Spirifer, both internally and externally. Shell structure punctate throughout except in the central, vertically striated region of the cardinal area. The external surface covered with a minute, textile-like ornamentation except upon the central region of the cardinal area."

Genotype: Syringothyris typa Winchell. Proc. Acad. Nat. Sci. Phil. vol. 15, p. 6. 1863.

DESCRIPTION OF SPECIES

A few recent terms describing brachiopod morphology are employed in the descriptions of new species. Reference is made at the first use of the term to the publication in which the definition of the term is given. Throughout the descriptions three terms describing the sizes of the brachiopods are used: small specimens are those whose diameter varies from 1 mm. to 25 mm; medium specimens from 25-40 mm.; and large specimens 40 mm. or more. The number of lateral plicae always refers to the number of plicae on one lateral slope excluding the plica that bounds the sinus.

New species and varieties have not been given names. It seems advisable to wait until the new species may be checked against the type specimens of related specimens before applying specific names.

All species described in this paper are preserved in the Museum of Paleontology of the State University.

Genus ATRYPA Dalman

For generic description see page 27

Atrypa sp. undet.

Plate I, Figs. 1-3.

Species known from several complete specimens.

DESCRIPTION: Shell small; pseudoresupinate; fold and sinus present; postero-lateral margins straight, subparallel; anterior margin deeply rounded; hinge line very short. Dimensions of average sized specimen, length of pedicle valve 20 mm.; length of brachial valve 18.5 mm.; greatest width of shell 20 mm.; thickness of complete specimen 11 mm.; length of hinge line 6 mm.

Pedicle valve subplano-convex; greatest convexity in umbonal region. Umbo moderately prominent curving rapidly to cardinal margin, sloping gently to postero-lateral margins; beak obtusely pointed, projecting slightly beyond hinge line. Mesial sinus present anteriorly; shallow, ill defined; arising approximately 5 mm. from anterior margin. Cardinal area concealed, but small.

Brachial valve more convex than the pedicle valve; greatest convexity in middle of valve; profile of valve semicircular along midline from beak to anterior margin. Umbo essentially absent; beak small inconspicuous; extending posteriorly only to hinge line. Mesial fold present; not defined posteriorly; arises approximately 7 mm. from anterior margin.

Fifteen to 16 plicae on each valve; strong, rounded; four plicae on fold; three on sinus, originate by bifurcation of one plicae near beaks; remaining plicae bifurcate close to beaks, or occasionally at midlength,

thence continuing without division to anterior margin. Plicae crossed at irregular intervals, 2 mm. plus or minus, by strong concentric raised ridges that form small, rounded nodes at the point where they cross plicae.

REMARKS:- Only one species of the genus, Atrypa infrequens has been reported from the Mississippian. Weller described the form as a rare member of the Kinderhook fauna. The species here described does not agree with Weller's description, and has not been identified because the genus Atrypa is typically a Devonian form. It is possible that the Madison species represents a new occurrence of a known, long ranged Devonian form.

Locality and Formation: Locality 21, zone 2; and loose. Basin Butte, north of Danaher Creek, Powell County, Montana. Madison limestone, Rooney chert member.

Genus BRACHYTHYRIS McCoy

For generic description see page 28

Brachythyris n. sp. 1

Plate I, Figs. 4, 5.

Species known from several pedicle valves.

DESCRIPTION: Pedicle valve small; fold and sinus present; cardinal extremities rounded; hinge line less than greatest width. Dimensions, length of pedicle valve 12 mm.; width 12 mm.; thickness 4 mm.

Pedicle valve strongly convex; greatest convexity in anterior portion of umbo; surface sloping uniformly from umbonal region to point on posterior margin. Beak sharply pointed, curved over cardinal area but

not projected beyond hinge line. Cardinal area rounded into postero-lateral slopes of valve; not sharply defined. Delthyrium not observed. Mesial sinus sharply defined to beak; angular in cross section; bounded by strong angular plications.

Five lateral plicae on each slope; originate at beak; do not bifurcate; plicae bounding sinus bifurcate; give rise to first lateral plicae on slope; sinus bears single fine median plica, weaker than lateral plicae. Remarks:- The generic position of this shell is difficult to determine. The form is close to the genus Spirifer as characterized by the species S. bifurcatus Hall and might be considered as a variety of that species. The genus Brachythyris was described to include those spiriferoid shells characterized by a hinge line less than the greatest width of the shell, broad rounded plications, rounded cardinal extremities and generally with a broad, nonplicate fold and sinus. The species here described appears to fit this description except for the nature of the plicae which are angular and sharply defined and thus agree closely with those of S. bifurcatus. In view of the fact that S. bifurcatus exhibits a variation in the nature of the cardinal extremities from rounded to subrectangular which would place it in the genus Brachythyris; the writer believes it advisable to place the new species in the genus Brachythyris rather than in the genus Spirifer.

Brachythyris n. sp. 1 may be distinguished from other species of the genus by the fine, single median plica of the sinus, the bifurcating bounding plicae of the sinus, and in the angularity of the lateral plicae.

Locality and Formation: Locality 7, zone 2. On Yakinikak Creek, in the NE ¼ sec. 30; T. 37 N., R. 22 W., 20 feet above the contact of the Yakinikak limestone and quartzites of Kintla age. Flathead County, Montana. Yakinikak limestone. (Broadwater)

Brachythyris n. sp. 2

Plate I, Figs. 6, 7.

Species known from several pedicle valves.

DESCRIPTION: Pedicle valve small; fold and sinus present; cardinal extremities rounded; hinge line less than the greatest width of valve. Dimensions, length of pedicle valve 17 mm.; width 16 mm.; thickness 4 mm.

Pedicle valve depressed convex; greatest convexity opposite mid-length; umbonal region not strongly differentiated from general curvature of valve; surface curving rapidly from umbo to cardinal margin. Beak pointed; tip incurved but not proturberant beyond hinge line. Cardinal area apsacline;[15] delthyrium higher than wide; extending to beak. Sinus sharply defined to beak.

Six lateral plicae on each slope; first lateral plica originates from plica bounding sinus by bifurcation in umbonal region; sinus bears strong median plica that originates at beak; two weaker plicae on lateral slopes of sinus derived from inner side of bounding plicae. Concentric markings absent.

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[15] Charles Schuchert, and George Cooper, "Brachiopod genera of the suborders Orthoidea and Pentameroidea," Memoirs of the Peabody Museum of Natural History, vol. IV, pt. 1, pp. 20-21, 1932.
The following terms for describing the angle between the cardinal area and the plane of the valve are here defined. Ventral valve, anacline, orthocline, apsacline, catacline, and procline. Dorsal valve, hypercline, anacline, orthocline, and apsacline.

REMARKS: This species is characterized by the strong plicae, rounded cardinal extremities, and the presence of three plicae in the sinus. The closest allied species is Brachythyris n. sp. 1, from which it differs in having three plicae instead of a single median one.

Locality and Formation: Locality 7, zone 2, on Yakinikak Creek, in the NE. ¼ sec. 30; T. 37 N., R. 22 W., 20 feet above the contact of the Yakinikak limestone and quartzites of Kintla ? age. Flathead County, Montana. Yakinikak limestone. (Broadwater)

Brachythyris n. sp. 3

Plate I, Figs. 8, 9.

Species known from a single pedicle valve.

DESCRIPTION: Specimen small; fold and sinus present; cardinal extremities rounded; hinge line less than greatest width of shell. Dimensions, length of pedicle valve 21 mm.; width 20 mm.; thickness 8 mm.

Pedicle valve strongly convex; greatest depth approximately in middle; umbonal region high and prominent; surface curving rapidly from umbo to cardinal margin. Beak pointed; tip incurved but not projecting beyond hinge line. Cardinal area well defined along cardinal margin; 3.5 mm. in height; apsacline.

Delthyrium equilateral in outline, extending to beak. Sinus poorly defined at beak; shallow throughout.

Eleven discernable lateral plicae on each slope; but on cardinal extremities additional plicae may have existed; plicae broad, flattened, separated by narrow, fine furrows. Sinus bears nonbifurcating median plica; lateral slopes of sinus each bear single plica of equal strength

to median one; bounding plicae slightly stronger than lateral ones. Concentric growth lines of varying strength present.

REMARKS: This species is closely related to Brachythyris choteauensis Weller, but may be distinguished from that species by the greater prominence of the umbo; the larger number of plicae on the lateral slopes; the presence of three plicae in the sinus in place of four; and the smaller size. The median plica in the sinus is not derived from the bounding plicae as in B. choteauensis but originates at the beak.

Locality and Formation: Locality 17, Rattler Gulch, west of Drummond, Granite County, Montana. Madison limestone, Rooney chert ? member.

Genus CAMAROTOECHIA Hall and Clarke

For generic description see page 29

Camarotoechia n. sp. 1

Plate I, Figs. 10-14.

Species known from three incomplete specimens that show portions of both valves.

DESCRIPTION: Shell small; fold and sinus present; hinge line very short; rostral angle less than 90°. Dimensions, length of pedicle valve 9 mm.; length of brachial valve 6 mm.; greatest width of specimen 8 mm.; thickness 4 mm.

Pedicle valve moderately convex; greatest convexity in middle; umbonal region not differentiated from general curvature of valve. Surface curving abruptly to posterior lateral margins; inflected approximately at 90° to plane of valve. Beak pointed, slightly incurved over beak of opposite valve. Cardinal area concealed by beak of brachial valve;

delthyrium not observable. Mesial sinus not defined at beak; may originate anterior to middle; recognizable at midlength, at which point it widens rapidly.

Brachial and pedicle valves subequally convex. Umbonal region not developed. Beak small, pointed; incurved beneath that of pedicle valve; projecting slightly beyond hinge line. Cardinal area absent. Mesial fold scarcely differentiated from surface of valve; fold develops and widens in manner similar to sinus of pedicle valve; more strongly marked by furrows at point of widening.

Five to six lateral plicae on each slope of pedicle valve and seven on each lateral slope of brachial valve; plicae rounded; become stronger and more prominent after passing midlength of shell.

REMARKS: This species is most similar to C. herrickana Girty, the only other species of Camarotoechia which is characterized by two plicae in the sinus. It is distinguished from C. herrickana by the rostral angle. The angle formed by the postero-lateral slopes of C. herrickana is approximately 120° while that of the above described species is less than 90°.

Locality and Formation: Locality 33-3, Big Saddle, on knob at elevation of 7750 feet, northeast of large saddle separating East Pryor Mt. from its northeast spur, in the SW. ¼ sec. 25; T. 7 S., R. 26 E., Pryor Mt. division, Custer National Forest, Carbon County, Montana. Madison limestone, basal 50 feet.

Camarotoechia n. sp. 2

Plate I, Figs. 15-17.

Species known from several pedicle valves.

DESCRIPTION: Shell small; fold and sinus very slightly developed; rostral angle less than 90°. Dimensions, length of pedicle valve 7 mm.; width 6 mm.; thickness 5 mm.

Pedicle valve convex, greatest convexity in umbonal region; umbonal region prominent and elevated above and separated from general curvature of valve by strong concentric ridge 3 mm. from beak, giving to umbo appearance of cap on valve. Beak pointed; slightly incurved. Cardinal area not observed. Mesial sinus not present but flattened area extends longitudinally along median line of valve, in part gently depressed below surface of valve.

Brachial valve convex; greatest convexity at anterior of umbonal region; umbo prominent, set off by concentric ridge similar to that of pedicle valve but less pronounced; surface of umbonal region flat, making an angle of approximately 120° with anterior slope of valve. Beak small, pointed; extending only to hinge line. Cardinal area absent. Mesial fold differentiated from surface of valve by two furrows stronger than those separating lateral plicae.

Total of ten lateral plicae on pedicle valve; all originate close to beak; plicae strongly marked anteriorly to ridge which sets off umbo from rest of valve; continue without bifurcation to anterior margin. Brachial valve carries 12 lateral plicae similar to those of opposite valve; concentric markings consist of few indistinct growth lines immediately anterior to umbonal ridge.

REMARKS: This group of peculiarly "capped" brachiopods was submitted to Dr. Carey Croneis, Walker Museum, University of Chicago for comment. Dr. Croneis placed the forms in the genus Camarotoechia and said in regard to the specific identification,[16]

> "I am not at all certain in regard to the specific determination but some of the individuals resemble some specimens of C. Choteauensis Weller which we have in our collections. They also resemble some of our specimens of C. mutata Hall. I think that you would be safe for the time being in describing them as belonging to a new species."

The writer thinks that the peculiarly capped umbonal region is a character of specific importance and therefore has described the form as a new species. It differs from C. choteauensis and C. mutata in having a rostral angle less than 90° instead of a wider angle. From C. mutata it may be separated by the rounded anterior margin, as opposed to the truncated margin of C. mutata.

Locality and Formation: Locality 33-3, Big Saddle, on knob at elevation of 7750 feet, northeast of large saddle separating East Pryor Mt. from its northeast spur, in the SW. ¼ sec. 25; T. 7 S., R. 27 E., Pryor Mt. division, Custer National Forest, Carbon County, Montana. Madison limestone, basal 50 feet.

Camarotoechia n. sp. 3

Plate I, Figs. 18, 19.

Species known from a single pedicle valve.

DESCRIPTION: Pedicle valve small; fold and sinus present; hinge line very short; rostral angle 70°. Dimensions, length of pedicle valve 13-14 mm.; width 8-9 mm.; thickness 4 mm.

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[16]Personal communication.

Pedicle valve convex, arched in semicircle from beak to anterior margin along median line, greatest convexity at midlength; umbonal region prominent; sloping rapidly to postero-lateral margins and curving steeply to hinge line. Beak pointed sharply; tip slightly incurved. Cardinal area not observed. Sinus originating at beak; poorly defined posteriorly; stronger anterior to midlength.

Total of 10 lateral plicae; originate at beak; bifurcate close to beak. Sinus bears four distinct plicae in bottom; originate at beak; derived from single plica; lateral slopes of sinus carry one indistinct plica derived from inner side of plicae that bound sinus.

REMARKS: The species is characterized by smaller rostral angle and relatively larger size than is possessed by any other Mississippian members of the genus. Camarotoechia subglobosa Weller is similar to Camarotoechia n sp. 3 although it differs in possessing a smaller rostral angle; a more elongate form; and a more sharply defined sinus.

Locality and Formation: Locality, 33-3, Rig Saddle, on knob at elevation of 7750 feet, north of large saddle separating East Pryor Mt. from its northeast spur, in the SW. ¼, sec. 25; T. 7 S., R. 27 E. Pryor Mt. division, Custer Nat. Forest, Carbon County Montana. Madison limestone, basal 50 feet.

Genus COMPOSITA Brown.

For generic description see page 31

Composita n. sp. 1

Plate I, Figs. 20-24.

Species known from several pedicle valves and a few doubtful brachial valves.

DESCRIPTION: Pedicle valve small; without sinus; hinge-line short; rostral angle 100°. Dimensions, length of pedicle valve 12 mm.; width 14 mm.; thickness 4 mm.

Pedicle valve moderately convex; greatest convexity in middle; surface describing semi-circle from beak to anterior margin along median line; surface curving abruptly to posterior lateral margins; inflected in smooth curve to edges of delthyrium, forming poorly defined cardinal area. Umbonal region not differentiated from general curvature of valve; beak obtusely pointed; perforated at apex by pedicle foramen. Foramen joined to delthyrium at its apex. Delthyrium broadly triangular, presence of delthyrial covering not observed.

Shell smooth, without external ornamentation except concentric growth lines which become stronger near anterior margin.

REMARKS: This species has been placed in the genus Composita because of the smoothness of the shell in the anterior portion, the lack of strong lamellar banding which is characteristic of the allied genus Athyris, and the absence of imbricating, flat spines of the genus Cliothyridina to which it bears a strong resemblance. From other species of the genus Composita, C. n. sp. 1 may be distinguished by its lack of fold and sinus.

Locality and Formation: Locality 33-3, Big Saddle, on knob at elevation of 7750 feet, northeast of large saddle separating East Pryor Mt. from its northeast spur, in the SW. ¼ sec. 25; T. 7 S., R. 27 E. Pryor Mt. division, Custer National Forest, Carbon County, Montana. Madison limestone, basal 50 feet.

Composita n. sp. 2

Plate I, Figs. 25, 26.

Species known from three pedicle valves.

DESCRIPTION: Pedicle valve small; without sinus; hinge-line very little shorter than greatest width of valve; rostral angle approximately 130°. Dimensions, length of pedicle valve 9 mm.; width 8-9 mm.; thickness 4 mm.

Pedicle valve strongly convex; greatest convexity at midlength. Umbonal region prominent, strongly elevated; surface curves abruptly to hinge-line, but less so to postero-lateral margins; slightly compressed to form small auricular expansions. Beak rather sharply pointed, perforated by pedicle foramen. Cardinal area poorly defined; rounded into lateral slopes of valve; delthyrium present but concealed by beak.

Shell smooth except for few, fine, concentric growth lines.

REMARKS: This species is closely allied to Composita n. sp. 1 by reason reason of the absence of the fold and sinus. It differs from that species in the large rostral angle; the higher, tumid, more prominent umbonal region; and in the small compressed auricular extensions of the pedicle valve.

Locality and Formation: Locality 33-3, Big Saddle, on knob at elevation of 7730 feet, northeast of large saddle separating East Pryor Mt. from its northeast spur, in the SW. ¼ sec. 25; T. 7 S., R. 27 E. Pryor Mt. division, Custer National Forest, Carbon County, Montana. Madison limestone, basal 50 feet.

Composita n. sp. 3

Plate I, Figs. 27-29.

Species known from three pedicle valves.

DESCRIPTION: Pedicle valve small; without sinus; hinge line short; rostral angle 80°. Dimensions, length of pedicle valve 13 mm.; width 10 mm.; thickness 4.5 mm.

Pedicle valve convex in posterior portion of valve; surface curving abruptly to hinge line and to cardinal extremities, but gently to anterior margin. Umbonal region strongly arched; prominent; beak incurved moderately; perforated by a foramen. Cardinal area and delthyrium not observed.

Shell smooth; marked by clearly defined concentric growth lines; disposed at 1 mm. intervals from beak to anterior margin.

REMARKS: This species is characterized by the lack of a mesial sinus. It differs from the nonsinuate species of this genus which are described in this paper, by reason of the small rostral angle; the high, tumid, umbonal region; and elongate shape.

Locality and Formation: Locality 33-3, Big Saddle, on knob at elevation of 7750 feet, northeast of large saddle separating East Pryor Mt. from its northeast spur, in the SW. ¼ sec. 25; T. 7 S., R. 27 E. Pryor division, Custer National Forest, Carbon County, Montana. Madison limestone, basal 50 feet.

Composita n. sp. 4

Plate I, Figs. 30-32.

Species known from two pedicle valves.

DESCRIPTION: Pedicle valve small; without sinus; hinge-line short; rostral

angle 75-80°. Dimensions, length of pedicle valve 12 mm.; width 10 mm.; thickness 4 mm.

Pedicle valve flatly convex; surface of valve curving abruptly to cardinal margins; gently to anterior margin. Umbonal region narrow; strongly convex; standing well above curvature of valve; extended posteriorly approximately one-third length of specimen. Beak sharply pointed, incurved; perforated by small foramen. Cardinal area not defined; rather rounded region lying beneath beak; delthyrium joining foramen.

Shell smooth except for fine concentric growth lines.

REMARKS: Species is characterized by lack of a sinus, in which character it closely resembles the other species of the genus described in this paper. The most similar species is Composita lewisensis Weller from which it is easily distinguished by the lack of sinus in the pedicle valve. It may be distinguished from the nonsinuate forms by the narrow, extended, pointed umbonal region.

Locality and Formation: Locality 33-3, Big Saddle, on knob at elevation of 7750 feet, northeast of large saddle separating East Pryor Mt. from its northeast spur, in the SW. ¼ sec. 25; T. 7 S., R. 27 E., Pryor Mt. division, Custer National Forest, Carbon County, Montana. Madison limestone, basal 50 feet.

Genus DIELASMA King.

For generic description see page 32

Dielasma n. sp. 1

Plate I, Figs. 1, 2.

Species known from single pedicle valve.

DESCRIPTION: Specimen of medium size; sinus slight; outline pentagonal; greatest width of shell anterior to middle; rostral angle approximately 45°. Dimensions, length of pedicle valve 30 mm.; width 19-20 mm.; thickness 8 mm.

Pedicle valve moderately convex; middle third of surface essentially parallel to plane of valve; sloping anteriorly and posteriorly at equal angles from flattened area; curving abruptly to posterior lateral margins; inflected so as to lie at acute angle to plane of valve. Umbonal region not differentiated from posterior portion of valve; beak bluntly pointed; incurved. Mesial sinus present only in extreme anterior portion of valve; originates at point where rapid curvature to anterior margin begins.

Shell smooth except for strong concentric growth lines which extend from beak around shell to anterior margin. Entire shell finely punctate.

REMARKS: Dielasma n. sp. 1. is closely allied to Dielasma arkansanum Weller, from which it differs in the subgeniculate bend near the anterior margin. Dielasma n. sp. 1 also has a more distinctly pentagonal outline; and more angularly inflected posterior lateral margins. The sinus of D. arkansanum originates much higher on the slope of the valve than the sinus of the new species.

Locality and Formation: Locality 33-6, Wells Pasture, south rim of Dryhead canyon, 50 feet below Forest Service triangulation cairn, lying in sec. 23; T. 7 S., R. 27 E. Pryor Mt. Division, Custer National Forest, Carbon County, Montana. Madison limestone, upper 100 feet.

Genus ECHINOCHONCHUS Weller

For generic description see page 34

Echinochonchus n. sp. 1.

Plate II, Fig. 3.

Species known from a single specimen.

DESCRIPTION: Specimen of medium size; without sinus; cardinal extremities rounded; hinge-line long; width greater than length. Dimensions, length of pedicle valve 28-30 mm.; width 40 mm.; thickness approximately 10 mm.

Pedicle valve strongly convex; greatest convexity in posterior portion. Umbo prominent; extending beyond hinge-line; beak pointed; strongly incurved over hinge line. Surface strongly curved to cardinal margins from umbonal region; sloping less strongly to postero-lateral areas which are strongly compressed, and distinctly differentiated from general surface of valve. Sinus absent.

Shell marked by strong concentric bands; separated 1 mm. on umbo; 2.5 mm. on anterior portion; bands of uniform strength; 1 mm. in width; angular in cross section; steepest slope directed anteriorly. Spines originate as fine radial costae on posterior slopes of concentric bands; develop into round spines at crest of bands; not continuing down anterior slope; radial ornamentation gives appearance of continuous ribbing.

REMARKS: This species resembles Echinochonchus genevievensis Weller but differs in the lack of the mesial sinus, and in the large compressed auricular extensions of the valves. The extensions are strongly differentiated from the convexity of the valve, and are broadly extended. This feature clearly distinguishes Echinochonchus n. sp. 1 from all previously described species of the genus.

Locality and Formation: Locality 21, zone 2. Basin Butte, north of Danaher Creek, Powell County, Montana. Madison limestone, Dean Lake ? chert member.

Echinochonchus n. sp. 2

Plate II, Figs. 4, 5.

Species known from single pedicle valve.

DESCRIPTION: Specimen large; without sinus; hinge line long; width and length subequal. Dimensions, length of pedicle valve 45 mm.; width 50-55 mm.; thickness 25 mm.

Pedicle valve strongly tumid; greatest convexity at midlength. Umbo large, prominent; protruding beyond hinge line; beak pointed, strongly incurved, apparently twisted to left. Surface of valve curving strongly to all margins from midline, but more strongly to postero-lateral than to anterior margin. Cardinal extremities roumded; slightly compressed. Mesial sinus absent; slight mesial depression exists along the median line near point of maximum curvature of valve; not extended to beak or to anterior margin.

Ornamentation consists of closely crowded concentric bands of varying strength; crossed by fine anastomosing radial lines which tend to develop into fine spines at point where the lines cross concentric bands.

REMARKS: This form closely approaches an unnamed, undescribed, but figured specimen by Weller[17]. Echinochonchus n. sp. 2 differs from that form in having the width greater than the length; cardinal extremities

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[17]Stewart Weller, "Mississippian Brachiopoda," Illinois State Geological Survey, Monograph I, plate 17, figs. 8, 9. 1914.

rounded in place of obtusely angular; and in the subgeniculate angle of the pedicle valve.

Locality and Formation: Along roadway at diversion dam, North Fork Sun River Canyon, Lewis and Clark County, Montana. Madison limestone, undifferentiated.

Genus GIRTYELLA Weller

For generic description see page 35

Girtyella n. sp. 1

Plate II, Figs. 6-10.

Species known from a single, complete individual.

DESCRIPTION: Specimen small; sinus present; hinge line short; shell longer than wide; subcircular in cross section; rostral angle 70°. Dimensions, length of pedicle valve 11 mm.; length of brachial valve 10 mm.; width of specimen 9 mm.; thickness of complete specimen 9 mm.

Pedicle valve strongly convex; greatest convexity in middle; curvature of surface describing semi-circle from beak to anterior margin along median line. Umbo prominent; surface inflected along postero-lateral margins adjacent to umbonal region so as to lie at right angles to plane of valve; beak sharply pointed; incurved over beak of brachial valve; foramen not observed though probably present. Mesial sinus originates in umbonal region; poorly defined laterally; deeper anteriorly; rounded in cross section.

Brachial valve subequally convex to pedicle valve; greatest convexity in middle; umbo prominent, curving rapidly to postero-lateral margins which are inflected at right angles to plane of valve; mid-portion of valve

flattened parallel to commissure, then sloping gently to anterior margin. Beak pointed; incurved beneath beak of pedicle valve. Mesial fold absent; fold replaced by slight median sinus bounded by two low ridges which extend posteriorly one-third length of valve; sinus and adjacent fold produce tripartite condition reflected in anterior commissure; bounding ridges of sinus in turn bordered by extremely illy defined, shallow, short sinuosities of shell; extended less posteriorly than ridges.

Shell smooth throughout; finely punctate, which condition not found in any other described member of genus.

REMARKS: This species is closely allied to Girtyella turgida (Hall) but differs in the character of the brachial valve. G. turgida has a low median fold in the brachial valve, the fold situated in a broad, illy defined sinus. Girtyella n. sp. 1 has an opposite character, a small low sinus in the brachial valve bordered by two low ridges.

Locality and Formation: Locality 7, zone 2. On Yakinikak Creek, in the NE. ¼ sec. 30; T. 37 N., R. 22 W. 20 feet above the contact of Yakinikak limestone with quartzites of Kintla ? age, Flathead County, Montana. Yakinikak limestone. (Broadwater).

Genus SPIRIFER Sowerby.

For generic description see page 36

Spirifer calvini n. var. 1

Plate II, Figs. 11, 12.

Variety known from a single incomplete pedicle valve.

DESCRIPTION: Specimen medium; fold and sinus present; hinge line apparently equalling greatest width of valve. Dimensions, length of pedicle valve

25 mm.; width 40 mm.; thickness 15 mm.

REMARKS: Spirifer calvini Weller is characterized by the elevated, high cardinal area, and the greatly flattened plicae of the fold and sinus. Spinifer calvini n. var. 1 is closely related to S. calvini in the first two characters. However, the plications of the new variety are more rounded and not flattened, and are also more numerous in the sinus. The striking feature of the variety is the wide cardinal area, and the thick shell material. Because the variety has the wide cardinal area, and general contour of S. calvini it has not been described as a new species.

Locality and Formation: Locality 13 west side of Monitor Mt., east of the Continental Divide between the Dearborn River and the South Fork of Falls Creek, in the Coopers Lake quadrangle, Montana. Madison limestone.

Spirifer calvini var. 2

Plate II, Figs. 13-15

Variety known from a single pedicle valve.

DESCRIPTION: Valve approximately medium in size; fold and sinus present; hinge line equalling greatest width of shell. Dimensions, length of pedicle valve 30 mm.; width 40 mm.; thickness 12 mm.

REMARKS: Because of the high cardinal area, the general shell shape and the nature of the delthyrium, this variety has been referred to the species Spirifer calvini Weller. It differs from that species in the more angular plicae, and in the very sharply defined mesial sinus. Spirifer calvini n. var. 2 differs from S. calvini n. var. 1 in the thinner shell material, the larger delthyrium, and the more sharply defined sinus.

Locality and Formation: Locality 32-2, east of the head of Ruby Creek, elevation 8500 feet, lying in the SW. ¼ sec. 35; T. 7 S., R. 26 E. Pryor Mt. division, Custer National Forest, Carbon County, Montana. Madison limestone, middle portion.

Spirifer centronatus Winchell

Plate III, Figs. 1, 2.

Figure 1 illustrates a large brachial valve which agrees in shape, number of plicae, presence of fine radiating striae, and in the ratio of width to length, with Spirifer centronatus Winchell. The striking character is the larger size, the dimensions being twice those given as average for the species.

Locality and Formation: Locality 21, loose. Basin Butte, north of Danaher Creek, Powell County, Montana. Madison limestone, Rooney chert member.

Figure 2 illustrates a second example of the large size attained by S. centronatus, and is characterized further by the larger number of plicae than Girty[18] gives as specific variation for the species. This form may prove to be a new species, but the specimen at hand is not well enough preserved to warrant description.

Locality and Formation: Locality 33-6, Wells Pasture, north rim of Dryhead Canyon, 50 feet below Forest Service triangulation cairn, lying in sec. 23, T. 7 S., R. 27 E., Pryor Mt. division, Custer National Forest, Carbon County, Montana. Madison limestone upper 100 feet.

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[18] G. H. Girty, "Devonian and Carboniferous Fossils:" U. S. Geol. Survey, Monograph 32, pt. 2, p. 547. 1899.

Spirifer increbescens n. var. 1

Plate II, Figs. 16-18.

Variety known from single pedicle valve.

REMARKS: This form agrees very closely with the form described by Weller as Spirifer increbescens. The striking difference is the complete lack of either radial or concentric striae on the plications. Because of this difference it has been designated a new variety.

Locality and Formation: Locality 13, west side of Monitor Mt., lying east of the Continental Divide between the Dearborn River and the South Fork of Falls Creek, in the Coopers Lake quadrangle, Montana. Madison limestone.

Spirifer forbesi n. var. 1.

Plate III, Fig. 8.

Variety known from two pedicle valves.

REMARKS: This variety differs from Spirifer forbesi Norwood and Pratten as described by Weller in the following respects; 1, more transverse along the hinge line; 2, lack of subimbricating concentric growth lines; and 3, narrow cardinal area of pedicle valve.

Locality and Formation: Locality 13, west side of Monitor Mt., lying east of Contenental Divide between the Dearborn River and the South Fork of Falls Creek, in the Coopers Lake quadrangle, Montana. Madison limestone.

Spirifer forbesi var. 2.

Plate III, Fig. 9

Variety known from single pedicle valve.

REMARKS: This variety is characterized by the greatly elevated umbonal region, and the generally tumid character of the valve. The examples of the species

figured by Weller[19] have a low umbonal region with the beak only slightly elevated. In other characters this variety agrees closely with Spirifer forbesi Norwood and Pratten.

Locality and Formation: Locality 32-2, East of head of Ruby Creek, elevation 8500 feet, lying in the SW. ¼ sec. 35; T. 7 S., R. 26 E. Pryor Mt. division, Custer National Forest, Carbon County, Montana. Madison limestone.

Spirifer missouriensis Swallow

Plate III, Fig. 7.

Species known from several pedicle valves.

REMARKS: The specimen figured on Plate III was also figured in the unpublished thesis of R. C. Rowe[20] as the holotype of a new species, Spirifer fissilplicatus. Rowe distinguished this specimen from S. missouriensis by the greater number of lateral plicae. Rowe cites 24 plicae as compared to 20 for Swallow's form. In a form noted for numerous bifurcations of the plicae this discrepancy does not appear significant to the writer. Rowe also uses the character of the cardinal extremities to distinguish between the two spedies. Inasmuch as the cardinal extremities of the figured specimen are damaged this character becomes useless. For these reasons the author has referred the form to the previously described species S. missouriensis.

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[19] Stewart Weller, "Mississippian Brachiopoda," Illinois State Geol. Survey, Monograph I, pl. XLII, figs. 1-3.

[20] R. C. Rowe, "Description and correlative evidence of the brachiopoda and other faunal members of the Montana Madison limestone," Unpub. thesis, University of Montana. 1927.

Locality and Formation: Dupuyer Creek, Pondera County, Montana. Madison limestone.

Spirifer n. sp. 1

Plate IV, Figs. 1-3

Species known from a single pedicle valve.

DESCRIPTION: Pedicle valve medium sized; outline subquadrate; fold and sinus present; hinge line equal to greatest width; cardinal extremities acutely angular. Dimensions, length of pedicle valve 25 mm.; width approximately 34 mm.; thickness 9 mm.

Pedicle valve moderately convex; greatest convexity opposite mid-length; umbonal region prominent, elevated above cardinal margin; beak pointed, incurved slightly over wide cardinal area; area orthocline; lateral margins sharply defined, curving rapidly from beak to point two-thirds from beak to cardinal extremities, from which point they continue essentially parallel to hinge line until extremities of valve are reached. Delthyrium large; broader than high. Surface of valve describing semicircle from beak to anterior margin along median line; curving rapidly from umbonal region to lateral margins of cardinal area; gently to postero-lateral margins.

Nine to ten lateral plicae on each slope; plicae distinctly rounded; not bifurcated; extend to beak; furrows narrower than plicae; median plica of sinus does not bifurcate, originates near beak; lateral slopes of sinus bear one or two plicae of equal strength to median one.

REMARKS: This species belongs to a small group of Mississippian spirifers that is characterized by the wide or high cardinal area. Spirifer n. sp. 1

resembles Spirifer legrandensis Weller and Spirifer calvini n. var. 1 in this feature. However both the latter species have apsacline areas while Spirifer n. sp. 1 has an orthocline area, thus clearly distinguishing it from the other two.

Locality and Formation: Locality 17, Rattler Gulch, 5 miles west of Drummond, Granite County, Montana. Fossils were collected from the upper portion of the formation at a point two miles from the mouth of Rattler Gulch. Madison limestone, Rooney chert ? member.

Spirifer n. sp. 2

Plate IV, Figs. 4, 5.

Species known from a single pedicle valve.

DESCRIPTION: Specimen of medium size; outline triangular; fold and sinus present; hinge line equalling greatest width; cardinal extremities acutely angular. Dimensions, length of pedicle valve 25 mm.; width 25 mm.; thickness 10 mm.

Pedicle valve moderately convex, greatest convexity in umbonal region; umbo prominent, protruberant beyond hinge line. Surface of valve curved abruptly from umbo to lateral margins of cardinal area, and to point half way to cardinal extremities. Cardinal extremities compressed. Beak pointed, sharply incurved over cardinal area; cardinal area not observed. Sinus sharply defined thoughout length, V shaped in cross section at beak; bottom flatter and wider anteriorly.

Sixteen or 17 lateral plicae on each slope; plicae distinctly angular; two plicae bifurcate; first lateral plica derived from one bounding sinus, at point 2 mm. from beak; third lateral plica bifurcates at point approximate-

ly one-half distance from beak to anterior margin; stronger plicae bound sinus; strong median plica in sinus bifurcates at midlength; originates at beak; lateral slopes of sinus bear weaker plicae derived from inner side of plicae that bound sinus. Concentric ornamentation never developed or removed by exfoliation.

REMARKS: The most similar species is Spirifer washingtonensis Weller, from which Spirifer n. sp. 2 may be distinguished by the sharply defined sinus, the bifurcate median plica of the sinus and the more acuminate cardinal extremities. The plicae of Spirifer n. sp. 2 are more angular and finer.

Locality and Formation: Locality 17, Rattler Gulch, five miles west of Drummond, Granite County, Montana. Fossils were collected from the upper part of the formation at a point two miles from the mouth of the gulch. Madison limestone, Rooney chert ? member.

Spirifer n. sp. 3

Plate IV, Figs. 6, 7.

Species known from two pedicle valves.

DESCRIPTION: Specimen small; outline transversely triangular; fold and sinus present; hinge line equals greatest width; cardinal extremities compressed; acutely angular. Dimensions, length of pedicle valve 15 mm.; width 30 mm.; thickness 5 mm.

Pedicle valve moderately convex, greatest convexity in umbonal region; umbo prominent, extends beyond lateral margin of cardinal area; beak sharply pointed; strongly incurved. Cardinal area narrow, well defined; apsacline; delthyrium small, higher than wide. Surface of valve curving abruptly from umbo to lateral margins of cardinal area, gently to postero-lateral and

anterior margins. Sinus sharply defined at beak; broader and shallower anteriorly where it is scarcely depressed below surface of valve.

Nine lateral plicae that do not bifurcate, except first lateral plica derived from outer side of plica bounding sinus at point close to beak. Plicae subangular to rounded in cross section; separated by narrower furrows. Sinus bears strong median plica which extends from beak to anterior margin; lateral slopes of sinus bear one weaker plica derived from inner side of plica bounding sinus, at point near anterior portion of umbonal region; plicae bounding sinus stronger than lateral ones; concentric markings absent.

REMARKS: This species is closely allied to Spirifer biplicoides Weller, but may be distinguished from it by the more strongly developed umbo, the strong median plica that extends to beak; the less roubded nature of the plicae that bound the sinus, and by the lack of mucronate cardinal extremities.

Locality and Formation: Locality 17, Rattler Gulch, five miles west of Drummond, Granite County, Montana. Fossils were collected from upper part of formation at a point two miles from mouth of gulch. Madison limestone, Rooney chert ? member.

Spirifer n. sp. 4.

Plate IV, Figs. 8, 9.

Species known from a single pedicle valve.

DESCRIPTION: Specimen poorly preserved; medium sized; outline transversely triangular; fold and sinus present; hinge line probably equalling greatest width of shell. Dimensions, length of pedicle valve 20 mm.; width 36-40 mm.;

thickness 6 mm.

Pedicle valve very slightly convex; greatest convexity in umbonal region; surface of valve sloping rapidly from umbonal region to lateral margins of cardinal area; extended essentially without curve to postero-lateral and anterior margins. Umbo not differentiated from surface of valve; beak pointed; incurved slightly over cardinal area. Cardinal area 5 mm. in height, orthocline; vertically striated; lateral margins sharply defined; delthyrium higher than wide, medium size. Sinus scarcely differentiated from surface of valve; widened anteriorly.

Fourteen lateral plicae on each slope; not bifurcated; extended to beak; plicae small, rounded; separated by narrower furrows. Sinus carries simple median plica originating at beak; lateral slopes of sinus bear weaker plicae derived from bounding plicae of sinus. Surface exfoliated so that any finer markings that have been present are destroyed.

REMARKS: Because the specimen is poorly preserved, the conclusion that it is a new specimen may be unwise. The fine plicae ally this form to Spirifer tenuimarginatus Hall, and to Spirifer tenuicostus Hall. Spirifer n. sp. 4 may be distinguished from the former by its lack of rounded extremities, and from the latter by its greater number of lateral plicae; 28-34 on Spirifer n. sp. 4 in place of 14 18 on Spirifer tenuicostus. Spirifer n. sp. 4 is characterized by the moderately high orthocline cardinal area, the fineness of plicae, and the flatly convex character of the pedicle valve.

Locality and Formation: Locality 17, Rattler Gulch, five miles west of Drummond, Granite County, Montana. Fossils collected from the upper part of the formation at a point two miles from mouth of gulch. Madison lime-

stone, Rooney chert ? member.

Spirifer n. sp. 5.

Plate IV, Figs. 10-12.

Species known from a single pedicle valve.

DESCRIPTION: Specimen small; outline broadly triangular; fold and sinus present; hinge line equalling greatest width of valve; cardinal extremities slightly compressed. Dimensions, length of pedicle valve 22 mm.; width 17 mm.; thickness 8 mm.

Pedicle valve strongly convex; greatest convexity at anterior portion of umbo; surface of valve curving abruptly from umbo to point one-half distance from beak to cardinal extremities, curving uniformly to anterior margin. Umbo projecting beyond cardinal area; beak pointed, incurved. Cardinal area small; apsacline; delthyrium small; higher than wide.

Thirteen lateral plicae, rounded and somewhat flattened; bifurcate close to beak; first lateral plica derived from outer margin of plica that bounds sinus; sinus bears single fine, nonbifurcate, median plica; lateral slopes of sinus bear two or three plicae derived by bifurcation from inner margins of plicae that bound sinus; plicae bounding sinus stronger than lateral plicae. Concentric markings absent.

REMARKS: This species is closely related to Spirifer vernonensis Swallow from which it differs in the finer median plica of the sinus, the more rotund transverse section, lesser length, and lack of lamellar concentric ornamentation.

Locality and Formation: Locality 13, west side of Monitor Mt., situated east of Continental Divide between the Dearborn River and the South Fork of Falls Creek; in Coopers Lake quadrangle, Montana. Madison limestone.

Spirifer n. sp. 6.

Plate V, Figs. 1-3

Species known from one complete specimen.

DESCRIPTION: Specimen large; outline subquadrate; fold and sinus present; hinge line equalling greatest width; cardinal extremities subrectangular with slight acuminate extension. Dimensions; length of pedicle valve 50-55 mm.; length of brachial valve not determinable; greatest width of specimen 92-96 mm.; thickness of complete specimen 50-53 mm.

Pedicle valve strongly convex; greatest convexity at midlength. Umbonal region strongly elevated; terminated posteriorly by lateral margin of cardinal area; surface of valve curving rather gently to postero-lateral and antero-lateral margins. Beak obtusely pointed; scarcely incurved. Cardinal area high, large; apsacline; horizontally striated; delthyrium large; higher than wide; closed by deltidium; extends from hinge line to beak. Sinus broad shallow; rounding into lateral slopes of valve; apparently without plicae; deflected in anterior portion to form an extension. Crushed condition of shell does not permit of accurate description of sinal extension.

Brachial valve more strongly convex than pedicle; greatest convexity approximately at midlength; umbonal region not prominent; flattened; surface of valve curving gently to the cardinal extremities. Beak obtusely pointed. Cardinal area not observed. Mesial fold well defined by reason of elevation; semicircular in cross section; strongly elevated anteriorly.

Twenty, coarse, rounded, nonbifurcating plicae on each lateral slope; plicae 4 mm. from crest to crest; furrows shallow, narrower than plicae;

plicae originate near beak.

REMARKS: This species is closely allied to the form Spirifer logani Hall, from which it differs in having a cardinal area approximately twice the height of that of S. logani, and in having 20 plications instead of 30 on each lateral slope.

Locality and Formation: Locality 8, Pentagon Mt. situated approximately two miles north west of the Continental Divide, in the north-central part of the Lewis and Clark Range, in sec. 14; T. 25 N., R. 12 W. Fossils collected on southeast slope of mountain at elevation of 8600 feet. Madison limestone.

Spirifer n. sp. ?.

Plate IV, Figs. 12-14.

Species known from a single pedicle valve.

DESCRIPTION: Specimen of medium size; greatest convexity opposite midlength; outline transversely triangular; fold and sinus present; hinge line equal to greatest width. Dimensions, length of pedicle valve 19-20 mm.; width 30 mm.; thickness 11 mm.

Pedicle valve strongly convex; surface describing semi-circle from beak to anterior margin along median line. Umbo not differentiated from general surface of valve; surface sloping in straight line from beak to cardinal extremities. Beak pointed; incurved slightly; projecting beyond lateral margins of cardinal area. Cardinal area wide; triangular; apsacline; delthyrium large; higher than wide; 5 mm. in width. Sinus sharply defined from beak to anterior margin by strong subangular plicae; broadly V-shaped in cross section.

Fourteen lateral plicae on each slope; progressively smaller toward cardinal extremities; subangular in cross section; furrows separating plicae narrower; sinus bears nonbifurcating median plica; lateral slopes of sinus carry two faint plicae derived from inner side of plicae bounding sinus. Finer surface markings destroyed by exfoliation.

REMARKS: This species is characterized by the wide cardinal area; but is not close to the other species of Spirifer which exhibit this feature. The form may be distinguished from the other spirifers bearing a high cardinal area, by the very weak plicae in the sharply defined sinus.

Locality and Formation: Locality 33-6, Wells Pasture, north rim of Dryhead Canyon, 50 feet below Forest Service triangulation cairn, lying in sec. 23, T. 7 S., R. 27 E., Pryor Mt. division, Custer National Forest, Carbon County, Montana. Madison limestone, upper 100 feet.

Spirifer n. sp. 8

Plate IV, Figs. 15-18.

Species known from several well preserved, entire specimens and pedicle valves.

DESCRIPTION: Shell small to medium size; outline triangular; fold and sinus present; hinge line equal to greatest width of shell; cardinal extremities acutely angular, tending to become mucronate. Dimensions, length of pedicle valve 15 mm.; length of brachial valve 13 mm.; greatest width of specimen 30 mm.; thickness of complete specimen 10 mm.

Pedicle valve moderately convex; greatest convexity in umbonal region; surface sloping rapidly from umbonal region to cardinal margins and to postero-lateral margins. Umbo prominent; beak pointed, incurved. Cardinal

area narrow; lateral margins subparallel to hinge line; delthyrium not observed. Sinus broadly U-shaped; sharply defined; nonplicate; extending to beak; produced anteriorly as short extension beyond general curvature of anterior margin.

Brachial valve less convex than pedicle; greatest convexity near mid-length. Umbo low; beak small; pointed; only slightly incurved. Cardinal area narrow; lateral margins subparallel to hinge line. Fold rises at beak; well defined by furrows; becoming strongly elevated anteriorly; subrectangular in cross section; marked by incipient median furrow that originates anterior to middle of shell.

Twelve lateral plicae on each slope of valve; nonbifurcating, except for first lateral plica on each slope of pedicle valve, derived from the outer margin of bounding plica of sinus; plicae progressively smaller toward cardinal extremities. Brachial valve bears plicae similar in form and number to pedicle valve. Concentric ornamentation lacking.

REMARKS: This form is tentatively designated a new species. Its most striking character is the smooth nonplicate fold and sinus; but this character is found among the Devonian spirifers so that the condition is not unique to the genus. Until the Devonian forms of the genus may be checked by means of specific keys, the form is considered as a new Mississippian species.

Locality and Formation: Locality 21, zone 2. Basin Butte, north of Danaher Creek, Powell County, Montana. Madison limestone, Dean Lake chert member.

Spirifer n. sp. 9.

Plate VI, Figs. 2, 3.

Species known from single pedicle valve.

DESCRIPTION: Pedicle valve small; fold and sinus present; hinge line equalling greatest width; cardinal extremities angular. Dimensions, length of pedicle valve 15 mm.; width 25-27 mm.; thickness 6 mm.

Pedicle valve flatly convex; greatest convexity opposite hinge line; umbonal region not differentiated from surface of valve; surface sloping essentially in one plane from beak to anterior margin; surface sloping uniformly from beak to cardinal extremities, line of slope defined as a sharp ridge between lateral slopes of valve and upper surface of cardinal area. Beak obtusely pointed; very slightly incurved. Cardinal area high; sharply defined; apsacline; horizontally striate; delthyrium large; higher than wide; apex reaches beak. Sinus defined to beak; broad; shallow; flat in bottom anteriorly; margins diverge from beak at angle of 30°.

Eight or nine lateral plicae; nonbifurcating, rounded, originating at beak. Furrows separating plicae narrower; more sharply angular in bottom than tops of plicae. Sinus bears no radiating plicae; bottom in anterior portion shows a few fine striae; plicae bounding sinus equal in strength to those on lateral slopes.

REMARKS: This species is close to Spirifer legrandensis Weller but differs from that species by having 8-9 lateral plicae in place of 16-18. The nonplicate sinus is the most distinctive feature of the species but as has been stated previously, species of Spirifer exhibiting this character are known from the Devonian. Until a key of Devonian species of the genus is made and this form carefully studied it is described tentatively as a new species.

Locality and Formation: Locality 33-3, Big Saddle on knob at elevation of 7750 feet, northeast of large saddle separating East Pryor Mt. from its northeast spur, in the SW. ¼ sec. 25., T. 7 S., R. 27 E. Pryor Mt. division Custer National Forest, Carbon County, Montana. Madison limestone, basal 50 feet.

Spirifer n. sp. 10

Plate VI, Figs. 1, 4.

Species known from a single pedicle valve.

DESCRIPTION: Valve large; outline broadly triangular; hinge line equal to greatest width; fold and sinus present; cardinal extremities acuminate; small. Dimensions, length of pedicle valve 75 mm.; width 135 mm.; thickness 25 mm.

Pedicle valve flatly convex; umbonal region prominent; extending posteriorly beyond hinge line a distance equal to height of cardinal area; surface of valve slopes at angle of 25° from beak to point two-thirds distance from median line to cardinal extremities; slope to anterior margin not pronounced in any distinct region. Beak pointed, incurved. Cardinal area 25 mm. in height; orthocline except immediately beneath beak where it becomes 10° apsacline; horizontally furrowed; cardinal extremities extended in short acuminate points; immediately anterior to extremities shallow sinuosity is present extending toward beak and terminating at point where slope from beak meets horizontal line made by lateral margin of cardinal area. Sinus extending to tip of beak; angular in cross section on umbonal region; broad and flat in bottom where sinus approaches anterior margin.

Lateral plicae exist, but exfoliated condition allows no definite observation of their character; appear relatively coarse and extended to beak; not bifurcated. Bottom of sinus in umbonal region marked by fine radiating striae. Prominent concentric growth lines show upon the mould of interior where shell material has been removed. Growth lines strong; deflected outward as they approach postero-lateral margins; following outline of acuminate cardinal extremities.

REMARKS: The form here described is the largest of all known Mississippian spirifers. The great size coupled with the extremely flatly convex character of the shell makes Spirifer n. sp. 10 distinctive. Spirifer logani Hall approaches it most closely in size, but is a strongly tumid form, and does not exhibit acuminate cardinal extremities.

Locality and Formation: Locality 21, zone 3. Basin Butte, north of Danaher Creek, Powell County, Montana. Madison limestone, Rooney chert member.

Spirifer n. sp. 11

Plate VI, Fig. 5

Species known from several pedicle valves.

DESCRIPTION: Specimen large; outline triangular; fold and sinus present; hinge line equal to greatest width of shell. Dimensions, length of pedicle valve approximately 60 mm.; width 90 mm.; thickness 15 mm.

Pedicle valve flatly convex; greatest convexity in umbonal region; surface of valve curving abruptly to cardinal margin, gently to postero-lateral margins. Cardinal extremities acutely angular; greatly compressed. Umbo prominent elevated well above general curvature of valve; beak pointed; tip incurved over cardinal area. Cardinal area moderately high; vertically

striated; orthocline. Delthyrium narrow and high; apex at beak; delthyrial covering not observed. Sinus present; originates at beak; ill defined throughout entire length; broadly V-shaped in cross section.

Twenty-five to 27 plicae on each lateral slope; plicae originate at beak, few bifurcate in umbonal region; flatly rounded; separated by furrows narrower than plicae. Sinus bears bifurcate median plica that originates at beak; each lateral slope of sinus bears three to four plicae derived from inner margin of plicae bounding sinus, or by the bifurcation of plicae so derived. Concentric markings consist of strong growth lines which diverge outward to cardinal extremities and reflect acuminate character of extremities.

REMARKS: This species rather closely resembles Spirifer subaequalis Hall but differs in being much larger in size, in having a greater width in proportion to its length, and in having fewer plicae in the sinus. Spirifer n. sp. 11 is more similar to Spirifer haydenianus Girty than to any other species. The principal difference between these two forms is the greater number of plicae on the latter. Girty lists 100 or more, slightly fasciculate plicae for the pedicle valve of S. haydenianus instead of approximately 60 nonfasciculate plicae for Spirifer n. sp. 11.

Locality and Formation: Locality 21, zone 3. Basin Butte, north of Danaher Creek, Powell County, Montana. Madison limestone, Rooney chert member.

Spirifer n. sp. 12

Plate VII, Figs. 1, 4.

Species known from several pedicle valves.

DESCRIPTION: Pedicle valve large; fold and sinus present; hinge line equalling

greatest width of shell; cardinal extremities acutely angular, 75-80°; slightly more acuminate at point. Dimensions, length of specimen figured in Fig. 1, Plate VII, 65-70 mm.; width of pedicle valve 110 mm.; thickness approximately 18 mm.

Pedicle valve flatly convex; greatest convexity one-third distance from beak to anterior margin; umbonal region not differentiated from general surface of valve; surface curves rather steeply to the cardinal margin for a distance of 20 mm. on each side of beak; surface sloping gently; uniformly; to postero-lateral and antero-lateral margins. Beak pointed but only moderately incurved over cardinal area; cardinal margins meet at beak to form angle of approximately 150°. Cardinal area high; orthocline; vertically striated; lateral margins clearly defined, sloping uniformly from beak to extremities. Delthyrium moderate size; higher than wide. Sinus extends to beak; sharply defined for distance of approximately 30 mm. anteriorly from beak, at which point becomes shallow; rounded into lateral slopes of valve; scarcely discernable.

Thirty-five discernable lateral plicae; cardinal extremities exfoliated, not permitting observation; plicae derived from smaller number at beak; bifurcate close to beak, also on lateral slopes; plicae rounded; separated by furrows slightly narrower than plicae. Sinus bears bifurcating median plica, first bifurcation close to beak, second occurs near anterior margin. Lateral slopes of sinus bear six or seven bifurcated plicae derived from lesser number near beak. Exact bounding plicae of sinus apparently absent; replaced by a group of plicae. Strong concentric growth lines in anterior portion of shell following acuminate outline of cardinal extremities.

REMARKS: This species is characterized by the large size, and flatly convex condition of the pedicle valve. The flatness of the pedicle valve distinguishes Spirifer n. sp. 12 from all other spirifers of the type exemplified by Spirifer logani Hall. Spirifer n. sp. 10 most closely resembles Spirifer n. sp. 12 but may be distinguished from it by the presence of smaller plicae on the latter; the illy defined sinus; and by the presence of plicae in the sinus. R. C. Rowe[21] figured a specimen which is catalogued No. 5074 in the Museum of Paleontology of the State University, as a variety of Spirifer logani Hall. The writer has already pointed out the differences between S. logani and Spirifer n. sp. 12. Other specimens have been added to the collection, one of which is figured in this paper.

Locality and Formation: Locality 8, Pentagon Mt., approximately two miles northwest of the Continental Divide, in the north-central part of the Lewis and Clark range, in sec. 14; T. 25 N., R. 12 W. Fossil locality on southeast slope of mountain at elevation of 8600 feet.

Spirifer n. sp. 13

Plate III, Figs. 3-5.

Species known from several pedicle valves.

DESCRIPTION: Pedicle valve large; fold and sinus present; outline broadly triangular; hinge line equalling greatest width of shell. Dimensions, length of pedicle valve 24 mm.; width 55 mm.; thickness 6 mm.

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[21] R. C. Rowe, "Description and Correlative evidence of the Brachiopoda and other faunal members of the Montana Madison limestone," Unpub. thesis, University of Montana, p. 64, Pl. 11, fig. 11. 1927.

Pedicle valve slightly convex; greatest depth in umbonal region; umbonal region prominent; beak pointed; strongly incurved. Cardinal area not observed; cardinal extremities acutely angular. Surface curving rapidly to lateral margins of cardinal area, gently to postero-lateral and anterior margins. Mesial sinus sharply defined at beak, clearly defined throughout; shallow, scarcely depressed below surface of the valve in anterior portion of valve.

Twenty to 22 plicae on each lateral slope; nonbifurcating, except for first lateral plica, derived from outer margin of plica bounding sinus; originate at beak; plicae and furrows of approximately equal strength; slightly rounded in cross section. Sinus marked by bifurcated median plica originating at beak; three plicae on each lateral slope of sinus derived by repeated bifurcation of inner margin of bounding plicae of sinus; plicae in sinus of equal strength to lateral plicae. Concentric ornamentation absent.

REMARKS: This species closely resembles Spirifer forbesi Norwood and Pratten. It differs from that species in having a bifurcating median plica in sinus, 20 plications in place of 25-30 on each lateral slope, and less lamellate ornamentation.

Locality and Formation: Locality 17, Rattler Gulch, five miles west of Drummond, Granite County, Montana. Fossils collected from upper portion of formation at a point two miles from mouth of gulch. Madison limestone, Rooney chert ? member.

Spirifer n. sp. 14

Plate III, Fig. 6.

Species known from single pedicle valve.

DESCRIPTION: Specimen of large size; fold and sinus present; hinge line equalling greatest width of valve. Dimensions, length 35 mm.; width 48-50 mm.; thickness 7 mm.

Pedicle valve depressed convex; greatest convexity in umbonal region; umbo flattened, not prominent; beak pointed; incurved over cardinal area; cardinal area not observed. Surface of valve sloping steeply to cardinal margin at each side of umbo; gradually to the postero-lateral and anterior margins. Sinus sharply defined at beak; rounded into lateral slopes anteriorly; barely depressed below surface of valve.

Eighteen discernable, rounded, lateral plicae on each slope. Plicae on compressed cardinal extremities either obsolete or nonexistent; furrows narrower than plicae; plicae indistinctly fasciculate on umbo; originate in groups of three near beak by bifurcation of center plica of group; fasciculations becoming less marked anteriorly until at margin bundles are scarcely recognizable. Sinus carries bifurcating median plica that originates close to beak; tends to bifurcate on inner margin at approximately midlength; sinus not bounded by distinct costae but by bundle of three plicae. Concentric ornamentation consists of few strong growth lines.

REMARKS: Spirifer n. sp. 14 belongs to a small group of Mississippian spirifers characterized by the fasciculation of plicae, which includes Spirifer missouriensis Swallow, Spirifer mortonanus Miller, and Spirifer montgomeryensis Weller. Spirifer n. sp. 14 differs from these species in that the fasciculations, though pronounced on posterior portion of the shell are essentially absent at the anterior margin. The most similar form is Spirifer cameratus Morton, a fasciculate Pennsylvanian form. From this form Spirifer n. sp. 14 differs in the bifurcating median plica of

the sinus, the more flatly convex character of the pedicle valve, and particularly in the narrower and much shallower sinus.

Locality and Formation: Locality 5, Spotted Bear Mt., four miles S. 75° E. of the junction of Spotted Bear River and South Fork of Flathead River. Fossils collected at an elevation of 7000 feet on south point of mountain in sec. 25; T. 25 N., R. 15 W. Madison limestone.

Genus SYRINGOTHYRIS Winchell

For generic description see page 39

Syringothyris n. sp. 1

Plate VII, Figs. 2, 3, 5.

Species known from single incomplete specimen.

DESCRIPTION: Shell large; outline transversely triangular; fold and sinus present; hinge line equalling greatest width of valve; cardinal extremities acutely angular. Approximate dimensions, length of pedicle valve 30 mm.; length of brachial valve 25 mm.; greatest width of shell 47 mm.; thickness 40 mm.

Pedicle valve strongly convex; greatest convexity at midlength; umbonal region well developed; surface curving rapidly to cardinal margin for a distance of 15 mm. on each side of beak; curving uniformly to postero-lateral and anterior margins. Beak broken; apparently broadly pointed; slightly incurved. Cardinal area large, 15 mm. in height; well defined laterally; apsacline. Delthyrium large; higher than wide; extending to beak; covered by a delthyrial plate, which is perforated in central region by subcircular opening, external representation of syrinx. Sinus extending

to beak; well defined; rounded in bottom; nonplicated; becomes deep anteriorly, extended toward brachial valve.

Brachial valve strongly convex; less convex than pedicle valve; umbonal region not prominent; curvature of valve stronger from umbonal region to hinge line than to margins. Beak obtuse; incurved to fill base of delthyrium. Cardinal area absent or essentially so. Fold defined to beak; relatively weaker than sinus; subcircular in cross section. Short median septum extending anteriorly 10 mm. from beak; exposed by exfoliation of shell; only observable internal feature.

Shell material almost completely exfoliated, traces of 15 lateral plicae can be seen, though faint. Plicae appear to have been broadly rounded, separated by narrower furrows. Shell material not punctate.

REMARKS: Though the specimen described lacks some of the features of the genus Syringothyris the writer believes it to be more closely related to Syringothyris than to Spirifer. The characters in which it is not in agreement with the genus Syringothyris are; 1, lack of three differentiated regions of the cardinal area which may be due to exfoliation, 2, lack of punctate shell structure, and 3, absence of so called "twilled" ornamentation. The shell agrees closely in being spiriferoid, large, having a wide cardinal area, large delthyrium, and external evidence for syrinx.

Syringothyris n. sp. 1 is most closely related to Syringothyris textus Hall from which it differs in having a lower cardinal area, being 18 mm. in height in place of 30 mm. S. textus has a catacline cardinal area while Syringothyris n. sp. 1 is characterized by an apsacline cardinal area.

Locality and Formation: Locality 13, west side of Monitor Mt., east of the Continental divide between the Dearborn River and the South Fork of Falls Creek, in the Coopers Lake quadrangle, Montana. Madison limestone.

FAUNAL CHART

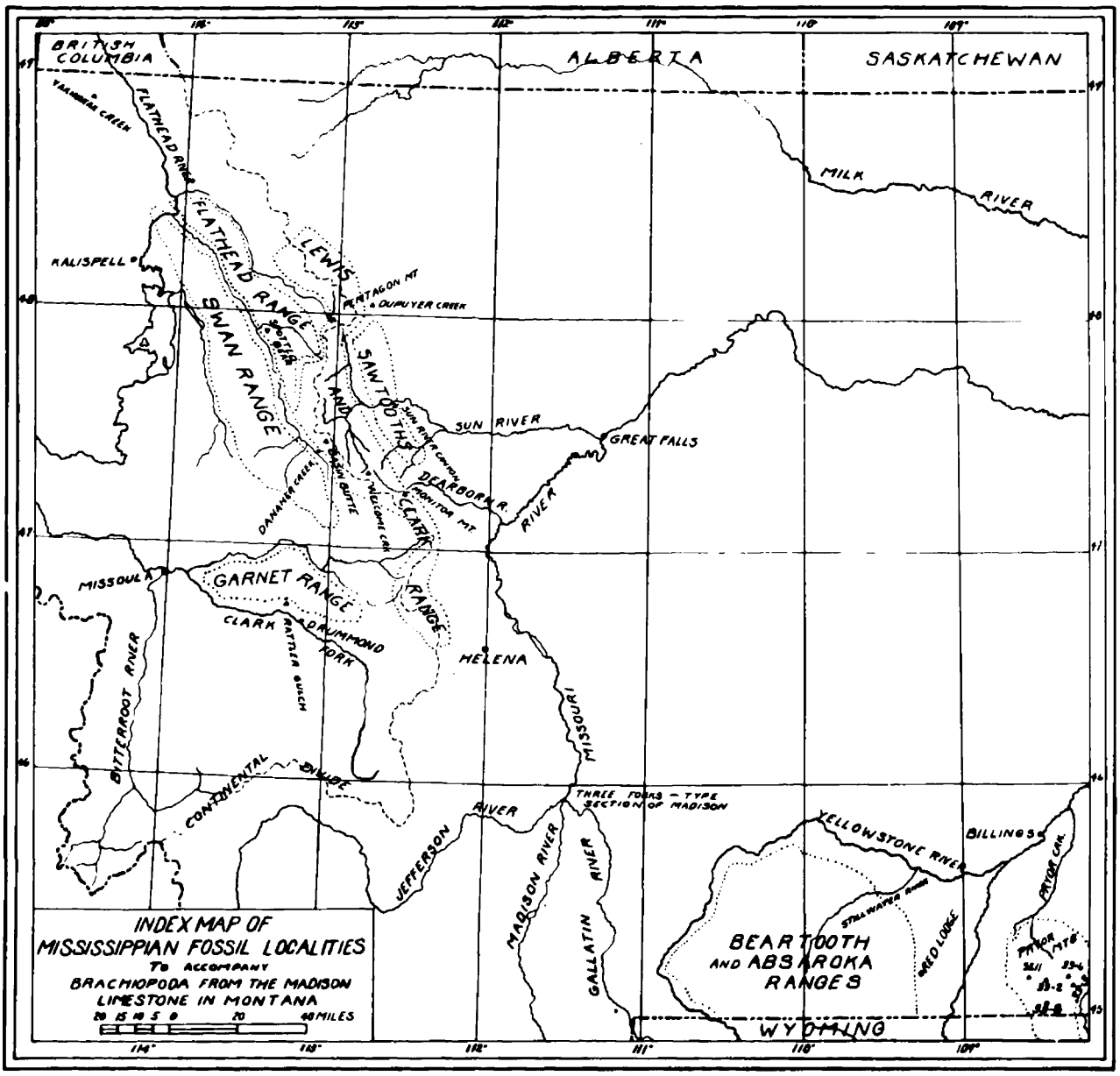
SPECIES	LOCALITIES											AGE				
	Yakinikak Creek	Dupuyer Creek	Spotted Bear 5/3	Pentagon Mt. 8/3	Pentagon Mt. 8/4	Sun River Canyon	Basin Butte 21/2	Basin Butte 21/3	Basin Butte loose	Dansher Creek	Welcome Creek	Monitor Mt.	Rattler Gulch	Ruby Creek	Big Saddle	Wells Pasture	Red Pryor Sta.	Sage Creek R. S.	Kinderhook	Osage	Meramec	Chester	Madison
Amboecelia mimuta											X								X				
Athyris hannibalensis								X											X				
lamellosa	X							X											X	X			
Brachythyris suborbicularis								X												X			
n. sp. 1	X																						
n. sp. 2	X																						
n. sp. 3													X										X
Camarotoechia camarifera															X				X	X			
chotesuensis												X			X				X				
elegantula															X					X			
mutata	X																				X		
purduei var. agrestis															X						X		
subglobosa															X				X				
tuta												X			X				X	X			
n. sp. 1															X								X
n. sp. 2															X								X
n. sp. 3															X								X
Camarophorella missouriensis												X			X				X				
lenticularis															X	X			X				
Chonetes logani												X							X				
ornatus												X							X				
shumardanus												X						X	X				
Cliothyridian elegans							X														X	X	
glenparkensis							X		X										X				
incrassata							X													X			
obmaxima							X												X	X			
tenuilineata			X				X												X	X			
Composita subquadrata			X																			X	
sulcata	X																					X	
trinuclea	X																				X	X	
n. sp. 1															X								X
n. sp. 2															X								X
n. sp. 3															X								X
n. sp. 4															X								X
Cranaena sulcata	X																				X		
Delthyris missouriensis												X							X				
Dielasma chotesuensis																X			X				
formosum						X															X		

FAUNAL CHART (continued 2)

SPECIES	LOCALITIES																		AGE				
	Yakinikak Creek	Dupuyer Creek	Spotted Bear 5/3	Pentagon Mt. 8/3	Pentagon Mt. 8/4	Sun River Canyon	Basin Butte 21/2	Basin Butte 21/3	Basin Butte loose	Danaher Creek	Welcome Creek	Monitor Mt.	Rattler Gulch	Ruby Creek	Big Saddle	Wells Pasture	Red Pryor Sta.	Sage Creek R. S.	Kinderhook	Osage	Meramec	Chester	Madison
Dielasma n. sp. 1																x							x
Dielasmella compressa	x														x				x				
Echinochonchus biseriatus	x												x								x		
genevievensis									x												x		
n. sp. 1							x																x
Girtyella turgida	x																				x		
n. sp. 1	x																						
Leptaena analoga							x					x	x						x	x			
convexa							x												x				
Lingula sp. indet.	x																						
Pugnoides ottumwa ?															x						x		
Productus arcuatus																	x		x				
magnus						x														x			
parviformis													x										x
tenuicostus																x					x		
Rhipidomella burlingtonensis															x					x			
dimimutiva							x					x							x	x			
jerseyensis							x												x				
missouriensis											x								x				
tenuicostata											x								x				
Schuchertella rubra				x															x				
Spirifer albertensis						x							x										x
bifurcatus	x																				x		
biplicatus												x							x				
biplicoides	x				x		x					x	x						x				
calvini n. var. 1												x											x
calvini n. var. 2														x									x
centronatus						x		x								x	x	x	x	x			
crawfordsvillensis													x							x			
floydensis															x				x				
forbesi					x					x		x	x							x			
n. var. 1												x											x
n. var. 2														x									x
grimesi								x	x											x			
increbescens													x									x	
n. var. 1												x											x
keokuk																	x			x			
latior													x		x				x				

FAUNAL CHART (continued 3)

SPECIES	LOCALITIES																			AGE				
	Yakinikak Creek	Dupuyer Creek	Spotted Bear 5/3	Pentagon Mt. 8/3	Pentagon Mt. 8/4	Sun River Canyon	Basin Butte 21/2	Basin Butte 21/3	Basin Butte loose	Dunaher Creek	Welcome Creek	Monitor Mt.	Battler Gulch	Ruby Creek	Big Saddle	Wells Pasture	Red Pryor Sts.	Sage Creek R. S.		Kinderhook	Osage	Meramac	Chester	Madison
Spirifer legrandensis															x					x				
leydi	x																						x	
louisianensis									x			x	x		x					x				
missouriensis		x										x								x				
montgomeryensis				x																	x			
mundulus												x						x			x			
osagensis															x					x				
platynotus						x						x	x	x	x	x	x	x		x				
shepardi																	x			x				
striatiformis									x							x				x	x			
subequalis								x	x												x	x		
vernonensis													x							x				
washingtonensis	x												x								x			
n. sp. 1													x											x
n. sp. 2													x											x
n. sp. 3													x											x
n. sp. 4													x											x
n. sp. 5												x												x
n. sp. 6				x																				x
n. sp. 7																x								x
n. sp. 8							x																	x
n. sp. 9															x									x
n. sp. 10								x																x
n. sp. 11								x																x
n. sp. 12		x			x																			x
n. sp. 13													x											x
n. sp. 14			x																					x
Spiriferella latior								x	x			x									x			
plena								x	x	x			x								x			
Streptorhynchus ruginosum																		x				x		
tenuicostatum															x					x				
Syringothyris textus													x							x				
n. sp. 1												x												x


BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MILK RIVER
FLATHEAD RANGE
KALISPELL
LEWIS
PENTAGON MT
QUIRUYER CREEK
SWAN RANGE
SAWTOOTH
SUN RIVER
GREAT FALLS
DEARBORN R.
RIVER
DAHAMER CREEK
BASIN BUTTE
WILLOWS CR.
MONITOR MT
CLARK
MISSOULA
GARNET RANGE
CLARK RANGE
DRUMMOND
FORK
RATTLER GULCH
HELENA
BITTERROOT RIVER
CONTINENTAL DIVIDE
MISSOURI
THREE FORKS — TYPE SECTION OF MADISON
JEFFERSON RIVER
MADISON RIVER
GALLATIN RIVER
YELLOWSTONE RIVER
BILLINGS
PRYOR CR.
STILLWATER RIVER
RED LODGE
BEARTOOTH AND ABSAROKA RANGES
WYOMING
INDEX MAP OF MISSISSIPPIAN FOSSIL LOCALITIES
TO ACCOMPANY
BRACHIOPODA FROM THE MADISON LIMESTONE IN MONTANA
20 15 10 5 0 20 40 MILES

LIST OF LOCALITIES

Localities

7. On Yakinikak Creek, in the NE. ¼ sec. 30; T. 37 N., R. 22 W., 20 feet above the contact of the Yakinikak limestone and quartzites of Kintla age. Flathead County, Montana. Yakinikak limestone. (Broadwater)

-. Dupuyer Creek, Pondera County, Montana. Exact locality unknown. Madison limestone.

5. Zone 3, Spotted Bear Mt., four miles S. 75° of the junction of Spotted Bear River and South Fork of Flathead River. Fossils collected at an elevation of 7000 feet on south point of mountain in sec. 25; T. 25 N., R. 15 W. Madison limestone.

8. Zones 3, 4. Pentagon Mt., situated approximately two miles northwest of the Continental Divide, in the north-central part of Lewis and Clark range, in sec. 14; T. 25. N., R. 12 W. Fossils collected on southeast slope of mountains at elevation of 8600 feet.

-. Roadway at diversion dam, North Fork of Sun River Canyon, Lewis and Clark County, Montana. Madison limestone, undifferentiated.

21. Zones 2 and 3. Basin Butte, north of Danaher Creek, Powell County, Montana. Madison limestone, zone 2 Dean Lake chert member, zone 3 Rooney chert member.

-. Danaher Creek, located on the northeast side of Fool Hen Creek, Ovando quadrangle, Powell County, Montana.

19. Welcome Creek, 8300 foot peak, situated N. 45° E., of Scapegoat Mt., Lewis and Clark Range, Coopers Lake quadrangle, Lewis and Clark

Localities

County, Montana. Madison limestone, Dean Lake chert member.

13. West side of Monitor Mt., situated east of the Continental Divide between Dearborn River and South Fork of Falls Creek, in the Coopers Lake quadrangle, Montana. Madison limestone.

17. Rattler Gulch, 5 miles west of Drummond, Granite County, Montana. Fossils collected from upper part of formation, at a point two miles from mouth of gulch. Madison limestone, Rooney chert ?member.

33-2. East of the head of Ruby Creek, elevation 8500 feet, lying in the SW¼ sec. 35; T. 7 S., R. 26 E., Pryor Mt. division, Custer National Forest, Carbon County, Montana. Madison limestone, middle portion.

33-3. Big Saddle, on knob at elevation of 7750 feet, northeast of large saddle separating East Pryor Mt. from its northeast spur, in the SW. ¼ sec. 25; T. 7 S., R. 26 E., Pryor Mt. division, Custer National Forest, Carbon County, Montana. Madison limestone, basal 50 feet.

33-6. Wells Pasture, north rim of Dryhead Canyon, 50 feet below Forest Service triangulation cairn, lying in sec. 23; T. 7 S., R. 27 E., Pryor Mt. division, Custer National Forest, Carbon County, Montana. Madison limestone, upper 100 feet.

33-8. Red Pryor Station. Three fourth of a mile N. 35° W. of Red Pryor triangulation station; sec. 19; T. 8 S., R. 26 E. Pryor Mt. division, Custer National Forest, Carbon County, Montana. Madison limestone, upper 100 ? feet.

33-11. Sage Creek Ranger Station. On ridge southeast and immediately above the Sage Creek Ranger Station site; at an elevation of 7300 feet; sec. 29; T. 7 S., R. 26 E. Pryor Mt. division, Custer National Forest,

Carbon County, Montana. Madison limestone, approximately 150 feet from base of formation.

STRATIGRAPHIC CONCLUSIONS

Seventy-two species whose stratigraphic ranges have been determined in relation to the type Mississippian section are represented in the Madison fauna of Montana. The names of these species and their geologic ranges are listed in the faunal chart. Thirty-six of these species are Kinderhook, nine are common to the Kinderhook and Osage, fifteen are limited to the Osage, and one species is common to the Osage and Meramac. Fifty-five species or 75 per cent of the total fauna are limited to the Kinderhook and Osage, and thus the Madison is definitely correlated with the Lower Mississippian of the Mississippi basin.

Twelve species were collected from the Yakinikak limestone. Of these, nine, or 75 per cent are Meramac and Chester and three are Kinderhook and Osage. The presence of the Kinderhook and Osage species among an assemblage that is dominantly Upper Mississippian is probably an example of a recurrent fauna. The species may have originated during Waverlyan time and persisted in some unknown region until Upper Mississippian invasions of the sea allowed them to enter northwestern Montana. The Yakinikak limestone cannot be correlated with the Madison, but may possibly be correlated with the Brazer. Weller[22] considered the Yakinikak lime-

[22] Stewart Weller, "Stratigraphy and structure, Lewis and Livingston ranges, Montana;" Bull. Geol. Soc. Am., vol. 13, pp. 324-325. 1902.

stone equivalent in age to the St. Louis limestone. Evidence obtained from the fossils studied by the writer substantiates Weller's conclusion.

In addition to the Upper Mississippian species collected from the Yakinikak limestone the fauna studied also contains nine other species that occur in the Upper Mississippian. These nine species were collected from widely separated localities, and occur in association with Kinderhook and Osage forms. There are two explanations suggested for their occurrence: 1, These species may be varieties of those to which they are considered equivalent but because of the rather poorly preserved material, the varietal characters could not be observed; 2, These forms may have had their inception in the Pacific seas, entered the cordilleran region in the Lower Mississippian but did not reach the Mississippi basin until the Upper Mississippian. The latter suggestion seems most plausible.

Correlation between localities throughout the State is possible by means of interpolation. No single species occurs in all localities, but enough species are common to several localities to make correlation between them possible.

The Pryor Mountain localities, when considered as a unit, show the following relation to localities in northwestern Montana. Exclusive of new species described in this paper, 26 are from the Pryor Mountains. Four of these are common to Rattler Gulch, six to Monitor Mt., two to the Sun River Canyon locality, one each to zones 2 and 3 Basin Butte, and Yakinikak Creek.

The Monitor Mt. fossils were not placed in zones, but were collected from a portion of the measured section thought by Deiss[23] to represent the Dean Lake and Rooney chert members of the Madison limestone. In the Basin Butte section, Locality 21, Deiss[24] considers zone 2 equivalent of the Dean Lake chert member, and zone 3 the equivalent of the Rooney chert. The Rattler Gulch section has not been measured but is relatively well known because it has been mapped on several occasions by the field classes of the State University. Deiss considers the upper part of the formation as exposed in the vicinity of Drummond, Montana the equivalent of the Rooney chert member of the Madison limestone. The following correlation was obtained between these three localities, i. e., Monitor Mt., Basin Butte and Rattler Gulch.

Twenty-two species were recorded from Monitor Mt., twenty-two from zones 2 and 3, Basin Butte, and twenty from Rattler Gulch. Five species are common to Monitor Mt. and Rattler Gulch; three to Basin Butte and Rattler Gulch; four to Basin Butte and Monitor Mt., and two to all three localities.

This is the first attempt at zonal correlation that has been made in the Madison of Montana. The correlation is not conclusive. The lack of more common species may have resulted from incomplete collections from the respective localities, rather than from nonequivalence of the strata.

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[23] C. F. Deiss, "Paleozoic formations of northwestern Montana:" State Bureau of Mines and Geology, Memoir 6, pp. 45-48. 1933.

[24] C. F. Deiss, personal communication.

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Beecher, C. E., "North American species of Strophelosia:" Am. Jour. Sci., 3d series, vol. 40, p. 244, pl. 9, figs. 18-24. 1890.

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Bevan, Arthur, see Clapp, C. H., 1921.

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Blackwelder, Elliot. "New or little known faunas from Wyoming and Idaho:" Am. Jour. Sci., 4th series, vol. 186, p. 174.

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Boutwell, J. M., "Geology and ore deposits of the Park City district Utah:" U. S. Geol. Survey Professional Paper 77, pp. 231, map. 1912.

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Statement of general lithology, and extent of formation.

Collier, A. J., "Bowdoin Dome, Montana, a possible oil and gas reservoir:" U. S. Geol. Survey Bull. 661, pp. 193-209, map, 1917.

Madison limestone does not outcrop in this area.

Formation mentioned in generalized section for eastern Montana.

---------- "The possibility of finding oil in laccolithic domes south of the Little Rocky Mountains:" U. S. Geol. Survey Bull. 736, pp. 171-178, 2 figs., 1922.

Table of formations with generalized sections.

---------- "The unconformity between the Madison limestone and the Ellis formation in northern Montana:" Jour. Washington Academy of Science, vol. 17, no. 5, pp. 130-131, 1927.

General statement of the extent of the Madison.

Condit, Dale, "Relations of the late Paleozoic and early Mesozoic formations of southwestern Montana and adjacent parts of Wyoming:" U. S. Geol. Survey Prof. Paper 120, pp. 111-121, 1918.

Brief mention of the uniformity of Madison; occasional capping by beds bearing pebbles of Madison limestone; and relation to Jurassic baseleveling.

Cooper, G. Arthur, see Schuchert, Charles, 1932.

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Definitions, descriptions, and correlation of members of Madison limestone.

Douglass, Earl, "Some notes on the geology of southwestern Montana:" Carnegie Museum, Annals III, pp. 407-428, 1905.

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Emmons, W. H., "Gold deposits of the Little Rocky Mountains, Montana:" U. S. Geol. Survey Bull. 340, pp. 96-116, 1908.

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---------- (and Calkins, F. C.) "Geology and ore deposits of the Phillipsburg quadrangle, Montana:" U. S. Geol. Survey Prof. Paper 78, 1913.

Complete measured section of Madison and faunal list.

Emmons, W. H., "The Granite-Bimetallic and Cable Mines, Phillipsburg quadrangle, Montana:" U. S. Geol. Survey Bull. 315, pp. 31-55, 1917.

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Original description of genus Schuchertella

---------- "Notes on the Carboniferous fossils of the Bisbee quadrangle, Arizona:" U. S. Geol. Survey Prof. Paper 21, pp. 46-54, pls. 10-11, 1904.

Brief mention of typical fossils, no descriptions. Lithology; areal extent; but no measured sections of Mississippian strata.

---------- "The relations of some Carboniferous faunas:" Washington Acad. Sci. Proc. vol. 7, pp. 3-4, 1905.

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---------- "On some old and new species of Carboniferous fossils:" U. S. Nat. Mus. Proc., vol. 34, pp. 281-303, 1908.

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---------- "Faunas of the Boone limestone at St. Joe, Arkansas:" U. S. Geol. Survey Bull. 598, pp. 50, pls. 1-31, 1915.

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---------- "The fauna of the Batesville sandstone of northern Arkansas;" U. S. Geol. Survey Bull. 593, pp. 170, pls. 1-11, 1915.

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Girty, G. H., see, Roundy, P. V.

---------- "Descriptions of new species of Carboniferous and Triassic fossils from southeastern Idaho:" Appendix in U. S. Geol. Survey Prof. Paper 152, pp. 411-446, 7 pls., 1927.

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No mention of Madison; discussion of Devonian.

Hole, A. D., "Notes on the paleontology of certain Chester formations in southern Indiana:" Indiana Acad. Sci. Proc., pp. 183-185. 1919.

Faunal lists for Renault, Okaw, and Paint Creek limestones; correlation between Indiana and Illinois; no detailed sections.

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Iddings, J. P., see Weed, W. H., 1895.

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Brief mention of Madison.

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Synonymy of species formerly known as Spirifer triplicata and as Spirifer camerata.

Koninck, de L., "Recherches sur les animaux fossiles," Premier partie. Monographie des genres Productus et Chonetes. pp. 246, pls. 1-20, 1847.

Classification and grouping of genera Chonetes and Productus, with descriptions and figures of species.

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---------- "Preliminary paleontological report, consisting of lists and descriptions of fossils, with remarks on the ages of the rocks in which they are found:" U. S. Geol. Survey Terr. Sixth Annual Report,

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Lists few species; describes none, and considers fauna equivalent of the Spergen.

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Morse, W. C., "Paleozoic Rocks:" Mississippi Geol. Survey Bull. 23, pp. 1-212, pls. 1-23, 1930.

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Owen, Dale, "Geological Report of Wisconsin, Iowa, and Minnesota, 1852.

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Brief mention of Madison, and statement of general lithology.

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Condensed statement of lithology and approximate thickness of Madison.

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Section and lists of fossils as identified by Walcott.

Original use of formational name Madison. Discussion of general relation of fauna; no descriptions of new species.

Pirsson, L. V., see Weed, W. H., 1896.

Powers, Sidney, "Notes on the geology of the Sun River district:" Jour. Geology, vol. 22, pp. 556-559, 1914.

Few species listed from Gibson dam site, North Fork of Sun River. No sections.

Roundy, P. V. (and Girty, G. H., and Goldman, M. I.,) "Mississippian formations of San Saba County, Texas:" U. S. Geol. Survey Prof. Paper 146, 63 pp., 33 pls., 1926.

Two Mississippian formations recognized. Eleven new species described and figured.

Reeves, Frank, "Geology of the Big Snowy Mountains, Montana:" U. S.. Geol. Survey Prof. Paper 165-D, pp. 135-149, 1930.

General statement of lithology; thickness; and faunal lists.

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Stebinger, Eugene, "Oil and gas geology of the Birch Creek-Sun River area, northwestern Montana:" U. S. Geol. Survey Bull. 691, pp. 149, 184, 1918.

General statement of the Madison and Brazer lithology.

Stone, R. W., "Geolcgic relations of ore deposits in the Elkhorn Mountains, Montana:" U. S. Geol. Survey Bull. 470, pp. 75-98, map.1911.

Mentions occurrence and thickness of Madison.

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Brief mention of the Madison limestone and its general lithology.

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Descriptions but no figures. Descriptions largely found in Weller.

---------- "Some new varieties of Spirifer: "Trans. St. Louis Acad. Sci., vol. 2, pp. 408-410. 1862.

Descriptions poor; no figures. Varieties given of Spirifer lineatus, cameratus, kentuckiensis, leydi, increbescens, and keokuk.

Tansley, Wilfred, (and Schafer, Paul A., and Hart, Lyman), "A geological reconnaissance of the Tobacco Root Mountains, Madison County, Montana:" State Bur. Mines and Geology. Mem. no. 9, 1933.

Very brief mention of the Madison limestone.

Thom, W. T., "Oil and gas prospects in and near the Crow Indian Reservation, Montana:" U. S. Geol. Survey Bull. 736, pp. 35-53, 1 pl., map, 1922.

Gives general discussion of Madison, and unconformity separating it from Amsden.

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Tomlinson, C. W., "The middle Paleozoic stratigraphy of the central Rocky Mountain region:" Jour. Geology, vol. 25, pp. 112-134, 244-257, 373-394, 1917.

Fossils lists, diagramatic sections given for the localities where the sections were measured. Madison divided into members lithologically. Weak point is fact that sections are separated from one another by too great distances.

Walcott, C. D., "Paleontology of the Eureka district:" U. S. Geol. Survey Mon. 8, pp. 1-298, pls. 1-24, 1884.

Figures and describes large number of previously known forms, and also some new species of brachiopods.

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Faunal list; fauna compares closely to that from Liard river localities, and from Madison limestone of Montana and Wyoming.

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Measured sections of Mississippian limestones; discussion of its relation to Madison limestone; and description and figures of two new species; Spirifer cascadensis and roundlensis.

---------- "The Paleozoics of Crowsnest Pass, Alberta:" Royal Soc. Canada Proc. and Trans., 3d series, vol. 22, pp. 109-120, pl. 1, 1928.

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Warren, P. S., see Allan, J. A., 1932.

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Gives measured section of Madison.

---------- "The geology of the Little Rocky Mountains, Montana." Jour. of Geology, vol. 4, pp. 399-428. 1896.

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Weller, Stewart, "A bibliographic index of the North American carboniferous invertebrates:" U. S. Geol. Survey Bull. 153, 1898.

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faunal lists and discussion.

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Redefinition of the following new genera, Girtyella, Dielasmoides, Hamburgia, Dielasmella, and Rowleyella.

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Zittel, Karl A., von, "Textbook of Paleontology," vol. I, pp. 355-420. 2d ed., C. R. Eastman editor, 1913.

Excellent general reference.

EXPLANATION OF PLATE I

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Fig. 1. *Atrypa sp. undet* 42

View of brachial valve showing general outline of shell; rounded plicae; and small nodes developed on plicae in anterior portion of fold. Natural size.

Locality 21, zone 2.

Fig. 2. *Atrypa sp. undet.*

Lateral view of specimen shown in fig. 1, showing relative convexity of valves. Natural size.

Fig. 3. *Atrypa sp. undet.*

Posterior view of same specimen shown in fig. 1, showing relative convexity of valves; short hinge line; and small size of beaks. Natural size.

Fig. 4. *Brachytheris n. sp. 1* 43

View of pedicle valve showing rounded cardinal extremities; and fine median plica in sinus. Natural size.

Locality 7, zone 2. (Broadwater)

Fig. 5. *Brachythyris n. sp. 1*

Lateral view of specimen shown in fig. 4, showing relative convexity of valve. Natural size.

Fig. 6. *Brachythyris n. sp. 2* 45

View of pedicle valve showing outline of shell and character of plicae in sinus. Magnified 2 diameters.

Locality 7, zone 2. (Broadwater)

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Fig. 7. Brachythyris n. sp. 2

View of specimen shown in fig. 6, showing delthyrium. Magnified 2 diameters.

Fig. 8. Brachythyris n. sp. 3 46

View of pedicle valve showing prominent umbonal region, and nonbifurcating median plica in sinus. Natural size.

Locality 17.

Fig. 9. Brachythyris n. sp. 3

Lateral view of pedicle valve shown in fig. 8, showing angle of cardinal area; and convexity of valve. Natural size.

Fig. 10. Camarotoechia n. sp. 1 47

View of pedicle valve of nearly complete specimen; beak broken. Strong character of plications in anterior portion shown. Magnified 2 diameters.

Locality 33-3.

Fig. 11. Camarotoechia n. sp. 1

View of brachial valve of specimen shown in fig. 10, showing character of fold. Magnified 2 diameters.

Fig. 12. Camarotoechia n. sp. 1

Anterior view of specimen shown in fig. 10, showing character of fold and sinus at anterior margin. Magnified 2 diameters.

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Fig. 13. Camarotoechia n. sp. 1

Posterior view of specimen shown in fig. 10, showing beak of brachial valve; beak of pedicle valve removed. Magnified 2 diameters.

Fig. 14. Camarotoechia n. sp. 1

Posterior view of another individual slightly larger, showing relation of beaks; and variation in convexity of valves. Magnified 2 diameters.

Fig. 15. Camarotoechia n. sp. 2 49

View of pedicle valve showing umbonal ridge; and slightly flattened mesial portion of valve. Magnified 2 diameters.

Locality 33-3.

Fig. 16. Camarotoechia n. sp. 2

Lateral view of pedicle valve shown in fig. 15, showing umbonal "cap". Magnified 2 diameters.

Fig. 17. Camarotoechia n. sp. 2

View of brachial valve of another individual, showing four plications on flattened fold. Magnified 2 diameters.

Fig. 18. Camarotoechia n. sp. 3 50

View of pedicle valve, showing plicae in sinus. Rostral angle not clearly shown due to orientation of specimen. Magnified 2 diameters.

Locality 33-3.

page

Fig. 19. Camarotoechia n. sp. 3

Lateral view of pedicle valve shown in fig. 13. Magnified 2 diameters.

Fig. 20. Composita n. sp. 1 51

View of pedicle valve showing outline of shell. Sinus absent but appears to be present due to lighting. Magnified 2 diameters.

Locality 33-3.

Fig. 21. Composita n. sp. 1

View of specimen shown in fig. 20, showing foramen and delthyrium. Magnified 2 diameters.

Fig. 22. Composita n. sp. 1

Lateral view of specimen shown in fig. 20, showing general convexity of valve. Magnified 2 diameters.

Fig. 23. Composita n. sp. 1

View of pedicle valve of another individual. Magnified 2 diameters.

Locality 33-3.

Fig. 24. Composita n. sp. 1

Lateral view of specimen shown in fig. 23, showing convexity of valve. Magnified 2 diameters.

Fig. 25. Composita n. sp. 2 53

View of pedicle valve showing wide rostral angle; and small auricular expansions of valve. Magnified 2 diameters.

Locality 33-3.

Fig. 26. Composita n. sp. 2

Lateral view of valve shown in fig. 25, showing tumid character of pedicle valve. Magnified 2 diameters.

Fig. 27. Composita n. sp. 3 54

View of pedicle valve showing general outline. Magnified 2 diameters.

Locality 33-3.

Fig. 28. Composita n. sp. 3

Oblique view of specimen shown in fig. 27, showing curvature of umbonal region; pedicle foramen; and nature of cardinal area. Magnified 2 diameters.

Fig. 29. Composita n. sp. 3

Lateral view of specimen shown in fig. 27. Magnified 2 diameters.

Fig. 30. Composita n. sp. 4 54

View of pedicle valve showing extended umbonal region. Magnified 2 diameters.

Locality 33-3.

Fig. 31. Composita n. sp. 4

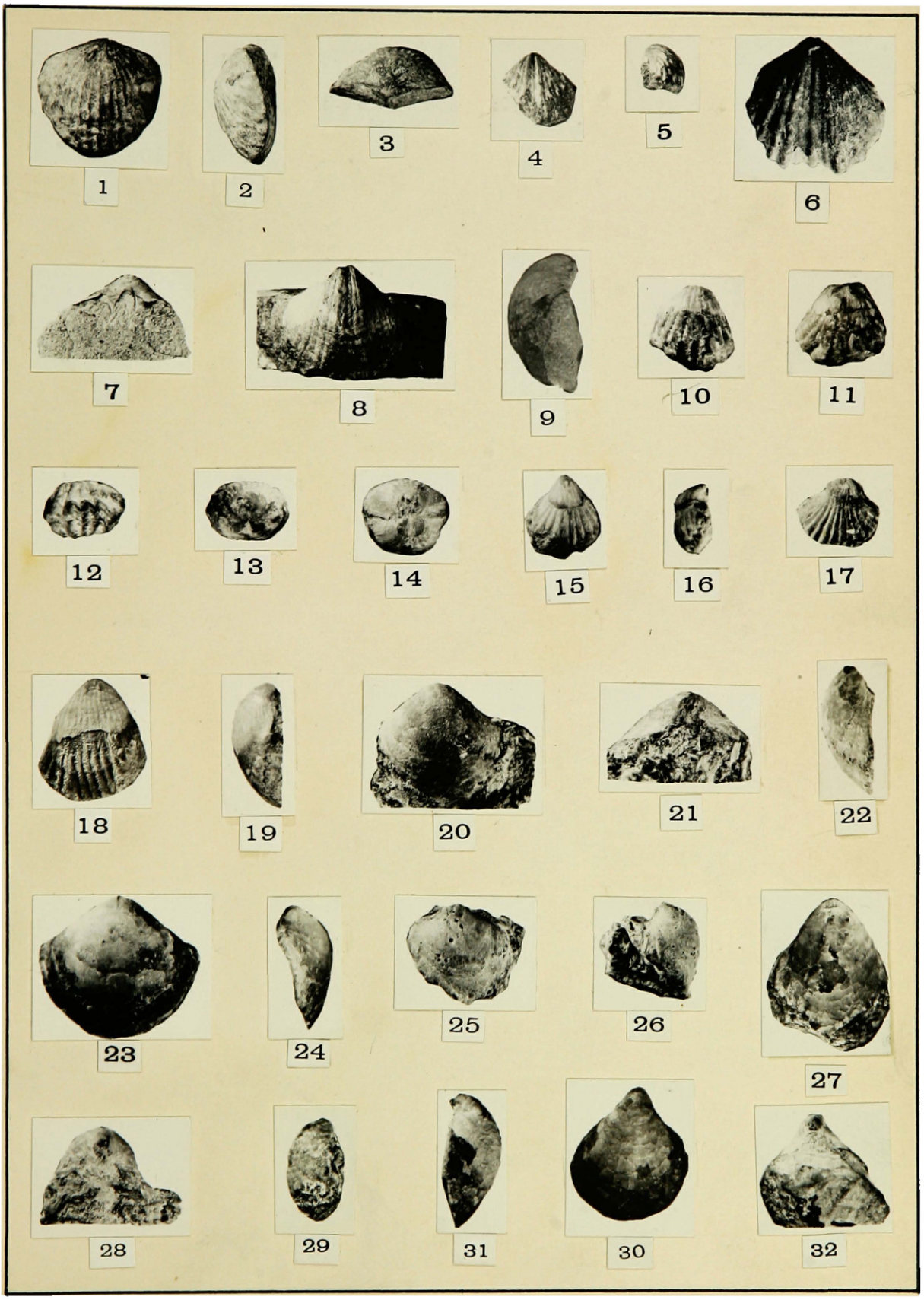
Lateral view of specimen shown in fig. 30, showing convexity of valve. Magnified 2 diameters.

Fig. 32. *Composita n. sp. 4*

View of cardinal area of specimen shown in fig. 30.

Magnified 2 diameters.

PLATE I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EXPLANATION OF PLATE II

page

Fig. 1. *Dielasma n. sp. 1* 55

View of pedicle valve showing pentagonal outline of valve. Natural size.

Locality 33-6.

Fig. 2. *Dielasma n. sp. 1*

Lateral view of specimen shown in fig. 1, showing curvature of valve. Natural size.

Fig. 3. *Echinochonchus n. sp. 1* 57

View of specimen showing concentric banding; radial ribbing; and widely extended circular expansions. Latter feature best shown on right of specimen. Natural size.

Locality 21, zone 2.

Fig. 4. *Echinochonchus n. sp. 2* 58

Lateral view showing convexity of pedicle valve. Natural size.

Locality, Sun River Canyon.

Fig. 5. *Echinochonchus n. sp. 2*

View of pedicle valve shown in fig. 4, showing tumidity of valve; and fine radial ornamentation. Natural size.

Fig. 6. *Girtyella n. sp. 1* 59

View of pedicle valve, showing slight mesial sinus. Magnified 2 diameters.

page

Locality 7, zone 2. (Broadwater)

Fig. 7. Girtyella n. sp. 1

View of brachial valve of specimen shown in fig. 6, showing sinus and bordering folds. Magnified 2 diameters.

Fig. 8. Girtyella n. sp. 1

Lateral view of specimen shown in fig. 6, showing relative convexity of two valves. Magnified 2 diameters.

Fig. 9. Girtyella n. sp. 1

Posterior view of specimen shown in fig. 6, showing beaks; and tumidity of valves. Magnified 2 diameters.

Fig. 10. Girtyella n. sp. 1

Posterior view of specimen shown in fig. 6, showing deflections of commissure. Magnified 2 diameters.

ig. 11. Spirifer calvini n. var. 1

View of pedicle valve showing nonbifurcated median plica in sinus; rounded plicae; and concentric growth lines. Natural size.

Locality 13.

g. 12. Spirifer calvini n. var. 1 .1..... 60

Lateral view of specimen shown in fig. 11, showing wide cardinal area; and thick shell material. Natural size.

page

Locality 32-2.

Fig. 13. Spirifer calvini n. var. 2 61

View of pedicle valve, showing broad rounded plicae. Natural size.

Locality 32-2.

Fig. 14. Spirifer calvini n. var. 2

Lateral view of specimen shown in fig. 13, showing wide cardinal area. Natural size.

Fig. 15. Spirifer calvini n. var. 2

Oblique view of cardinal area of specimen shown in fig. 13, showing nature of delthyrium. Natural size.

Fig. 16. Spirifer increbescens n. var. 1 63

View of pedicle valve. Natural size.

Locality 13.

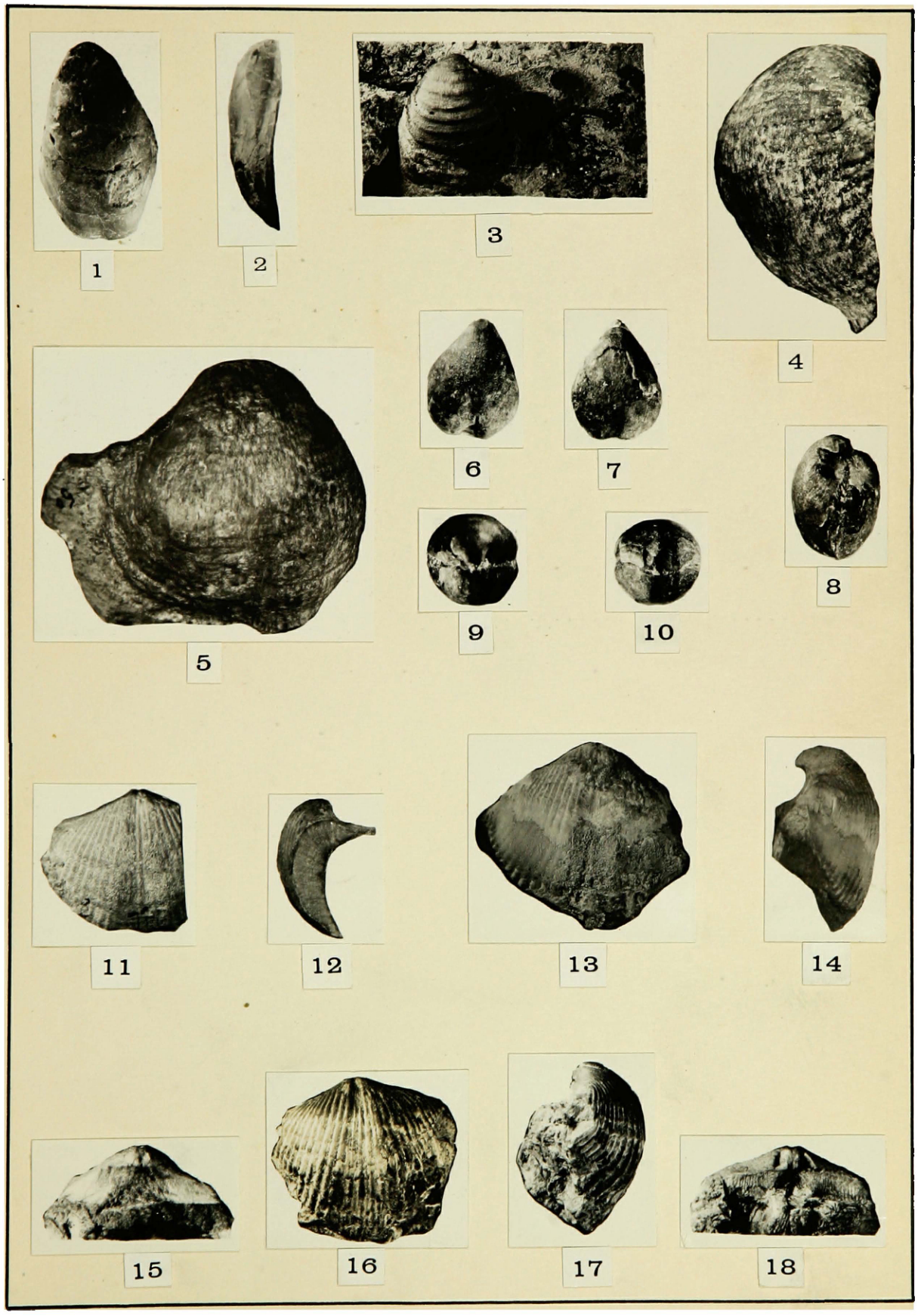
Fig. 17. Spirifer increbescens n. var. 1

Lateral view of specimen shown in fig. 16, showing convexity of valve. Natural size.

Fig. 18. Spirifer increbescens n. var. 1

View of cardinal area of specimen shown in fig. 16, showing vertically striated cardinal area; and delthyrium. Natural size.

PLATE II



EXPLANATION OF PLATE III

All figures natural size.

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Fig. 1. *Spirifer centronatus* Winchell 62

Large brachial valve.

Locality 21 - loose.

Fig. 2. *Spirifer centronatus* Winchell

Large brachial valve, showing greater number of plicae than average specimen.

Locality 33-6.

Fig. 3. *Spirifer n. sp. 13* 80

View of pedicle valve showing wide flat sinus; rounded plicae; and low umbonal region.

Locality 17.

Fig. 4. *Spirifer n. sp. 13*

View of another pedicle valve with shell material broken away to expose dental lamellae.

Locality 17.

Fig. 5. *Spirifer n. sp. 13*

View of a third pedicle valve, slightly distorted.

Locality 8.

Fig. 6. *Spirifer n. sp. 14* 81

View of pedicle valve showing poorly defined sinus; and fasciculate character of plicae.

Locality 5.

page

PLATE III

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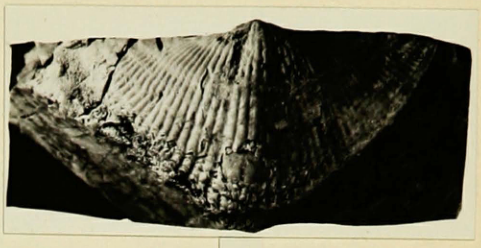

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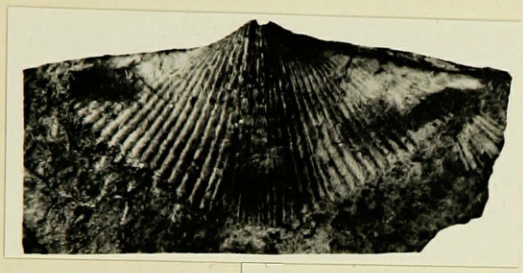

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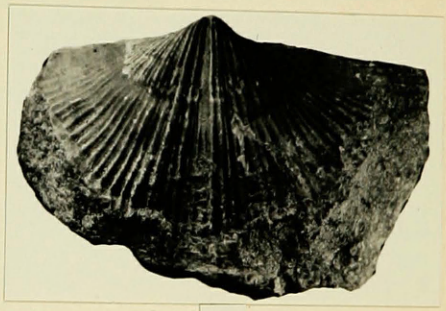

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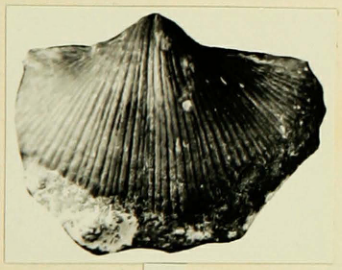

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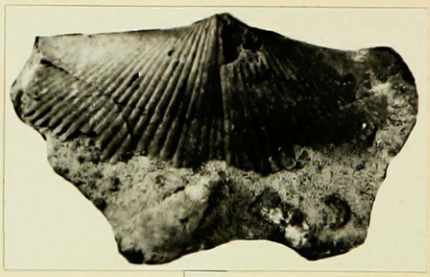

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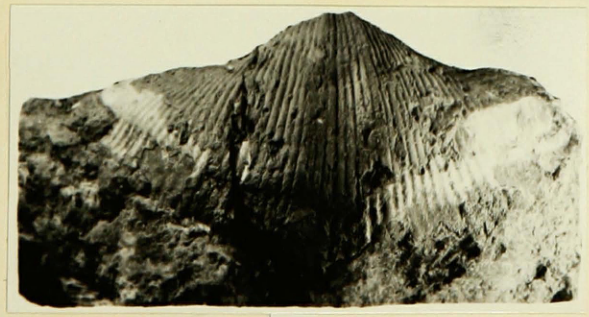

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EXPLANATION OF PLATE IV

All figures natural size.

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Fig. 1. Spirifer n. sp. 1 65

View of pedicle valve showing general shape of valve.

Locality 17.

Fig. 2. Spirifer n. sp. 1

Lateral view of specimen shown in fig. 1, showing orthocline cardinal area.

Fig. 3. Spirifer n. sp. 1

View of cardinal area of specimen shown in fig. 1, showing delthyrium.

Fig. 4. Spirifer n. sp. 2 66

View of pedicle valve showing outline; and angular nature of plicae.

Locality 17.

Fig. 5. Spirifer n. sp. 2

Lateral view of specimen shown in fig. 4, showing convexity of valve; and narrow cardinal area.

Fig. 6. Spirifer n. sp. 3 67

View of pedicle valve showing general shape.

Locality 17.

Fig. 7. Spirifer n. sp. 3

Lateral view of specimen shown in fig. 6, showing convexity of valve.

page

Fig. 8. *Spirifer n. sp. 4* 68

View of pedicle valve showing shallow sinus.

Locality 17.

Fig. 9. *Spirifer n. sp. 4*

View of cardinal area of specimen shown in fig. 8.

Fig. 10. *Spirifer n. sp. 5* 70

View of pedicle valve showing general contour of shell; and rounded plicae.

Locality 13.

Fig. 11. *Spirifer n. sp. 5*

Lateral view of specimen shown in fig. 10, showing convexity of valve.

Fig. 12. *Spirifer n. sp. 7* 72

View of pedicle valve showing weak plicae in sinus.

Locality 33-6.

Fig. 13. *Spirifer n. sp. 7*

View of cardinal area of specimen shown in fig. 12, showing delthyrium.

Fig. 14. *Spirifer n. sp. 7*

Lateral view of specimen shown in fig. 12, showing wide cardinal area.

Fig. 15. *Spirifer n. sp. 8* 73

View of pedicle valve showing rounded plicae; non-plicated sinus; and submucronate cardinal extremities.

Locality 21, zone 2.

Fig. 16. Spirifer n. sp. 8

Lateral view of specimen shown in fig. 15, showing relative convexity of valves.

Fig. 17. Spirifer n. sp. 8

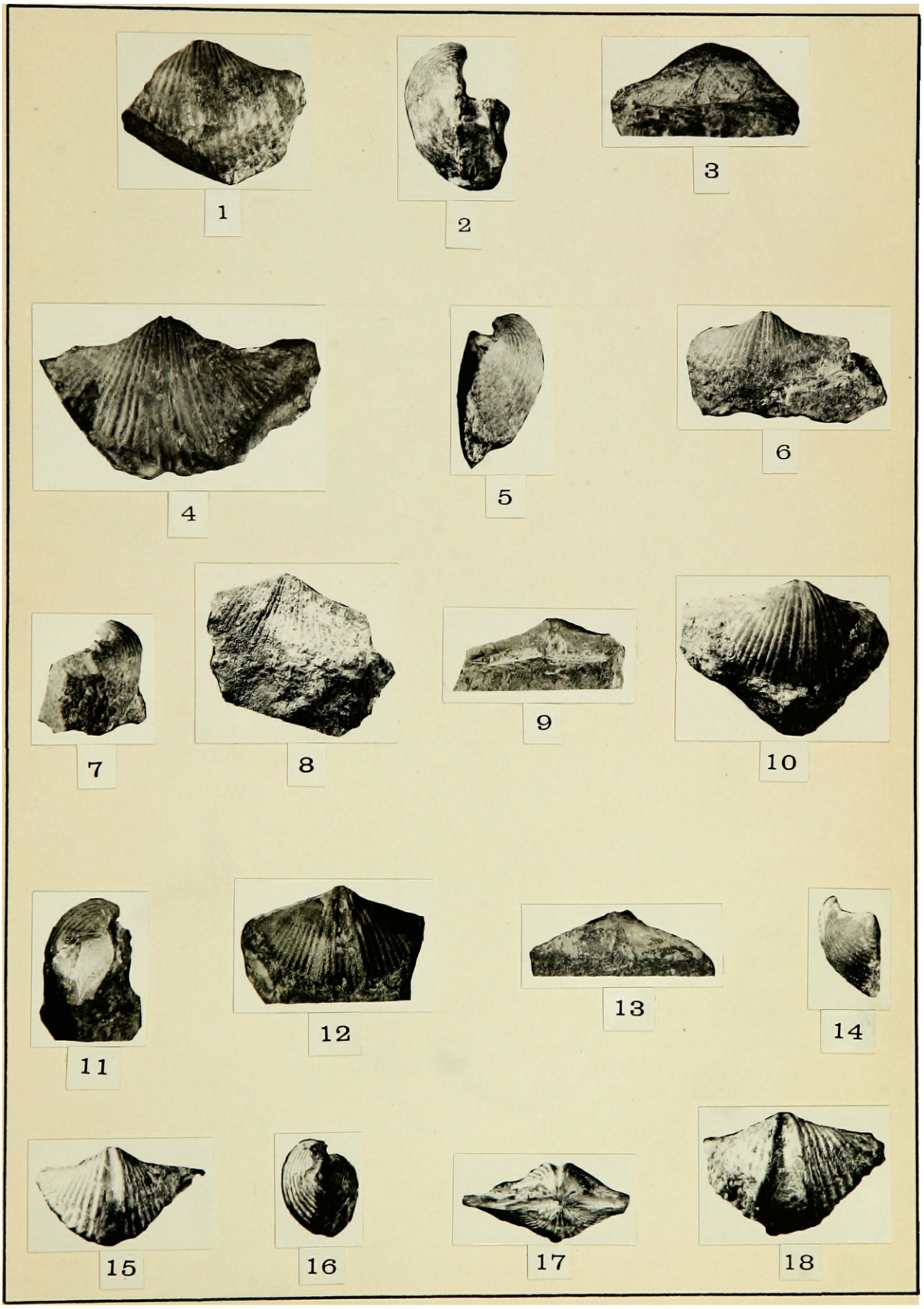
Posterior view of specimen shown in fig. 15, showing narrow cardinal area; and relation of beaks.

Fig. 18. Spirifer n. sp. 8

View of another pedicle valve of slightly larger size.

Locality 21, zone 2.

PLATE IV



EXPLANATION OF PLATE V

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Fig. 1. *Spirifer n. sp. 6* 71

View of pedicle valve showing nonplicate sinus; broad flattened plicae; and high umbonal region.

Locality 8.

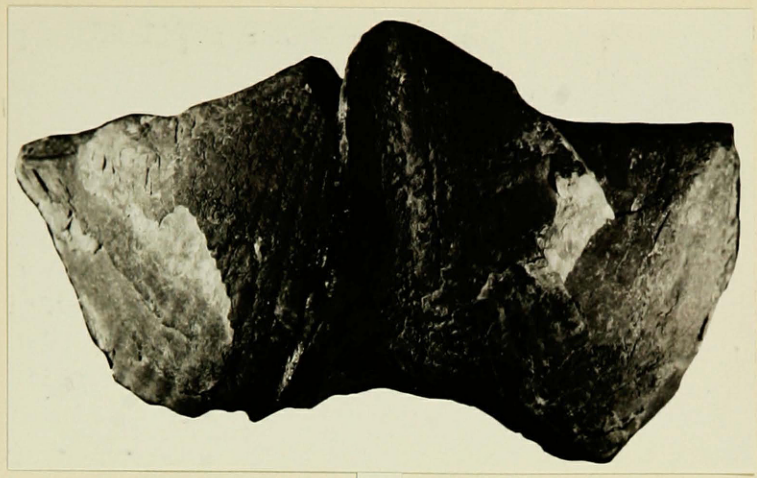
Fig. 2. *Spirifer n. sp. 6*

View of brachial valve of specimen shown in fig. 1, showing rounded fold; and relative height of beaks.

Fig. 3. *Spirifer n. sp. 6*

View of posterior of specimen shown in fig. 1, showing wide cardinal area; crushed condition of beak of brachial valve which causes it to fill base of delthyrium of pedicle valve; and relative convexity of valves.

PLATE V



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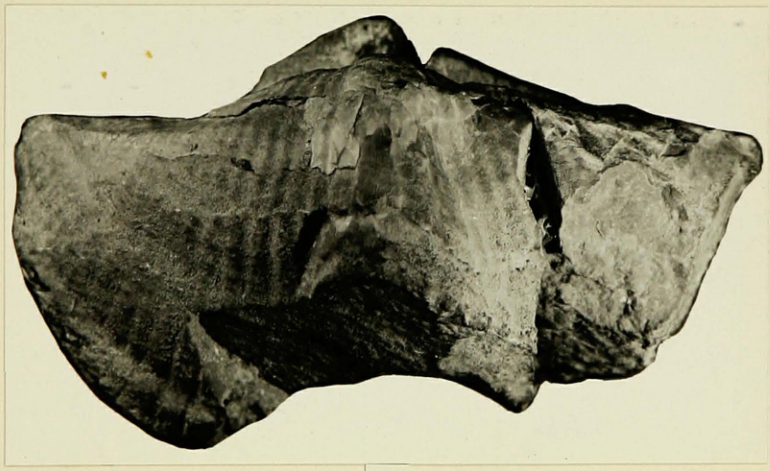

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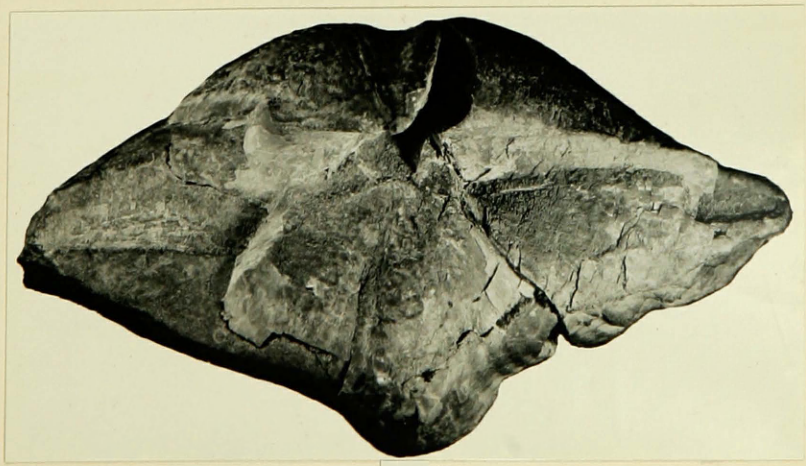

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EXPLANATION OF PLATE VI

page

Fig. 1. Spirifer n. sp. 10 76

View of pedicle valve showing high umbonal region; broad shallow sinus; faint plicae on lateral slopes; and acuminate cardinal extremities. Magnified 2/3 diameters.

Locality 21, zone 3.

Fig. 2. Spirifer n. sp. 9 74

View of pedicle valve showing nonplicated sinus; rounded plicae; and uniform slope of valve from beak to cardinal extremities. Natural size.

Locality 33-3.

Fig. 3. Spirifer n. sp. 9

View of cardinal area of specimen shown in fig. 2, showing delthyrium. Natural size.

Fig. 4. Spirifer n. sp. 10

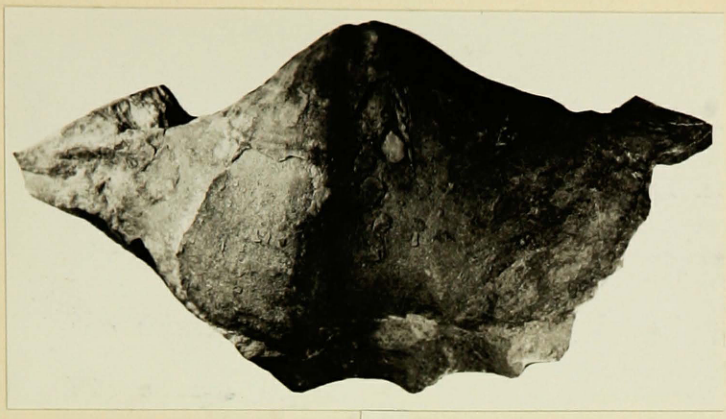
View of cardinal area of specimen shown in fig. 1, showing orthocline cardinal area; sinus extending to beak; and wide, large delthyrium. Magnified 2/3 diameters.

Fig. 5. Spirifer n. sp. 11 77

View of pedicle valve showing shallow, illy defined sinus; bifurcated median plica in sinus; and concentric growth lines. Natural size.

Locality 21, zone 3.

PLATE VI



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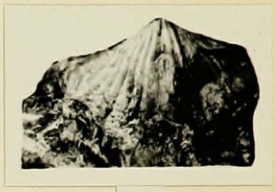

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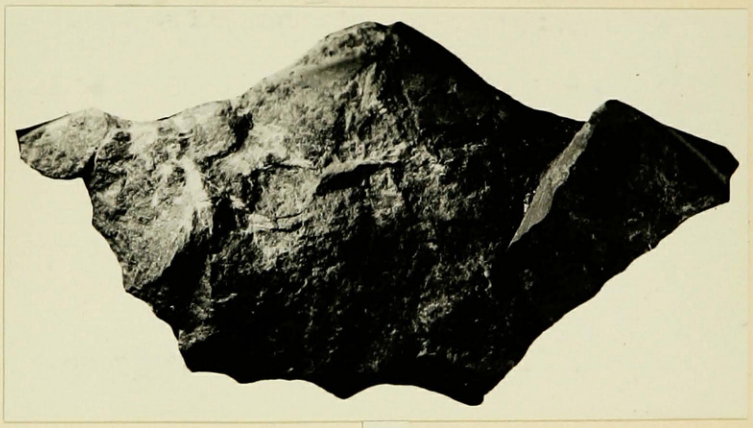

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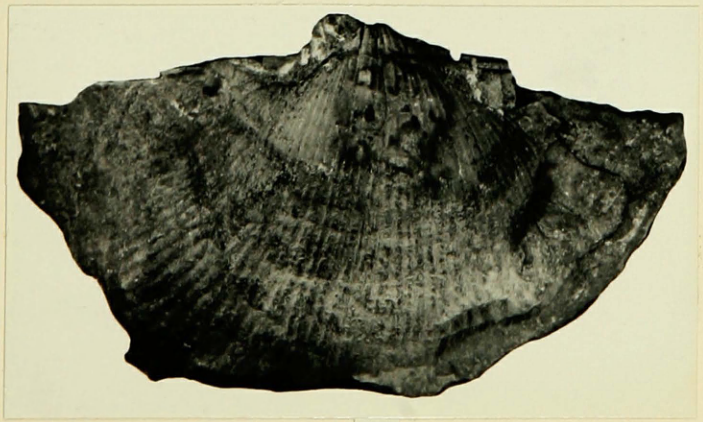

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EXPLANATION OF PLATE VII

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Fig. 1. Spirifer n. sp. 12 .....

View of pedicle valve, bearing catalogue number, 5074, Museum of Paleontology, State University. Figure shows shallow sinus; acuminate cardinal extremities; and strong growth lines in anterior portion of valve.

Locality on Dupuyer Creek.

Fig. 2. Syringothyris n. sp. 1

Lateral view of specimen showing wide cardinal area of pedicle valve.

Locality 13.

Fig. 3. Syringothyris n. sp. 1 83

View of cardinal area of specimen shown in fig. 2, showing large delthyrium; delthyrial plate perforated by syrinx; and slight median septum of brachial valve.

Fig. 4. Spirifer n. sp. 12

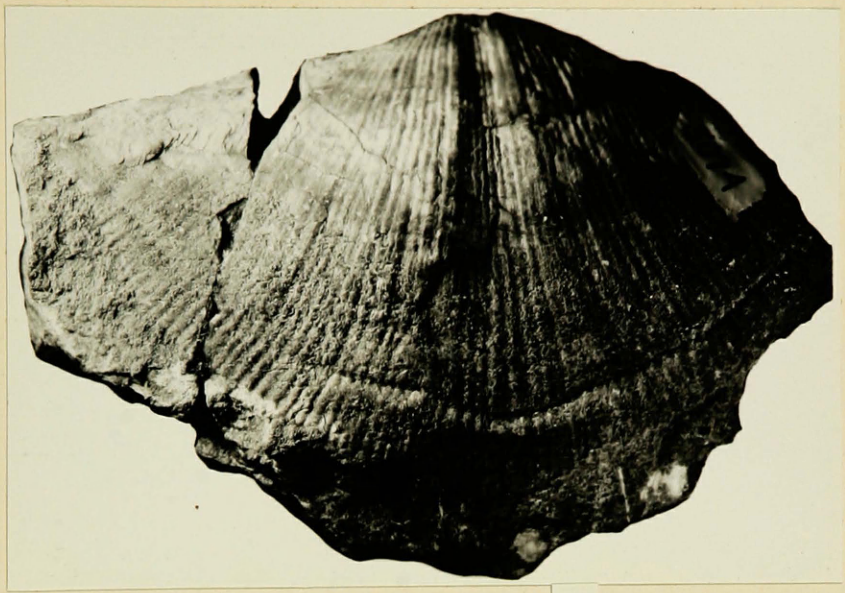
View of another pedicle valve.

Location 8.

Fig. 5. Syringothyris n. sp. 1

View of pedicle valve of specimen shown in fig. 2, showing outline of valve.

PLATE VII



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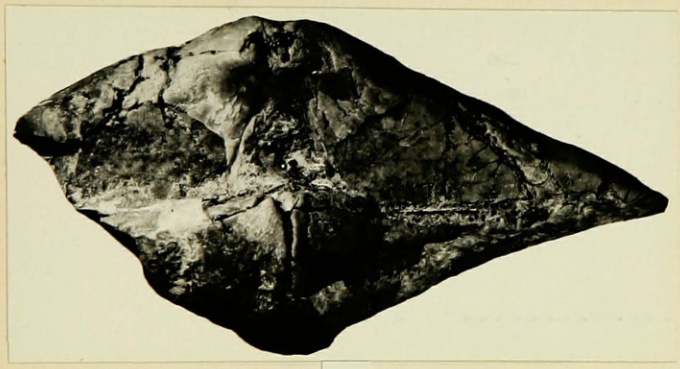

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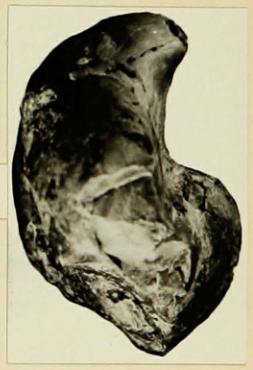

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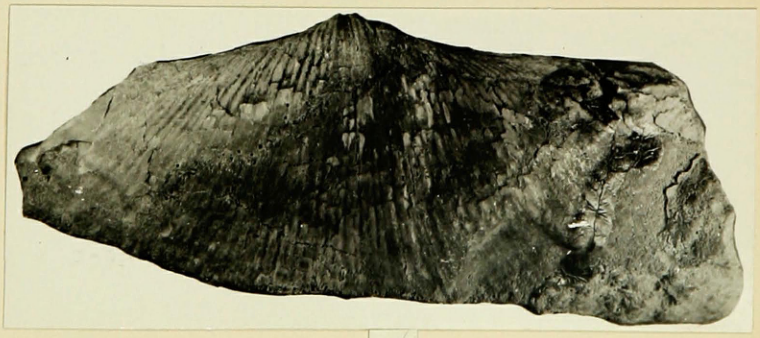

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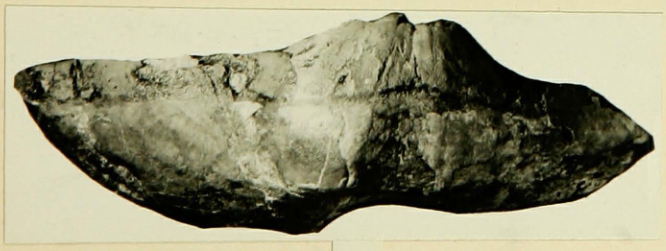

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