FAUNAS AND AGE OF THE AMSDEN FORMATION IN WYOMING

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A PERMIAN (WOLFCAMPIAN) FAUNA OF THE CASPER FORMATION OF SOUTHEASTERN WYOMING

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FAUNAS AND AGE OF THE AMSDEN FORMATION IN WYOMING

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ABSTRACT—A review of the fossils identified from the Amsden formation by previous workers indicates a Pennsylvanian rather than a Mississippian age for the Amsden in Wyoming. Six new faunas from the formation are believed to be Pennsylvanian in age, and include the following identifiable genera and species: *Dictyoclostus portlockianus, Linoproductus prattenianus, Cancrinella boonensis, Marginifera muricatina, Spirifer opimus, Composita subtilita* var. *subtilita, C. subtilita* var. *trinuclea, C. subtilita* var. *ovata, Wellerella osagensis, Allorisma terminale, Lingulodiscina, Marginifera, Spirifer, Composita, Naticopsis, Orthotetes?, Cleiothyridina?*, and an unidentifiable tetracoral and goniatite. One new species is proposed, *Eumetria sulcata*.

INTRODUCTION

THE Amsden formation of Wyoming, Montana, and Utah has been frequently studied and discussed since it was named and defined by N. H. Darton (1904, pp. 396–397), yet there has been no general agreement concerning its age and stratigraphic limits. Most of the published stratigraphic sections have recently been remeasured by C. A. Biggs, and additional sections measured, in an attempt to delimit and correlate the lithologic units of the Amsden. The results of this study are reported in an unpublished Master's thesis on file at the University of Wyoming. A sizeable collection of fossils was obtained by Biggs from several localities and units in the formation. This collection forms the basis for this paper.

I should like to express my sincere appreciation for the time given to me by Mr. Biggs in explaining the results of his work on the Amsden formation in Wyoming and the many stratigraphic problems involved. He also prepared all of the specimens for study.

This paper would not have been possible without the patience and guidance of Dr. Alan B. Shaw of the Department of Geology, University of Wyoming, to whom I am most sincerely indebted. I am grateful to Dr. H. D. Thomas of the Department of Geology, University of Wyoming, and the State Geologist of Wyoming, who read and criticized the manuscript; in addition, the Wyoming Geologic Survey supplied the film for the photographs included in this paper.

LITHOLOGY OF THE AMSDEN FORMATION

The Amsden formation of northwestern Wyoming consists of 150 to 350 feet of a somewhat variable succession of sandstones, red shales, limestones, dolomites, and cherts, with a basal member (the Darwin sandstone) of 50 to 150 feet of massive, generally tan, sandstones. The Darwin sandstone unconformably overlies the Mississippian Madison limestone, and the Amsden forma-

tion is overlain conformably by the Pennsylvanian Tensleep sandstone.

REVIEW OF THE LITERATURE

Because of the controversy over the age of the Amsden formation, it is first necessary to review all the literature in which Amsden faunas are mentioned. The history of the nomenclature and the present stratigraphic limits of the Amsden are shown in Figure 1. All generic assignments included in the following discussions are as they appeared in the original faunal lists, and are not necessarily in accord with modern taxonomy.

Darton (1906, pp. 33–34), while working in the central Bighorn Mountains west of Sheridan, Wyoming, collected a coral from the lower Amsden limestone which was identified by Girty as *Menophyllum excavatum*. Girty also identified ten other species collected by Darton from the upper cherty beds near the North Fork of Crazy Woman Creek in this same area: *Productus nebrascensis*, *Edmondia nebrascensis*, *Archaeocidaris* sp., *Murchisonia* aff. *M. lasallensis*, *Orthotetina* n. sp., *Aviculopecten occidentalis?*, *Pleurophorus* aff. *P. subcostatus*, *Euomphalus catilloides?*, *Pleurotomaria scitula?*, and *Bellerophon?* sp. Darton believed that this evidence indicated that the lower part of the formation is Mississippian in age and that the upper part is Pennsylvanian.

Blackwelder (1913, pp. 175–176) collected fossils from two zones near the middle of the Amsden along the crest of the Gros Ventre Mountains in northwestern Wyoming. These faunas were identified by Girty as follows: Upper (Brachiopod) Zone—*Echinocrinus* sp., crinoidal plates, *Batostomella* sp., *Rhombopora lepidodendroides?*, *Stenopora* sp., *Lingula umbonata?*, *L. carbonaria*, *Lingulodiscina* sp., *Derbyia robusta*, *Schizophoria* aff. *S. resupinoides*, *Chonetes geinitzianus*, *C. granulifer*, *Productus cora*, *P. semireticulatus*, *P. nebrascensis*, *Spirifer rockymontanus*, *Composita subtilita*, *Conocardium* sp., and a fish plate; Lower (Mollusk) Zone—large crinoidal stems, *Spirifer rockymontanus?*, *Squamularia perplexa?*, *Composita subtilita?*, *Myalina* sp., *Cypri-*

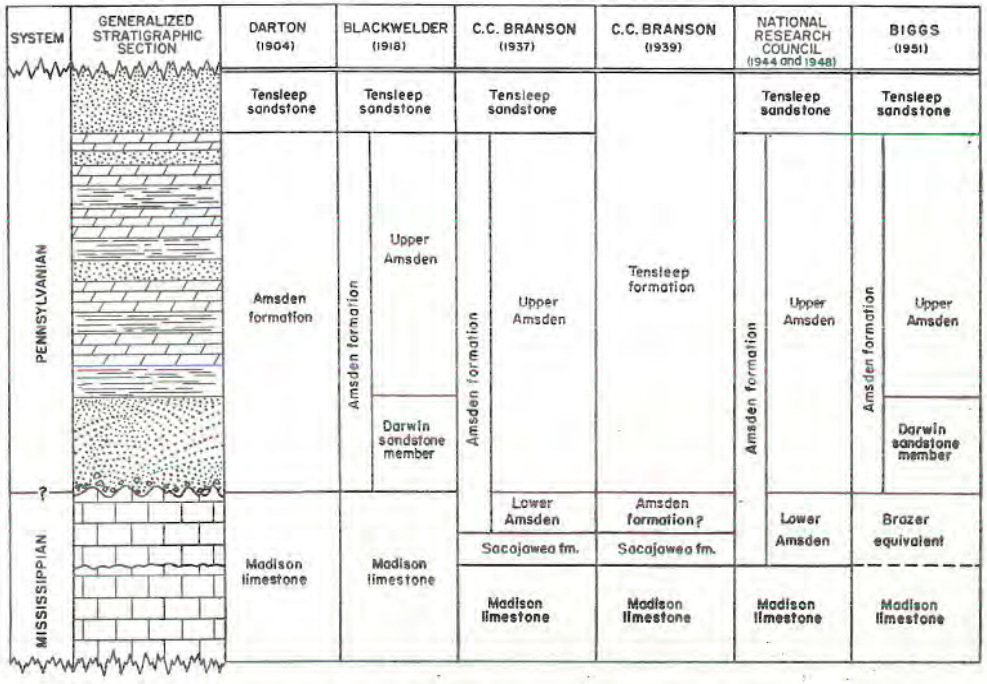

FIG. 1—History of the nomenclature of the Amsden and associated formations in northwestern Wyoming (modified after Biggs, 1951).

cardinia sp., *Pleurophorus* two sp., *Bucanopsis?* sp., *Euphemus?* sp., *Pleurotomaria* sp., *Naticopsis* sp., and *Euomphalus* sp.

Girty believed that the fauna of the upper horizon was definitely of Pennsylvanian age, but that the fauna of the lower horizon might be of Mississippian age. Of this Blackwelder (1913, p. 177) says, "Both faunules occur in a single formation of unified and distinctive character, separated from the known Mississippian rocks by a distinct unconformity. Therefore, unless there is strong evidence to the contrary, it seems probable that both faunules belong to the same period."

E. B. Branson and Greger (1918, p. 312) collected from what they believed to be the Amsden formation at Bull Lake Canyon and Cherry Creek in the Little Popo Agie region of the Wind River Mountains west of Lander, Wyoming. Biggs revisited these localities and demonstrated that their collection from Bull Lake Canyon was taken from the Mississippian Madison limestone, but that it is possible that part of their collection from Cherry Creek was taken from the lower Amsden. This cannot be established, however, since the beds are very poorly exposed and Biggs points out that the fossils could apparently be obtained only from slope wash. In view of this discovery, the fossils they obtained from Bull Lake Canyon cannot be used as a basis for dating the Amsden.

Because the Branson and Greger collections were the only ones described and figured, they became a standard reference for later geologists, and on this basis, the apparent Mississippian age of the Amsden was generally accepted by many Rocky Mountain geologists.

Lee (1927, p. 72) listed nine species identified by Girty, which were taken from the top limestone of the Amsden in the Wind River Range near Lander, Wyoming. Lee states that the Amsden of this area seems to correspond to beds in the Gros Ventre Range which Blackwelder (1913, pp. 175–176) found to contain many Pennsylvanian fossils. Lee's collection contained the following species: *Derbyia crassa?*, *Chonetes granulifer* var., *Productus cora*, *P. hermosanus*, *Pustula semipunctata*, *Marginifera splendens*, *Spirifer rockymontanus*, *Squamularia perplexa*, and *Composita subtilita*.

Morey (1935, pp. 475–482) described 17 species of ostracodes from the same localities in which Branson and Greger (1918) made their collections. All the specimens were collected from float which was estimated to have originated from somewhere near the middle of the Amsden formation. His collection included the ubiquitous *Paraparchites nicklesi* and 16 new species. Morey states that the age of this fauna is Mississippian, and probably Ste. Genevieve; but since his collection was taken from slope wash in Branson's and Greger's (1918) area, which was shown by Biggs to include the Mississippian Madison limestone, his conclusions cannot be regarded as bearing on the age of the Amsden formation.

C. C. Branson (1939, pp. 1201, 1213, 1217) reviewed and examined some of the faunas of earlier workers and added his own identifications to those already listed. Branson identified the following species from the fauna first listed by Darton (1906, pp. 33–34): *Derbyia* sp., *Orthotetina* sp., *Juresania nebrascensis*, *Edmondia* sp., *Deltopecten* sp., *Pleurophorus* sp., *Euomphalus* sp.; *Pleurotomaria* sp., *Bellerophon* sp., and *Ameura major*. Branson stated that the age of this fauna is certainly Pennsylvanian. He listed the following identifications from the fauna first reported by Lee (1927, p. 72): *Linoproductus prattenianus*, *Dictyoclostus hermosanus*, *Echinoconchus semipunctatus?*, *Chonetes* sp., *Composita subtilita*, and *Cleiothyridina?* sp. Branson believed that these species undoubtedly represent a Tensleep (Pennsylvanian) fauna and were probably not collected from the Amsden. Branson made the following identifications from the fauna first listed by Blackwelder (1913, pp. 175–176): Upper Fauna—*Lingula* sp., *Lingulodiscina* sp., *Derbyia crassa*, *Juresania nebrascensis?*, *Dictyoclostus hermosanus*, *Linoproductus prattenianus*, *Chonetes granulifer*, *Composita subtilita*, *Spirifer rockymontanus*, *Pleurophorus* sp., *Conocardium* sp., and crinoid, echinoid, and bryozoan remains; Lower Fauna—*Composita subtilita*, *Squamularia perplexa*, and *Spirifer rockymontanus*. Branson indicated he believed that these faunas are also characteristic of the Pennsylvanian Tensleep sandstone rather than the Amsden formation.

Love (1939, p. 28) collected fossils from a unit 66 feet above the base of the Amsden along the southern margin of the Absaroka Range, and identified the following forms: *Composita trinuclea, Spirifer pellaensis, Spiriferina?* sp., *Bellerophon?* sp., *Chonetes* sp., and four species of productids, a small horn coral, a loosely-coiled gastropod, and a large, high-spired gastropod. From a unit 200 feet above the base of the Amsden (10 feet below the top of the Amsden) Love collected several flat-spired gastropods and two silicified fusulinids identified as *Fusulinella* sp. The presence of these fusulinids would seem to demonstrate an Oklan age for at least the upper part of the Amsden.

MISSISSIPPIAN-PENNSYLVANIAN BOUNDARY

The Pennsylvanian Subcommittee of the National Research Council (Moore et al., 1944, p. 663) recognizes the Mississippian-Pennsylvanian boundary as follows: "The base of the Pennsylvanian is generally defined by (1) occurrence of an obviously significant structural discordance, (2) an important sedimentary hiatus, (3) a pronounced lithologic change, and (4) readily determined paleontologic evidence." The Mississippian Subcommittee reached the same conclusions regarding the upper boundary of the Mississippian, and added that "the magnitude, importance, and extent of this unconformity is one of the principal reasons for the recognition of the Mississippian and Pennsylvanian as independent systems by most American geologists." (J. M. Weller et al., 1948, p. 106.) All of these physical criteria normally characterizing the Mississippian-Pennsylvanian boundary were shown by Biggs to be present at the base of the Amsden formation.

Weller et al. (1948, p. 140) state that "Blackstone, Love, and Thomas recognize a widespread unconformity at the base of the Darwin sandstone, which they consider to be the lowest member of the Amsden, and they refer the entire formation . . . to the Pennsylvanian." Biggs concludes that "on the basis of regional relationships and stratigraphic position . . . the Amsden is entirely Pennsylvanian in age. The lowest part of the Amsden is probably Atokan or older, while the upper part is Desmoinesian or older."

AGE AND FAUNAL CONSIDERATIONS

No fossils have yet been collected from the Darwin sandstone member of the Amsden, and fossils are generally scarce throughout the formation. Those forms which have been reported in the literature have appeared mainly in faunal lists, and many of these were given only generic assignments.

There is no previously described fauna of known age which is comparable to the assemblage of fossils which has gradually been taken from the Amsden. In order to establish the age of the Amsden, it is necessary therefore, to examine the known ranges of all those forms which have been collected from beds above the Darwin sandstone. All of the Madison fossils, mistakenly assigned to the Amsden, are omitted from consideration, as well as those forms which were identified with hesitation. New species taken from the Amsden are also excluded from this tabulation.

The accompanying series of diagrams (Figs. 2–5) shows graphically the results of these range considerations. Those forms which were identified only to genus are separated in Figures 2–5 from those forms which were specifically identified. This is done of necessity because the ranges of the identified genera are in most cases greater than the ranges of the identified species.

Figure 2 shows the distribution by ranges of genera and species identified in previously published faunal lists. The majority of those forms identified specifically are known only from strata of Pennsylvanian age, and all of those forms which are exclusively Pennsylvanian are identified to species. The majority of forms having a range which includes both the Mississippian and Pennsylvanian are identified only to genus. No genus or species is exclusively Mississippian or older. Thus, it is apparent that none of the previously identified faunas have a range which conflicts with a Pennsylvanian age for the Amsden.

Figure 3 shows the distribution by ranges of the genera and species of the faunas described in this paper. The similarity in distribution of ranges with the previously described faunas (Fig. 2) is apparent, and in both instances the ratio between generic and specific identifications is nearly identi-

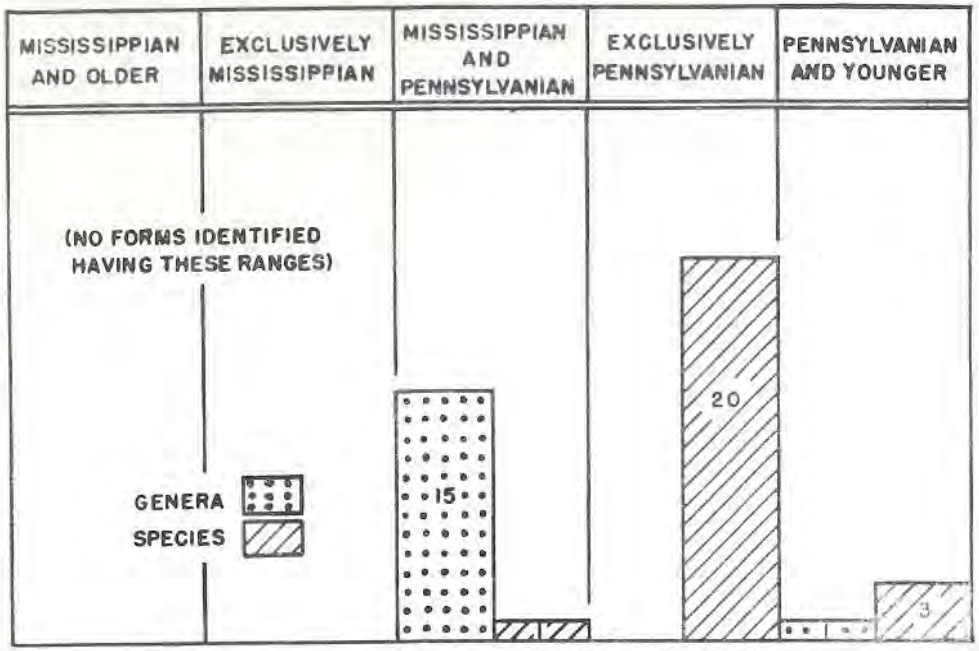

FIG. 2—Diagram showing distribution of Amsden fossils previously identified in published faunal lists.

cal. Figure 4 combines Figures 2 and 3 and presents the distribution of all forms identified from the Amsden, omitting all duplications.

Figure 5 shows the distribution of the total number of individual specimens in the present collection, according to the ranges of the identified genera or species. This shows that the large majority of the specimens are of species known only from rocks of Pennsylvanian age and younger.

Several conclusions are apparent from this series of figures. In each instance the greatest number of species are Pennsylvanian in age. There are no identifications which would conflict with a Pennsylvanian age for the Amsden, and there is none which supports an exclusively Mississippian age. If all the forms now generically identified, having a range including both the Mississippian and Pennsylvanian, were found to have been taken from the lower part of the Amsden it might suggest a late Mississippian age for this part of the formation, but an examination of all the faunal lists and the present collection shows that there are as many exclusively Pennsylvanian species known from just above the Darwin sandstone as there are genera and species which have a range including both the Mississippian and Pennsylvanian.

Further collection and study of Amsden fossils might make it possible to determine the Pennsylvanian series represented by Amsden deposits, but the present collection is too inadequate to form such conclusions. However, the faunal evidence pointed out in this paper makes it necessary to abandon the Mississippian age previously accepted for the Amsden, and confirms its Pennsylvanian age, in accord with the physical and stratigraphic relationships most recently discussed by Biggs.

LOCALITIES AND FAUNAS

The faunal localities are identified here according to the system used in the paleontologic collections at the University of Wyoming. The first two digits of the numerator show the township; the second two or three digits indicate the range. The denominator indicates the section and is followed by a letter to discriminate collections taken from the same section. The locations of the col-

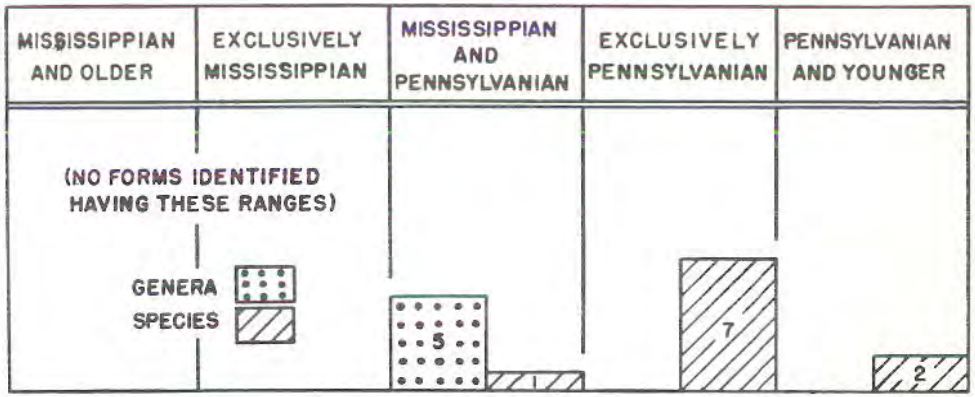

FIG. 3—Distribution by ranges of the fossils examined in the present faunas.

lections are shown on the map in Figure 6.

$\frac{2997}{6A}$···NW¼, Sec. 6, T. 29 N., R. 97 W., Beaver Creek, Fremont Co., Wyoming: 45 feet above the contact with the Madison limestone, in a pisolitic hematite bed. The collection contained three specimens, one each of *Spirifer opimus*, *Composita* sp., and an unidentifiable tetracoral.

$\frac{3099}{9A}$···Center, Sec. 9, T. 30 N., R. 99 W., South Pass, Fremont Co., Wyoming: 55 feet above the contact with the Madison limestone, in a buff to tan, fine-grained shale. The collection contained 51 specimens of the following species: *Linoproductus prattenianus* (3), *Cancrinella boonensis* (2), *Marginifera muricatina* (23), *Spirifer opimus* (16), *Cleiothyridina?* sp. (3), and *Allorisma terminale?* (4).

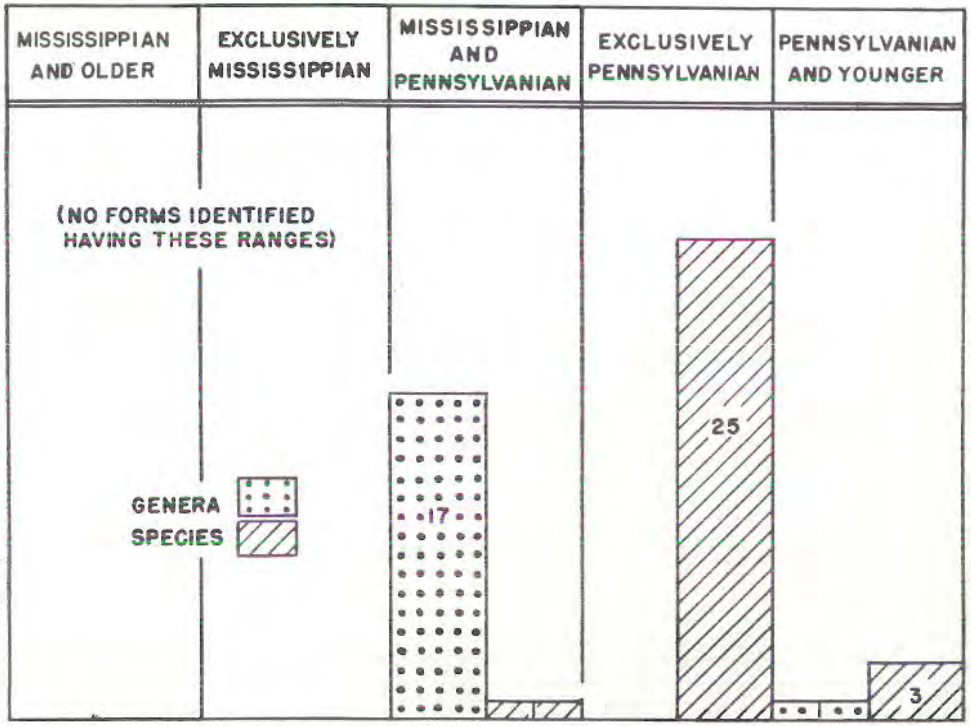

FIG. 4—Diagram showing distribution by ranges of all the forms identified to genus or to species which were taken from the Amsden formation in Wyoming.

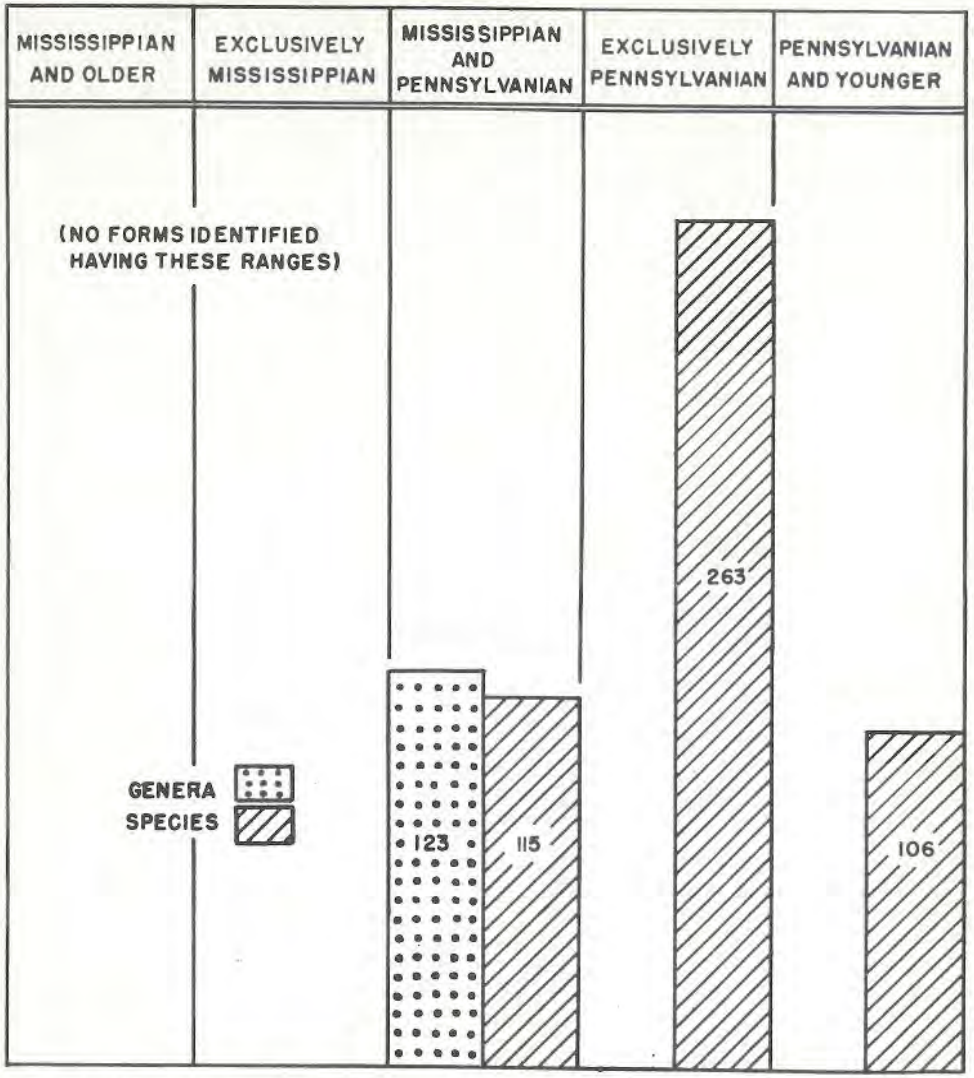

FIG. 5—Distribution by ranges of the number of identifiable specimens in the present faunas.

$\frac{3099}{9B}$···Center, Sec. 9, T. 30 N., R. 99 W., South Pass, Fremont Co., Wyoming: 50 feet above the contact with the Madison limestone, in a medium-grained, ferruginous sandstone. The collection contained 15 specimens of the following species: *Wellerella osagensis* (2), *Lingulodiscina* sp. (4), *Dictyoclostus portlockianus* (1), and *Spirifer opimus* (8).

$\frac{3199}{19A}$···NW¼, Sec. 19, T. 31 N., R. 99 W., Cherry Creek, Fremont Co., Wyoming: 60 to 90 feet above the contact with the Madison limestone, in float. The collection contained 483 silicified specimens of the following species: *Marginifera* sp. (1), *Spirifer opimus* (95), *Composita subtilita* var. *subtilita* (97), *C. subtilita* var. *trinuclea* (109), *C. subtilita* var. *ovata* (48), *Composita* sp. (93), *Wellerella osagensis* (31), *Eumetria sulcata* (7), *Marginifera* sp. (1), and an unidentified goniatite.

$\frac{43106}{19A}$···SW¼, Sec. 19, T. 43 N., R. 106 W., Horse Creek, Fremont Co., Wyoming: 90 feet above the contact with the Madison limestone, in a yellow to red shale below a resistant purple limestone unit. The collection contained 16 specimens of *Composita subtilita* var. *ovata*, and one of *Cleiothyridina* sp.

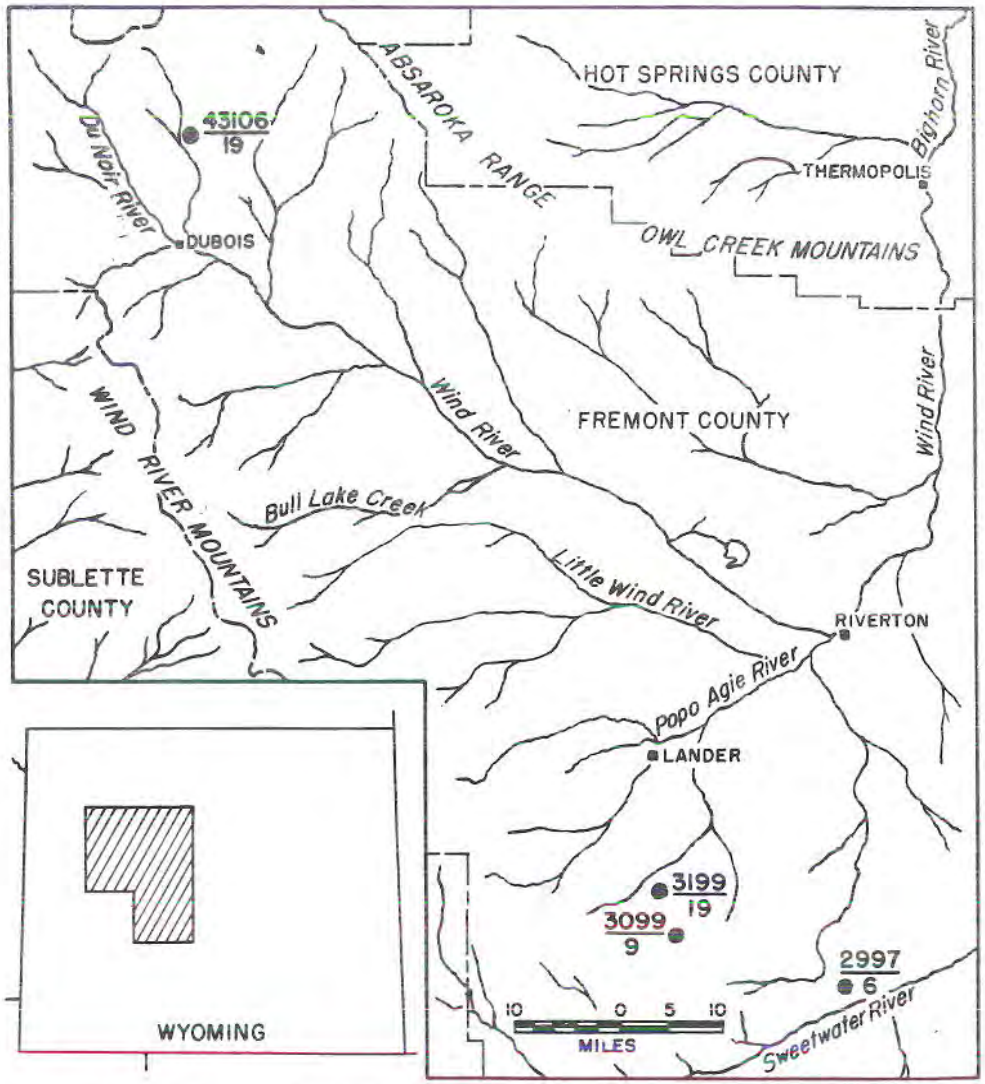

FIG. 6—Index map showing locations of faunal collections examined in this paper.

$\frac{43106}{19B}$···SW¼, Sec. 19, T. 43 N., R. 106 W., Horse Creek, Fremont Co., Wyoming: 94 feet above the contact with the Madison limestone, in a resistant purple limestone unit. The collection contained 59 specimens, 48 of which were silicified. The following species were identified: *Orthotetes?* sp. (1), *Dictyoclostus portlockianus* (8), *Linoproductus prattenianus* (2), *Spirifer* sp. (5), *Composita subtilita* var. *subtilita* (5), *C. subtilita* var. *trinuclea* (6), *C. subtilita* var. *ovata* (3), *Composita* sp. (10), *Cleiothyridina* sp. (11), *Wellerella osagensis* (4), and *Allorisma terminale* (4).

SYSTEMATIC PALEONTOLOGY

Phylum BRACHIOPODA

Genus LINGULODISCINA Whitfield, 1890

LINGULODISCINA sp.

Plate 1, figures 13, 14

Four dorsal valves of this genus were obtained from the collection. They are most similar to shells of *Lingulodiscina pleurites* (Meek), 1875, but are more lenticular in their mature outline and are considerably

less rounded on the posterior margin. The specimens represent an ontogenetic sequence: the smallest, with a diameter of 5.0 mm., is nearly circular in outline with a nearly centrally situated conical apex. The most mature specimen measures 23 mm. from the anterior to the posterior margin, and 22 mm. at the greatest width, which is 7 mm. from the anterior margin; the valve is highly depressed-conical with its apex projecting posteriorly, parallel to the plane of the valves and overreaching the posterior line of commissure. The valves are concentrically ornamented with elliptical growth lines, which are farthest apart along the anterior slope of the valve and closest along the posterior slope.

These specimens may represent an undescribed species, but insufficient material is at hand to justify erecting a new name.

Locality.— $\frac{3099}{9B}$.

Figured specimens.—U. Wyo. IT-184, IT-185.

Other specimens.—U. Wyo. IT-186.

Genus ORTHOTETES Fischer de Waldheim, 1837

ORTHOTETES? sp.

Plate 1, figure 1

A single, large, incomplete and poorly preserved specimen is here referred to *Orthotetes* with some doubt. Neither the outline nor the shape of the valve has been preserved. Only part of the surface ornamentation is apparent, and it is on this basis alone that the specimen is referred to this genus. The ornamentation of the Orthotetinae is generally not of generic importance, but the ribbing of this specimen does not resemble that of any of the other large genera as much as it does *Orthotetes*.

The valve is marked by prominent radial costae, separated by single, smaller ribs. Concentric ornamentation is present as indefinite, irregular growth lines. The valve is at least 30 mm. long at the median line, and 30 mm. at the greatest width.

Locality.— $\frac{43106}{19B}$.

Specimen.—U. Wyo. IT-187.

Genus DICTYOCLOSTUS Muir-Wood, 1930

DICTYOCLOSTUS PORTLOCKIANUS (Norwood and Pratten)

Plate 1, figures 29, 30

Productus portlockianus NORWOOD & PRATTEN, 1854, Acad. Nat. Sci. Philadelphia Jour., vol. 3, p. 15, pl. 1, figs. 9a–c.

Productus inflatus var. *coloradoensis* GIRTY, 1915, U. S. Geol. Survey Bull. 544, pp. 64–65, pl. 8, figs. 1–2.

Dictyoclostus portlockianus DUNBAR & CONDRA, 1932, Nebraska Geol. Survey Bull. 5, 2nd ser., pp. 215–217, pl. 33, figs. 1–3.

The shells are medium sized, with the length approximately equal to the width. The ventral valve is strongly convex and geniculate. The ventral beak is incurved over the hinge line, and the cardinal extremities are moderately auriculate. A ventral sulcus is irregularly developed, and where present it is shallow, narrow, and originates in the middle of the umbo. Spines are irregularly scattered along the costae of the ventral valve. The dorsal valve is gently concave over the visceral cavity and sharply geniculate anteriorly. The umbo is strongly semireticulate.

Although many specimens are fragmentary and exfoliated, they show as a group the typical features of the species. Shells most similar to *Dictyoclostus portlockianus* (Norwood and Pratten) are those of *D. inflatus* (McChesney), 1860 and *D. burlingtonensis* (Hall), 1858 which have a sharp ventral sulcus originating close to the beak, a strongly inflated umbo, and an arc of curvature of short radius from the beak to the tip of the trail.

Localities.— $\frac{3099}{9B}$, $\frac{43106}{19B}$.

Figured specimens.—U. Wyo. IT-188, IT-189.

Other specimens.—U. Wyo. IT-190, IT-191.

Genus LINOPRODUCTUS Chao, 1927

LINOPRODUCTUS PRATTENIANUS (Norwood)

Plate 1, figures 36, 37

Productus prattenianus NORWOOD in Norwood & Pratten, 1854, Acad. Nat. Sci. Philadelphia Jour., vol. 3, p. 17, pl. 1, figs. 10a–d.

Productus prattenianus MEEK, 1872, U. S. Geol. Survey Nebraska, Final Rept.; p. 163, pl. 2, fig. 5; pl. 5, fig. 13; pl. 8, fig. 10.

Linoproductus prattenianus DUNBAR & CONDRA, 1932, Nebraska Geol. Survey Bull. 5, 2nd ser., pp. 241–244, pl. 26, figs. 1–5, 9.

The shell is medium sized, with the hinge line equal to the greatest width of the shell. The ventral valve is subhemispherical and evenly convex from the beak to the trail. The ventral beak is small, pointed, and closely incurved over the hinge line. The surface of the ventral valve is finely costate, the costae increasing by implantation, and numbering from two to three costae per millimeter on the trail. The cardinal extremities are moderately wrinkled. Spines are small and the spine bases, scattered across the surface of the ventral valve, are inconspicuous. The dorsal valve is moderately concave and moderately geniculate.

All of the specimens in the collection are fragmentary or distorted, but as a group they clearly show the characters typical of the species. *Linoproductus prattenianus* is distinct from *L. ovatus* (Hall), 1858, because it contains shells having subequal dimensions, moderate concavity and geniculation of the dorsal valve, and distinct cardinal extremities arising sharply from the convex umbo.

Localities.— $\frac{3099}{9A}$, $\frac{43106}{19B}$.

Figured specimens.—U. Wyo. IT-192, IT-193.

Other specimens.—U. Wyo. IT-194.

Genus CANCRINELLA Fredericks, 1928

CANCRINELLA BOONENSIS (Swallow)

Plate 1, figure 35

Productus boonensis SWALLOW, 1858, Acad. Sci. St. Louis Trans., vol. 1, p. 217.

Productus pertenuis MEEK, 1872 (part), U. S. Geol. Survey Nebraska, Final Rept., p. 164, pl. 1, figs. 14a–c (not pl. 8, figs, 9a–d).

Cancrinella boonensis DUNBAR & CONDRA, 1932, Nebraska Geol. Survey Bull. 5, 2nd ser., pp. 258–260, pl. 32, figs. 1–5.

The shells are very small, the visceral area nearly circular, having a diameter of about 5 mm. The dorsal valve is flat to slightly concave and is not sharply geniculate. The ventral valve is only moderately convex and slopes gently toward the margins of the valve. The cardinal extremities are concentrically wrinkled, with the broad rugae extending over the umbonal area, but becoming indistinct toward the trail. This concentric ornamentation almost completely obscures the radial costae on the umbo. The costae are broad and flat, and are especially prominent near the trail. The spines and spine bases are most abundant on the lateral margins and cardinal extremities of the ventral valve.

The collection contains a single fragmentary ventral valve and an impression of a ventral valve. The ornamentation is clearly shown on this impression and is typical of the species, but the outline of the valve is not well preserved on either specimen. Both are about 5 mm. in diameter across the nearly circular visceral region.

Locality.— $\frac{3099}{9A}$.

Figured specimens.—U. Wyo. IT-195.

Other specimens.—U. Wyo. IT-196.

Genus MARGINIFERA Waagen, 1884

MARGINIFERA MURICATINA

Dunbar and Condra

Plate 1, figures 26–28

Productus muricatus NORWOOD & PRATTEN, 1854, not Phillips, 1836, Acad. Nat. Sci. Philadelphia Jour., vol. 3, 2nd ser., pp. 14–15, pl. 1, figs. 8a–e.

Marginifera muricata GIRTY, 1915, not Phillips, 1836, U. S. Geol. Survey Bull. 544, pp. 78–79, pl. 10, figs. 3–4a.

Marginifera muricatina DUNBAR & CONDRA, 1932, Nebraska Geol. Survey Bull. 5, 2nd ser., pp. 222–224, pl. 35, figs. 1–10.

Marginifera? muricatina COOPER in Shimer & Shrock, 1944, Index Fossils of North America, p. 351, pl. 137, figs. 24–26, John Wiley, New York.

The shells are small; a typical specimen is 1.8 cm. wide and 1.5 cm. long. The ventral valve is moderately and evenly convex from the beak to the trail. The hinge line is equal to or slightly less than the greatest width of the shell. The cardinal extremities are broadly angular or rounded. The dorsal valve is slightly to deeply concave. The trail is relatively short. The ventral sulcus is obsolete or entirely lacking, and the ventral valve is ornamented with coarse, irregular costae bearing numerous, scattered spine bases. Concentric rugae are more or less prominent at the beak and cardinal extremities but are absent on the trail. The

marginal flange of the interior of the dorsal valve is obsolete medially.

This species is recognizable by its coarse ribbing, incomplete marginal flange, and by the obsolescence or absence of the ventral sulcus. The collection contained 23 fragmentary specimens of this species.

Locality.— $\frac{3099}{9A}$.

Figured specimens.—U. Wyo. IT-197, IT-198.

Other specimens.—U. Wyo. IT-199.

MARGINIFERA sp.

The collection contained a single specimen which is silicified and fragmentary and only a part of the umbo, hinge line, and beak are present. It is not *M. muricatina*, as shown by the presence of a ventral sulcus on the umbo and a lack of reticulation at the beak. The shell was probably somewhat larger than the specimens of *M. muricatina* in the collection, and the ribbing is more irregular and discontinuous.

Locality.— $\frac{3199}{19A}$.

Specimen.—U. Wyo. IT-200.

Genus SPIRIFER Sowerby, 1818

SPIRIFER OPIMUS Hall

Plate 1, figures 16–22

Spirifer opimus HALL in Hall & Whitney, 1858, Report on the geological survey of Iowa (1855–1857), vol. 1, pp. 711–712, pl. 27, figs. 1a–b.

Spirifer opimus DUNBAR & CONDRA, 1932, Nebraska Geol. Survey Bull. 5, 2nd ser., pp. 320–322, pl. 43, figs. 10a–11b.

The shell is medium sized, moderately alate, and approximately as wide as long. The interareas are prominent, the dorsal being about one-fourth the height of the ventral, and the ventral interarea is marked by prominent vertical striations. There are initially three costae on the dorsal fold, but the central rib splits in the umbonal area to form two closely associated ribs which remain more prominent than the bordering costae. The lateral slopes show 8–10 ribs, most commonly eight. The ventral sulcus has three costae throughout most of its length, and there are normally eight costae on each lateral slope. The fold and sulcus are very pronounced, giving the shell a robust lateral profile.

Shells of this species can be distinguished from other spiriferaceans by their characteristic 8–10 lateral costae, subovate outline, prominent fold and sulcus, and the splitting of the central plication in the umbonal area.

Spirifer opimus is most similar to *S. leidyi* Norwood and Pratten, 1855, a Mississippian species, but can be recognized by the splitting of the lateral costae of the fold. Apparently these two species and *S. rockymontanus* Marcou, 1858, are very closely related.

The collection contained 120 specimens which could be referred to *S. opimus*, most of which are silicified and distorted, but together they show all of the features typical of the species.

Localities.— $\frac{2997}{6A}$, $\frac{3099}{9A}$, $\frac{3099}{9B}$, $\frac{3199}{19A}$.

Figured specimens.—U. Wyo. IT-201, IT-205.

Other specimens.—U. Wyo. IT-206, IT-209.

SPIRIFER sp.

Three fragmentary ventral valves and two fragmentary dorsals may represent an undescribed species but the collection is too incomplete to verify this possibility. They do not show the typical bifurcation of the lateral costae on the fold of *Spirifer opimus*.

The shells are alate, of small size, and moderately biconvex. The surfaces of the valves are marked by twelve angular costae, with two in the ventral sulcus and two on the high, narrow dorsal fold. Both valves are most convex in the umbonal region and are nearly plane anteriorly.

Locality.— $\frac{43106}{19B}$.

Specimens.—U. Wyo. IT-210.

Genus COMPOSITA Brown, 1845

Genotype.—*Spirifer ambiguus* Sowerby, 1821.

The shell is biconvex, subpentagonal or subovate in outline, with a uniplicate to parasulcate line of commissure. The hinge line is short and interareas are lacking.

The ventral beak is incurved over the obtuse dorsal beak. The delthyrium is nearly closed dorsally in adult forms, leaving an oval foramen at the tip of the beak. A dorsal fold and ventral sulcus are most prominent on the anterior part of the shell. The shell is smooth, except for the irregularly spaced concentric growth lines. The shell matter is impunctate and fibrous. The hinge teeth are supported by flange-like dental lamellae that are usually fused to the sides of the valve. Crura arise from the anterior margin of the hinge plate, and bear inflated, laterally directed spiralia.

Shells of this genus can be recognized among other rostrospiraceans by the absence of a dorsal median septum, and a hinge plate which is sub-quadrate in shape.

Separation of species.—The genus *Composita* includes common, long-range forms which are of little stratigraphic significance. The species are gradational and difficult to separate, as the morphology of the shell is simple and shows little distinctive variation. The discrimination of these species has been a continual problem to geologists wherever specimens of this genus have been encountered. This problem was discussed by Weller (1914, pp. 485–486) and by Dunbar and Condra (1932, pp. 363–369).

Three general shapes were recognized in the present collections which are comparable to the general forms commonly assigned to the species *Composita subtilita* (Hall), 1853, *C. trinuclea* (Hall), 1858, and *C. ovata* Mather, 1915. The features used to distinguish these groups are the general outline of the shell, which varies from ovate to sub-pentagonal, and the nature of the line of commissure, which progresses from uniplicate to strongly parasulcate. These features are discussed further under the diagnosis of the varieties, but it should be pointed out that although they are very prominent for typical forms, there is a gradation from the typical specimen of one group to the typical specimen of another group and many transitional specimens are difficult to assign to one particular form.

Inasmuch as it is impossible to separate clear-cut species within this genus, the most useful procedure seems to be to recognize varieties of a single species. The species *Composita trinuclea* and *C. ovata* will here be considered as varieties of *C. subtilita*. Typical specimens of these varieties are contrasted in figures 2–10 of Plate 1, and their most distinguishing characters are given in Table 1.

TABLE 1—GENERAL FEATURES OF THE VARIETIES OF *COMPOSITA SUBTILITA* (Hall), 1853

Variety	Anterior Line of Commissure	Outline of Shell
ovata	Uniplicate	Ovate
subtilita	Uniplicate	Sub-pentagonal
trinuclea	Parasulcate	Sub-pentagonal

COMPOSITA SUBTILITA var. SUBTILITA (Hall)
Plate 1, figures 5–7, 12

Terebratula subtilita HALL in Stansbury, 1853, Exploration and Survey of the Valley of the Great Salt Lake of Utah: House Exec. Document, no. 3, p. 409, pl. 4, figs. 1a–b, 2a–c.

Composita subtilita DUNBAR & CONDRA, 1932, Nebraska Geol. Survey Bull. 5, 2nd ser., pp. 363–366, pl. 43, figs. 7–13.

Composita subtilita COOPER in Shimer & Shrock, 1944, Index Fossils of North America, p. 335, pl. 128, figs. 9–12, John Wiley, New York.

The shells are sub-pentagonal in outline and moderately gibbous. The ventral beak is highly incurved but not so much as to conceal the delthyrium. There is a single dorsal fold and ventral sulcus which are most prominent at the anterior of the shell. The anterior line of commissure is strongly uniplicate to gently parasulcate. Both valves may be marked by more or less prominent lamellose growth lines, especially along the anterior margin (Plate 1, figure 12).

The collections contained 102 silicified specimens of this variety.

Localities.— $\frac{3199}{19A}$, $\frac{43106}{19B}$.

Figured specimens.—U. Wyo. IT-211, IT-212.

Other specimens.—U. Wyo. IT-213, IT-214.

COMPOSITA SUBTILITA var. OVATA Mather
Plate 1, figures 2–4, 11

Composita ovata MATHER, Denison Univ. Sci. Lab. Bull., vol. 18, p. 202, pl. 14, figs. 6–6a.

Composita ovata DUNBAR & CONDRA, 1932, Nebraska Geol. Survey Bull. 5, 2d ser., pp. 371–374, pl. 43, figs. 14–16.

The shell is medium sized, biconvex but not sharply arched, and flattened rather than gibbous. The shell is characteristically ovate in outline. The ventral beak is highly incurved, almost concealing the delthyrium. There is a single, slight dorsal fold and ventral sulcus. The fold may be obsolete or absent. The sulcus is narrow and begins near the posterior edge of the shell, extending to the anterior margin of the ventral valve with only a slight increase in prominence. The line of commissure is gently uniplicate. The shell is rarely marked by prominent growth lines.

The collections contained 67 specimens of this variety, most of which are silicified.

Localities.— $\frac{3199}{19A}$, $\frac{43106}{19A}$, $\frac{43106}{19B}$.

Figured specimens.—U. Wyo. IT-215-IT-217.

Other specimens.—U. Wyo. IT-218-IT-220.

COMPOSITA SUBTILITA var. TRINUCLEA (Hall)

Plate 1, figures 8–10

Terebratula trinuclea HALL, 1858, Albany Inst. Trans., vol. 14, p. 7.
Composita trinuclea WELLER, 1914, Illinois Geol. Survey Mon. 1, pp. 486–488, pl. 81, figs. 16–45.
Composita trilobata DUNBAR & CONDRA, 1932, Nebraska Geol. Survey Bull. 5, 2d ser., pp. 372–373, pl. 43, figs. 25–31.
Composita trinuclea COOPER in Shimer & Shrock, 1944, Index Fossils of North America, p. 335, pl. 128, figs. 16–20, John Wiley, New York.

Shells are medium sized, sub-pentagonal in outline, biconvex, and gibbous. The ventral beak is highly incurved, but not so much as to conceal the delthyrium. The anterior line of commissure is prominently parasulcate. The median ventral sulcus is apparent even on the posterior half of the valve, but the lateral sulci are less prominent. Both valves are marked in well-preserved specimens by lamellose growth lines, especially along the margins of the shell.

Dunbar and Condra (1932, pp. 372–373) described a group of shells from the Pennsylvanian of the Mississippi Valley as *Composita trilobata* which they considered to be specifically distinct from *C. trinuclea* (Hall) because of its larger size, although it is similar in every other respect to Hall's species. Size alone is not considered here to be of specific importance. Since Hall's species has priority, *Composita trilobata* Dunbar and Condra is here considered to be synonymous with *C. trinuclea*.

The collection contained 115 silicified specimens of this species.

Localities.— $\frac{3199}{19A}$, $\frac{43106}{19B}$.

Figured specimens.—U. Wyo. IT-221, IT-222.

Other specimens.—U. Wyo. IT-223, IT-224.

COMPOSITA sp.

The collections contained 104 specimens which were too poorly preserved to allow other than generic designation.

Localities.— $\frac{2997}{6A}$, $\frac{3199}{19A}$, $\frac{43106}{19B}$.

Specimens.—U. Wyo. IT-225-IT-227.

Genus CLEIOTHYRIDINA Buckman, 1906

CLEIOTHYRIDINA sp.

Plate 1, figure 15

The collections contain 15 specimens of this genus, all of which are too exfoliated or deformed to allow specific designation. The genus was identified by serial sections which showed the dorsal median septum and the posterior perforation of the dorsal hinge plate.

Localities.— $\frac{3099}{9A}$, $\frac{43106}{19A}$, $\frac{43106}{19B}$.

Figured specimens.—U. Wyo. IT-228.

Other specimens.—U. Wyo. IT-229, IT-230.

Genus EUMETRIA Hall, 1863

Genotype.—Retzia verneuilana Hall, 1856.

The shell is small or medium sized, subovate in outline, and moderately biconvex. The surface of both valves is marked by even, radial costae. The shell is commonly not sulcate, but there is a low ventral sulcus in advanced forms. There is no dorsal fold. The cardinal area contains very small interareas with the lateral margins abruptly

upturned. The shell matter is finely punctate.

Dental lamellae are lacking. The anterior and posterior parts of the dorsal hinge plate extend sharply in opposite directions. There are eight volutions in the spiralia. Muscle scars are unknown.

This is the only punctate spiriferoid with a subovate outline.

EUMETRIA SULCATA Burk, n. sp.
Plate 1, figures 31–34

The shell is medium sized, subovate in outline, and gently biconvex with the greatest convexity of both valves in the umbonal region. The greatest width is near the anterior of the shell. The surface of both valves is nearly always marked by 38 even, rounded costae. The ventral valve bears a broad, shallow sulcus at its anterior margin. The ventral beak is incurved, but not beyond the ventral interarea. The interareas are very small, and the delthyrium is almost entirely closed dorsally, but the pedicle aperture is large and round. The shell matter is very finely punctate.

This species is most similar to *Eumetria costata* (Hall), 1858, except for the presence of the ventral sulcus. No species of this genus have before been noted from Pennsylvanian rocks. *Eumetria sulcata*, therefore, represents a stratigraphically useful as well as easily recognizable species.

Locality.— $\frac{3199}{19A}$.

Holotype.—U. Wyo. IT-231.
Paratypes.—U. Wyo. IT-232.

Genus WELLERELLA Dunbar and Condra, 1932
WELLERELLA OSAGENSIS (Swallow)
Plate 1, figures 23–25

Rhynchonella (Camarophoria) osagensis SWALLOW, 1858, Acad. Sci. St. Louis Trans., vol. 1, p. 219, pl. 37, figs. 1–4.
Pugnax osagensis GIRTY, 1908, U. S. Geol. Survey Prof. Paper 58, pp. 317–318, pl. 24, figs. 16–16b.
Pugnoides osagensis GIRTY in Butler et al., 1920, U. S. Geol. Survey Prof. Paper 111, pl. 54, figs. 17–17a.
Wellerella osagensis DUNBAR & CONDRA, 1932, Nebraska Geol. Survey Bull. 5, 2nd ser., pp. 288–289, pl. 37, figs. 1–4.

The shell is small, subglobular, typically rhynchonelloid in shape, and subtriangular to subpentagonal in outline, with the greatest width near the anterior margin of the shell. The dorsal fold and ventral sulcus are very prominent, especially at the anterior margin of the shell. The line of commissure is uniplicate and crenulate. The fold and sulcus normally contain two to four costae, with from 6–12 costae on each lateral slope. Ventrally curved crura extend from the anterior margin of an undivided, triangular dorsal hinge plate, which is supported by a short, simple median septum.

In erecting this species, Swallow (1858, pp. 219–220) states that "this species is very variable; some gibbous, others depressed; in some the length is greater than the breadth, while the reverse is true in others. The sinus varies in width and depth, and is marked with from two to six plications; all of the plications are usually more strongly marked in a gibbous specimen." It is in this broad sense that Swallow's species is accepted in this paper.

Localities.— $\frac{3099}{9B}$, $\frac{3199}{19A}$, $\frac{43106}{19B}$.

Figured specimen.—U. Wyo. IT-233.
Other specimens.—U. Wyo. IT-234-IT-236.

Phylum MOLLUSCA
Genus ALLORISMA King, 1844
ALLORISMA TERMINALE Hall
Plate 1, figures 38–40

Allorisma terminalis HALL in Stansbury, 1853, Exploration and Survey of the Valley of the Great Salt Lake of Utah. House Exec. Document 3, p. 413, pl. 2, figs. 4a–b.

The shell is medium sized, elongate and ovate, and generally highly inflated in the umbonal region of both valves. The posterior extremities are subangular. The surface of both valves is marked by wide concentric ridges which diverge from the beak and are most prominent near the center of the valves. There are also very fine concentric striae accompanying these larger ridges.

Four poorly preserved internal impressions of *Allorisma terminale* were collected at Locality $\frac{43106}{19B}$. In addition, the collection from Locality $\frac{3099}{9A}$ contains four speci-

mens which are possibly referable to this species. All are fragmentary and distorted, and are much smaller than is typical of the species, the largest being only 15 mm. from the posterior to the anterior margins. Otherwise they are all very similar to *A. terminale*.

Localities.— $\frac{3099}{9A}$, $\frac{43106}{19B}$.

Figured specimens.—U. Wyo. IT-237-IT-239.

Other specimens.—U. Wyo. IT-240, IT-241.

Genus NATICOPSIS M'Coy, 1842

NATICOPSIS sp.

A single specimen of this genus is present in the collection from Locality $\frac{3099}{19A}$. It is fragmentary and preserves only the apex and first three whorls of a naticiform shell of indeterminable size. Although the shell is exfoliated, there are indications of vertical striations.

Specimen.—U. Wyo. IT-242.

Goniatite

The collection from Locality $\frac{3199}{19A}$ contains a single, crushed, immature goniatite. The specimen was examined for Biggs by Dr. Walter Youngquist who did not give it a taxonomic designation. He said, however, that it suggests a late Mississippian form but that it is too immature to be diagnostic.

Specimen.—U. Wyo. IT-243.

Tetracoral

A single, badly weathered, distorted, fragmentary tetracoral was taken from Locality $\frac{2997}{6A}$.

Specimen.—U. Wyo. IT-244.

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FIG. *1—Orthotetes?* sp. Unique specimen from Loc. $\frac{43106}{19B}$. ×1. U. Wyo. IT-187. (p. 9)

2–4, 11—Composita subtilita (Hall) var. *ovata* Mather. *2, 4.* Dorsal and lateral views showing shape and line of commissure. Loc. $\frac{3199}{19A}$. ×1. U. Wyo. IT-215. *3.* Anterior view showing line of commissure. Loc. $\frac{3199}{19A}$. ×1. U. Wyo. IT-216. *11.* Dorsal view showing shape of larger specimen. Loc. $\frac{43106}{19B}$. U. Wyo. IT-217. (p. 12)

5–7, 12—Composita subtilita (Hall) var. *subtilita. 5.* Dorsal view showing general shape. Loc. $\frac{3199}{19A}$. ×1. U. Wyo. IT-211. *6, 7.* Anterior and lateral views showing shape, line of commissure, and lamellose growth lines. Loc. $\frac{3199}{19A}$. ×1. U. Wyo. IT-212. *12.* Same specimen. ×2. U. Wyo. IT-212. (p. 12)

8–10—Composita subtilita (Hall) var. *trinuclea* (Hall). *8.* Dorsal view showing shape. Loc. $\frac{3199}{19A}$. ×1. U. Wyo. IT-221. *9, 10.* Anterior and lateral views showing shape and line of commissure. Loc. $\frac{3199}{19A}$. ×1. U. Wyo. IT-222. (p. 13)

13, 14—Lingulodiscina sp. *13.* Dorsal view of immature specimen. Loc. $\frac{3099}{9B}$. ×2. U. Wyo. IT-184. *14.* Dorsal view of mature specimen. Loc. $\frac{3099}{9B}$. ×1. U. Wyo. IT-185. (p. 8)

15—Cleiothyridina sp. Dorsal view of exfoliated specimen showing shape and median septum. Loc. $\frac{43106}{19A}$. ×1. U. Wyo. IT-228. (p. 13)

16–22—Spirifer opimus Hall. *16.* Dorsal view showing arrangement of costae. Loc. $\frac{3199}{19A}$. ×1. U. Wyo. IT-202. *17, 18.* Ventral and dorsal views showing shape and arrangement of costae. Loc. $\frac{3199}{19A}$. ×1. U. Wyo. IT-294. *19.* Posterior view of steinkern showing dental lamellae and striated interareas. Loc. $\frac{3099}{LA}$. ×2. U. Wyo. IT-201. *20.* Postero-ventral, showing sulcus and costae on ventral beak. Loc. $\frac{3199}{19A}$. ×1. U. Wyo. IT-203. *21, 22.* Anterior and lateral views showing shape and line of commissure. Loc. $\frac{3199}{19A}$. ×1. U. Wyo. IT-205. (p. 11)

23–25—Wellerella osagensis (Swallow). Dorsal, anterior, and lateral views showing shape and prominent fold and sulcus. Loc. $\frac{3199}{19A}$. ×2. U. Wyo. IT-233. (p. 14)

26–28—Marginifera muricatina Dunbar & Condra. *26.* Posterior view of trail showing coarse costae and spine bases. Loc. $\frac{3099}{9A}$. ×1. U. Wyo. IT-197. *27, 28.* Posterior and dorsal views showing shape and ornamentation. Loc. $\frac{3099}{9A}$. ×1. U. Wyo. IT-198. (p. 10)

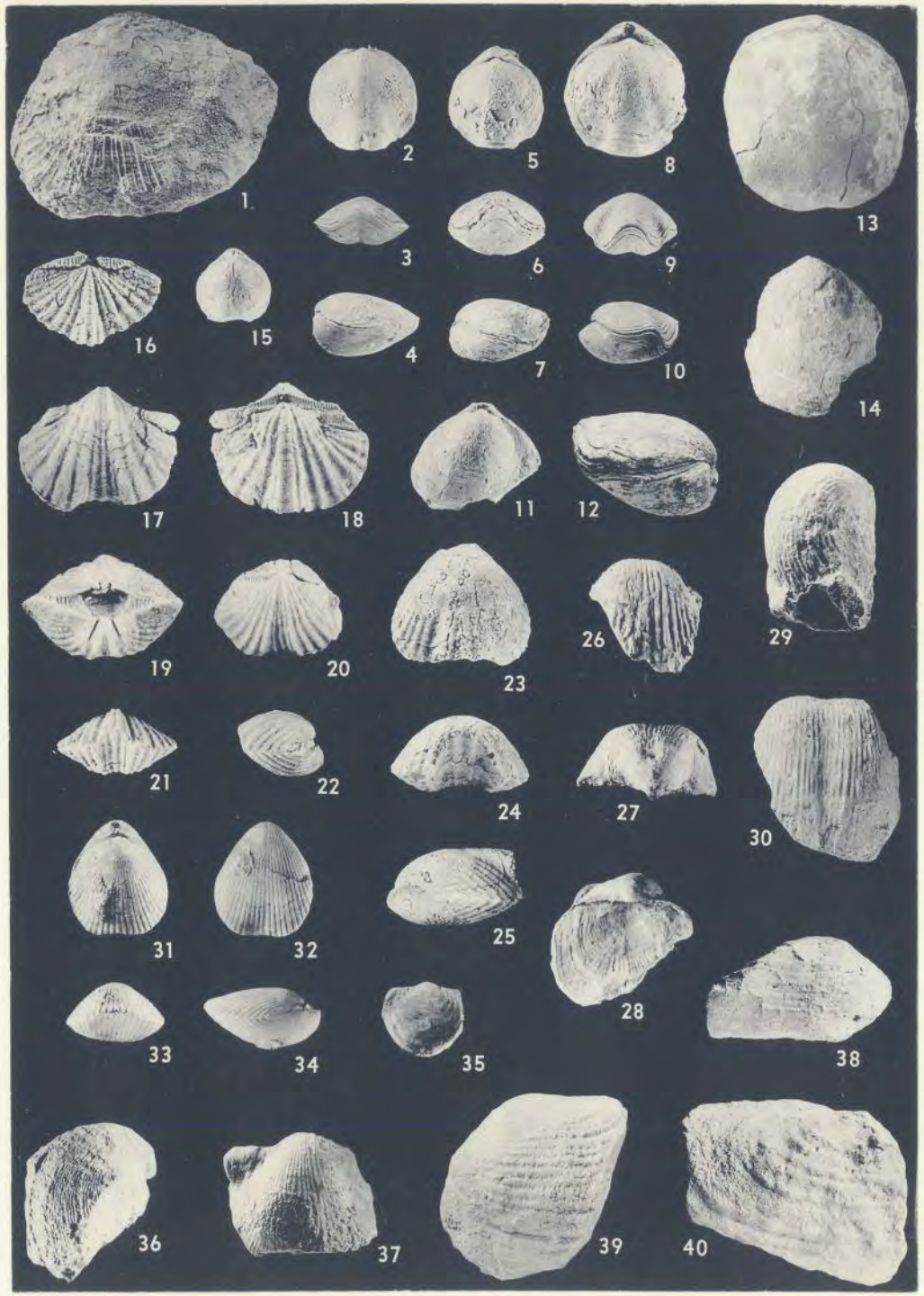
29, 30—Dictyoclostus portlockianus (Norwood & Pratten). *29.* Lateral view showing general shape. Loc. $\frac{43106}{19B}$. ×1. U. Wyo. IT-189. *30.* Anterior view showing ribbing and sulcus on trail. Loc. $\frac{43106}{19B}$. ×1. U. Wyo. IT-188. (p. 9)

31–34—Eumetria sulcata Burk, n. sp. Dorsal, ventral, anterior, and lateral views of holotype. Loc. $\frac{3199}{19A}$. ×1. U. Wyo. IT-231. (p. 14)

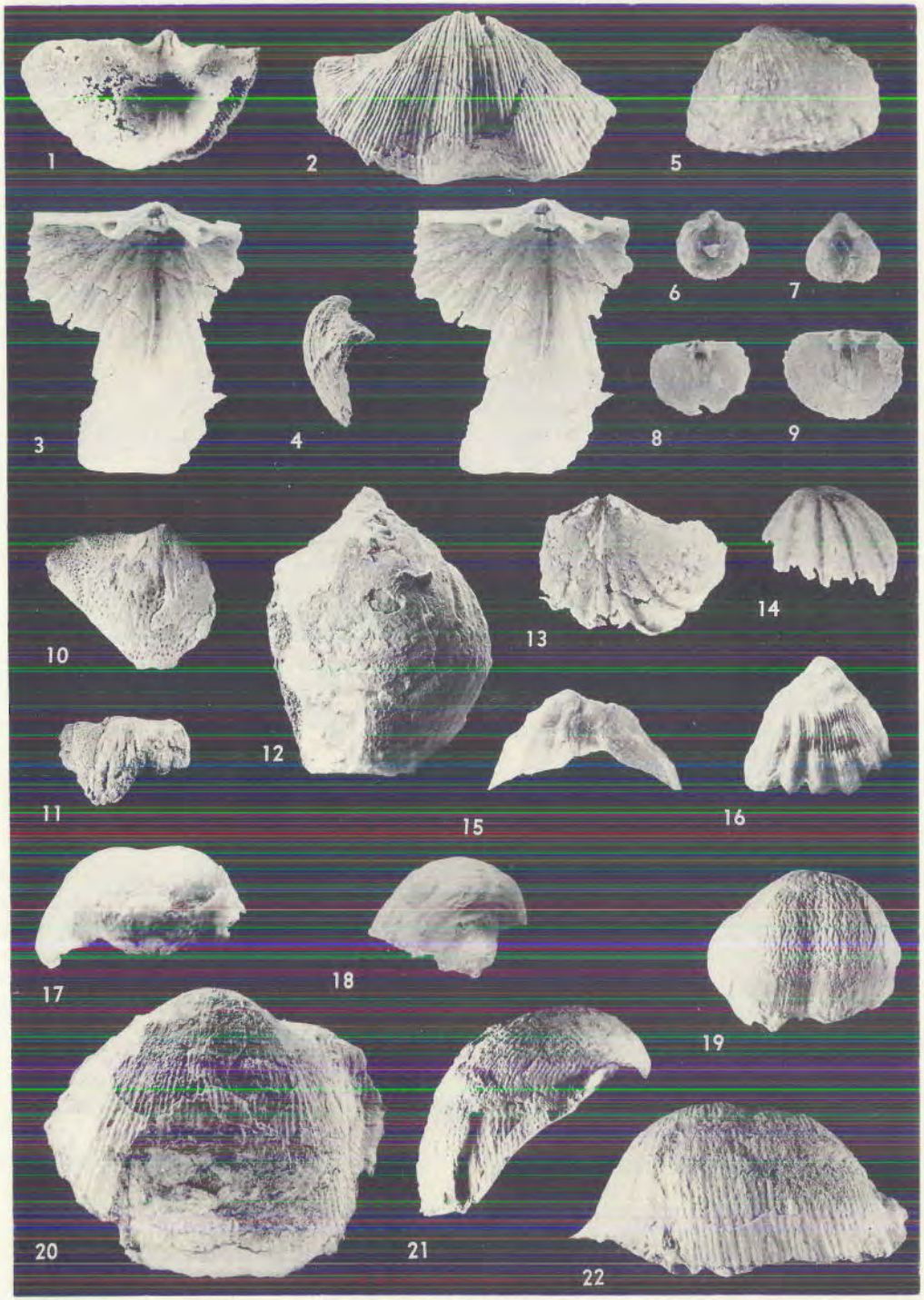
35—Cancrinella boonensis (Swallow). External impression of ventral valve, reverse-lighted, showing concentric rugae on umbo, and spine bases on cardinal extremities. Loc. $\frac{3099}{9A}$. ×2. U. Wyo. IT-195. (p. 10)

36, 37—Linoproductus prattenianus (Norwood in Norwood & Pratten). *36.* Lateral view showing shape and costae. Loc. $\frac{43106}{19B}$. ×1. U. Wyo. IT-192. *37.* View of ventral beak showing prominent wrinkled cardinal extremities. Loc. $\frac{43106}{19B}$. ×2. U. Wyo. IT-193. (p. 9)

38–40—Allorisma terminale Hall. *38.* Small specimen referred to this species with hesitation. Loc. $\frac{3099}{9A}$. ×2. U. Wyo. IT-237. *39.* Left valve. Loc. $\frac{43106}{19B}$. ×1. U. Wyo. IT-238. *40.* Right valve showing concentric ornamentation. Loc. $\frac{43106}{19B}$. ×1. U. Wyo. IT-239. (p. 14)



Burk, Amsden fauna



Pederson, Casper fauna

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A PERMIAN (WOLFCAMPIAN) FAUNA OF THE CASPER FORMATION OF SOUTHEASTERN WYOMING

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ABSTRACT—A new subspecies of *Neospirifer* was found in a bed 415 feet above the base of the Casper formation near Laramie, Wyoming. A complete description of the new subspecies, *N. bakeri wyomingensis*, is included.

The other genera in the fauna which marks the base of the Permian in the Laramie Range are *Dictyoclostus*, *Juresania*, *Marginifera*, *Meekella*, *Chonetes*, *Wellerella*, and *Composita*, which is the dominant genus.

INTRODUCTION

THE purpose of this paper is to describe a fauna which marks the base of the Permian part of the Casper formation in the Laramie Range near Laramie, Wyoming. This fauna includes a new subspecies. *Neospirifer bakeri wyomingensis* Pederson.

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STRATIGRAPHY

The fauna described below was discovered in NW ¼, Sec. 4, T. 16 N., R. 72 W., Sixth Principal Meridian, about 8 miles northeast of Laramie on the Ninth Street road, and is on the ridge above the University of Wyoming stone quarry. The locality

EXPLANATION OF PLATE 2

All specimens are from 415 feet above the base of the Casper formation in NW¼, Sec. 4, T. 16 N R. 72 W., Albany Co., Wyoming.

FIGS. *1–4*—*Neospirifer bakeri* (King), *wyomingensis* Pederson, n. subsp. *1*. Holotype. Interior of silicified ventral valve showing absence of dental plates. ×2. U. Wyo. IT-153. *2*. Paratype. Exterior of ventral valve showing low round radial plications and shallow sulcus. ×1. U. Wyo. IT-155. *3*. Paratype. Stereoscopic pair. Interior of silicified dorsal valve showing prominent dental sockets and gaping notothyrium. ×2. U. Wyo. IT-154. *4*. Paratype. Lateral view showing the short simple beak. ×1. U. Wyo. IT-156. (p. 18)

5—*Juresania nebrascensis* (Owen). Ventral valve showing quadrangular shape and pustulose spine bases. ×2. U. Wyo. IT-170. (p. 20)

6–9—*Composita ovata* Mather. *6, 7*. Silicified ventral valves. ×2½. U. Wyo. IT-158 b, a. *8, 9*. Silicified dorsal valves. ×2½. U. Wyo. IT-159 a, b. (p. 19)

10–11—*Chonetes* sp. indet. *10*. Ventral view showing the even radial rows of internal pustules. ×2. U. Wyo. IT-166. *11*. Internal impression of ventral valve showing muscle scars. ×1. U. Wyo. IT-165. (p. 20)

12—*Composita subtilita* (Hall). Dorsal view showing the sub-ovate outline and narrow beak. ×2. U. Wyo. IT-161. (p. 19)

13–14—*Wellerella* sp. indet. *13*. Interior of silicified dorsal valve showing median septum. ×2½. U. Wyo. IT-175. *14*. Exterior of silicified dorsal valve showing the plications. ×2. U. Wyo. IT-174. (p. 21)

15–16—*Meekella attenuata* Girty. *15*. Inverted posterior view of ventral valve showing the large triangular cardinal area. ×2½. U. Wyo. IT-162. *16*. Ventral view of ventral valve showing the fine radial lirae on broad, flattened plications. ×2. U. Wyo. IT-162. (p. 20)

17–19—*Marginifera haydenensis* Girty. *17*. Posterior view showing small dorsally deflected ears. ×2. U. Wyo. IT-172. *18*. Lateral view. ×2. U. Wyo. IT-172. *19*. Ventral view showing shallow mesial sinus. ×2. U. Wyo. IT-172. (p. 21)

20–22—*Dictyoclostus americanus* Dunbar & Condra. *20*. Ventral view showing costate ribbing. ×1. U. Wyo. IT-168. *21*. Lateral view. ×1. U. Wyo. IT-168. *22*. Anterior view showing ribbing. ×1. U. Wyo. IT-168. (p. 20)

is numbered $\frac{1672}{4A}$ in the University of Wyoming files.

The Casper formation is approximately 800 feet thick at this locality, consisting of interfingering arkosic grits, cross-laminated sandstones, and fossiliferous limestones. In the Laramie Basin region this sequence is the oldest sedimentary unit and is in contact with the pre-Cambrian Sherman granite below and the Permian Satanka red shale above (Miller and Thomas, 1936, p. 718; Thomas, 1949, p. 17).

The fauna was found in an eight-inch lavender silicified limestone at the top of a ten foot bed of massive, brown limestone bearing *Triticites*. The lavender bed lies approximately 415 feet above the granite but irregularities on the surface of the granite make this estimate subject to variation; Thompson and Thomas in an unpublished manuscript give the height above the granite as 390 feet. The collection from this bed is of Permian age, but a fauna collected and identified by Mr. Creighton A. Burk (unpublished) from a bed 10 feet lower is Pennsylvanian. Therefore, the fauna discussed here marks the base of the Permian within the Casper formation.

The silicified limestone contains few brachiopods that can be broken out, but silicified specimens are well preserved and were freed by etching in hydrochloric acid.

The fauna includes the following: *Dictyoclostus americanus* Dunbar and Condra, 1932 (4 specimens); *Juresania nebrascensis* (Owen), 1852 (1); *Marginifera haydenensis* Girty, 1903 (16); *Meekella attenuata* Girty, 1908 (13); *Chonetes* sp. indet. (12); *Wellerella* sp. indet. (3); *Composita ovata* Mather, 1915 (467); *C. subtilita* (Hall in Stansbury), 1853 (1); *Neospirifer bakeri wyomingensis* Pederson, n. subsp. (39); Unidentified specimens (3). Dr. H. D. Thomas (personal communication, Nov. 18, 1952) states that fusulinids from this bed have been identified by M. L. Thompson as *Triticites ventricosus* (Meek) 1852?, a Wolfcampian type.

SYSTEMATIC PALEONTOLOGY

Phylum Brachiopoda
Genus Neospirifer Fredericks, 1919

Spirifer (*Neospirifer*) King, 1930, Univ. Texas Bull. 3042, p. 115.

Neospirifer Dunbar & Condra, 1932, Nebraska Geol. Survey Bull. 5, ser. 2, pp. 326–328.

Neospirifer Cooper in Shimer & Shrock, 1944, Index Fossils of North America, p. 325, John Wiley.

Diagnosis.—The shell of the genus *Neospirifer* is characteristically large and transverse with fasciculate costae.

The shell is widest at the hinge line and subtriangular in outline. The cardinal area of the ventral valve is moderately deep and wide, and the ventral beak arches up over it. The dorsal valve has a fold with a coinciding sulcus on the ventral valve. The fasciculate surface is formed by plications which bifurcate on the younger part of the shell. The fascicles may extend to the margins or degenerate into normal costae before reaching the anterior margin. On the well-preserved parts of the shell fine concentric lines are visible crossing delicately sculptured radial lirae.

Internally, the crural plates are fused to the heavy socket plates in the dorsal valve. The muscle scars of the pedicle valve are commonly divided by a median ridge. The shell is generally thickened in the umbonal region. The dental plates are long and conical, and may extend to the floor of the valve.

Neospirifer bakeri wyomingensis
Pederson, n. subsp.
Plate 2, figures 1–4

Diagnosis.—This subspecies is characterized by an alate shape with a short ventral beak. It has a high fold on the dorsal valve and a low shallow sulcus on the ventral valve. It has strongly impressed muscle scars and a low median ridge. Dental lamellae are absent.

Description.—The shell is large with adult specimens measuring up to 53 mm. across the hinge and averaging 30 mm. long. The outer surface is covered by low, round, radial plications that remain low. On the dorsal valve the plications are bundled slightly on the posterior margin of the valve, but become indistinct anteriorly. On the ventral valve the bundling of the ribs is inconspicuous (fig. 2).

The ventral valve has a strongly developed apical callosity and the muscle scars are strongly impressed and are separated by a low median ridge (fig. 1). The

interareas are well developed with a wide delthyrium which has very small deltidial plates. The dental lamellae are absent (fig. 1).

The dorsal valve has prominent dental sockets and a gaping notothyrium (fig. 3). The interareas are high and subtriangular. The hinge teeth are supported by crural plates which are fused to the interareas.

Remarks.—The new subspecies most closely resembles *Neospirifer bakeri bakeri* (King) 1930. *N. bakeri bakeri* has short dental lamellae while *N. bakeri wyomingensis* has none. The muscle scars are invisible in *N. bakeri bakeri*, but are strongly impressed, with a low median ridge in *N. bakeri wyomingensis*. The dorsal fold of *N. bakeri bakeri* is low and the ventral sulcus is broad with a sharp ridge rising on each side while in *N. bakeri wyomingensis* the fold is high and the sulcus is low and narrow.

These differences, particularly regarding the dental lamellae, seem to warrant separation of the Casper form from *N. bakeri bakeri*, s.s., but because of the overall similarity of the Wyoming and Texas shells, the erection of a full species does not seem to be justified.

Comparison with other species.—The short simple beak and absence of dental lamellae distinguish *N. bakeri wyomingensis* from *N. dunbari*, *N. costella*, *N. pseudocameratus*, and *N. mexicanus* var. *latus*, all of which have incurved beaks and well-developed dental lamellae. The short simple beak and alate hinge distinguish *N. bakeri wyomingensis* from *N. huecoensis* which has a strongly incurved beak and a transversely elliptical, short-hinged shape. *N. costella*, *N. dunbari*, and *N. mexicanus* var. *latus* also have elliptical to subtriangular shapes.

Holotype.—U. Wyo. IT-153.

Paralypes.—U. Wyo. IT-154–157, 164.

Genus COMPOSITA Brown, 1849
COMPOSITA OVATA Mather, 1915
Plate 2, figures 6–9

Composita ovata MATHER, 1915, Denison Univ. Sci. Lab. Bull., vol. 18, p. 202, pl. 14, figs. 6–6c.

Composita ovata DUNBAR & CONDRA, 1932, Nebraska Geol. Survey Bull. 5, ser. 2, pp. 370–371, pl. 43, figs. 14–19.

The shell is medium sized with a convex ventral valve which is oval in outline. The delthyrium of the ventral valve is concealed by the upward curving of the beak. The sinus originates in the umbonal region and extends to the marginal edge of the valve and is shallow. The dorsal valve has a low broad fold. The surface of both valves is covered by fine concentric lines of growth, which are commonly crossed by fine thread-like radial striae.

The dorsal valve has a well-developed brachial apparatus. The dental sockets are supported by crural plates that form the inner sides of the sockets. A pair of ventrally curved processes arise from the front of the hinge-line. These serve as a base for the primary lamellae of the spiralia. The adductor scars are long and narrow and lightly impressed on the dorsal valve.

Figured specimens.—U. Wyo. IT-158 a, b, 159 a, b.

Other specimens.—U. Wyo. IT-160.

COMPOSITA SUBTILITA (Hall in Stansbury), 1853
Plate 2, figure 12

Terebratula subtilita HALL in Stansbury, 1853, Exploration and survey of the valley of the Great Salt Lake, Utah, Appendix E, p. 490, pl. 4, figs. 1a–2c.

Seminula subtilita GIRTY, 1903, U. S. Geol. Survey Prof. Paper 16, pp. 403–407, pl. 7, figs. 1–10.

Composita subtilita GIRTY, 1915, U. S. Geol. Survey Bull. 544, pp. 96–101, pl. 5, fig. 7; pl. 6, fig. 13; pl. 12, figs. 4–4c.

Composita subtilita DUNBAR & CONDRA, 1932, Nebraska Geol. Survey Bull. 5, ser. 2, pp. 363–366, pl. 43, figs. 7–13.

Composita subtilita COOPER in Shimer & Shrock, 1944, Index Fossils of North America, p. 335, pl. 128, figs. 9–12, John Wiley.

The shell is large and subovate in outline. It has a narrow beak while the anterior part is broadly rounded. The delthyrium is hidden by the close incurvature of the beak. The hinge-line is not visible but is short and without a cardinal area. A broad, rounded ventral sinus and corresponding dorsal fold mark the anterior half of the shell. The surface is smooth except for very fine growth lines.

Compared with *C. ovata*, *C. subtilita* is larger and has a narrow beak which hides the hinge-line completely. *C. subtilita* has a broad, deep, rounded ventral sinus and correspondingly high dorsal fold while *C. ovata* has a broad, shallow ventral sinus and a low dorsal fold.

Figured specimen.—U. Wyo. IT-161.

Genus MEEKELLA White & St. John, 1867

MEEKELLA ATTENUATA Girty, 1908

Plate 2, figures 15, 16

Meekella attenuata GIRTY, 1908, U. S. Geol. Survey Prof. Paper 58, pp. 205–208, pl. 24, figs. 7–9a; pl. 25, figs. 4–4d.

Meekella attenuata KING, 1930, Univ. Texas Bull. 3042, pp. 52–53, pl. 5, figs. 2–7.

The shell is small. The ventral valve has an irregularly convex shape with the hinge width equal to half the shell width. The deltidium is narrow with the lateral parts rising with concave slopes to a narrow and subangular median ridge (fig. 15). There are seven to ten fine ribs on each of the eight plications, which become indistinct towards the beak, leaving a small unplicated region (fig. 16).

The dorsal valve is subcircular in outline and strongly convex. It has a faint mesial sinus and no cardinal area. The surface has fine radial lirae on plications which are broader and flatter than those on the ventral valve. The dorsal plications arise gradually, some distance from the beak as on the ventral valve. Faint concentric lines cross the lirae and produce the characteristic orthotetid surface.

This species may be distinguished from *M. striatocostata* (Cox) 1857, which is also common in the Casper formation, by the attenuation of the ribbing posteriorly. In *M. striatocostata* the ribs are well defined on the umbo; in *M. attenuata* they are not.

Figured specimens.—U. Wyo. IT-162.

Other specimens.—U. Wyo. IT-163, 164.

Genus CHONETES Fischer, 1830–37

CHONETES sp. indet.

Plate 2, figures 10, 11

The ventral valves are only half as long as they are wide. The greatest width is at the hinge-line. The outline of the specimens is distinctly subquadrate, since the lateral margins are converging only slightly. The beak on the ventral valve is fairly prominent and the valve is gently convex and has a moderate sulcus, which distinguishes it from *C. granulifera*. The surface of the valve has fine capillate ornamentation.

The cardinal areas are rather narrow and taper gradually from the delthyrium to the cardinal extremities. Normally there are seven to eight spines on each side of the cardinal area. Markings caused by the fine papillae found on the inside of the shell may be seen in exfoliated specimens (fig. 10).

Figured specimens.—U. Wyo. IT-165, 166.

Other specimens.—U. Wyo. IT-167.

Genus DICTYOCLOSTUS Muir-Wood, 1930

DICTYOCLOSTUS AMERICANUS Dunbar & Condra, 1932

Plate 2, figures 20–22

Dictyoclostus americanus DUNBAR & CONDRA, 1932, Nebraska Geol. Survey Bull. 5, ser. 2, pp. 218–220, pl. 34, figs. 3–6.

Dictyoclostus americanus COOPER in Shimer & Shrock, 1944, Index Fossils of North America, p. 350, pl. 136, figs. 15–19, John Wiley.

The shell is large with a breadth of 5.0 cm. and a length of 4.2 cm., and is strongly concavo-convex. The hinge width is nearly the same as the greatest width of the shell. The ventral umbo is broad and only moderately convex. The ears are arched and small. The beak is small and obtuse. The surface has costate ribbing crossed by regular concentric rugae of equal thickness to form an even-textured reticulate pattern. The dorsal valve is moderately concave, and the shell has a moderate trail. The ventral valve bears a large number of slender spines which are irregularly distributed over the surface while the dorsal valve bears no spines.

This species may be distinguished from *D. portlockianus* (Norwood and Pratten), 1854, which is common in the Pennsylvanian parts of the Casper, by its ribbing, which is very fine over the visceral disc but becomes coarser and unequal on the anterior slope; in *D. americanus* the ribbing remains even-textured.

Genus JURESANIA Fredericks, 1928

JURESANIA NEBRASCENSIS (Owen), 1852(?)

Plate 2, figure 5

Productus nebrascensis MEEK, 1872, U. S. Geol. Survey Nebraska Final Rept., pt. 2, pp. 165–167, pl. 2, fig. 2; pl. 4, fig. 6; pl. 5, figs. 11a–c.

Productus nebraskensis GIRTY, 1903, U. S. Geol. Survey Prof. Paper 16, pp. 370–371, pl. 5, figs. 1–2, 2a.

Productus nebrascensis GIRTY, 1904, U. S. Geol. Survey Prof. Paper 21, p. 53, pl. 11, figs. 7–9.
Productus nebrascensis GIRTY, 1909, U. S. Geol. Survey Bull. 389, pp. 62–64, pl. 7, figs. 5–6.
Productus nebrascensis GIRTY, 1915 (part), U. S. Geol. Survey Bull. 544, pp. 65–68, pl. 10, figs. 6–7.
Juresania nebrascensis DUNBAR & CONDRA, 1932, Nebraska Geol. Survey Bull. 5, ser. 2, pp. 195–198, pl. 22, figs. 1–9, 13.
Juresania nebrascensis COOPER in Shimer & Shrock, 1944, Index Fossils of North America, p. 350, pl. 137, figs. 1–3, John Wiley.

The shell is small, with a width of 17 mm. and a length of 11 mm. It has moderate costae which are crossed by concentric bands upon which the spines are borne. The spines pass through the shell material at a low angle and emerge at a tangent to the surface, from prominent, elongate, pustulose spine bases (fig. 5).

The ventral valve is strongly convex and geniculate. It has a distinct quadrangular shape, and the hinge-line is not as wide as the greatest width. The ears are small and the beak overarches the hinge-line. The dorsal valve is nearly flat over the visceral area becoming curved up towards the margins so as to make it moderately convex.

Figured specimen.—U. Wyo. IT-170.
Other specimens.—U. Wyo. IT-171.

Genus MARGINIFERA Waagen, 1884
MARGINIFERA HAYDENENSIS Girty, 1903
Plate 2, figures 17–19

Marginifera haydenensis GIRTY, 1903, U. S. Geol. Survey Prof. Paper 16, pp. 380–381, pl. 5, figs. 9–11a.
Marginifera haydenensis DUNBAR & CONDRA, 1932, Nebraska Geol. Survey Bull. 5, ser. 2, pp. 232–234, pl. 36, figs. 12–17.

The shell is small, with a length of 12 mm. and a width of 17 mm. The ventral valve is strongly convex (fig. 18). The ventral valve has a shallow, moderate mesial sinus (figs. 17, 19). The submarginal ridges are exaggerated on both valves. The vault of the shell is usually large. The surface is marked by fine irregular longitudinal striae, and spines are commonly abundant. The dorsal valve is transverse and much smaller than the ventral valve. The only ornamentation found on the dorsal valve consists of concentric wrinkles or fine striae.

Figured specimens.—U. Wyo. IT-172.
Other specimens.—U. Wyo. IT-173.

Genus WELLERELLA Dunbar & Condra, 1932
WELLERELLA sp. indet.
Plate 2, figures 13, 14

The dorsal valve is convex and smooth on the umbo. Plications start 3 or 4 mm. from the beak of the dorsal valve. There is also a narrow sinus on the fold of the dorsal valve. There are three plications on the fold and three on each lateral slope. Internally the specimens show a dorsal median septum.

None of the specimens is well enough preserved to permit more than generic identification.

Figured specimens.—U. Wyo. IT-174, 175.
Other specimens.—U. Wyo. IT-176.

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