SHORTER CONTRIBUTIONS TO GENERAL GEOLOGY, 1920.

THE FAUNA OF THE CANNONBALL MARINE MEMBER OF THE LANCE FORMATION.

By TIMOTHY W. STANTON.

INTRODUCTION.

The Cannonball marine member of the Lance formation was first recognized as a distinct stratigraphic unit by E. Russell Lloyd, of the United States Geological Survey, in 1912, when he was mapping the Cannonball River lignite field, in Morton, Adams, and Hettinger counties, N. Dak. Lloyd's report on this field, published in 1914,[1] contains a brief description of the member with a map which shows its distribution in parts of Morton and Adams counties. A fuller description and discussion by Lloyd and C. J. Hares[2] soon followed, in which the member was mapped from Missouri River near Bismarck, N. Dak., southwestward to Grand River, S. Dak., and westward to longitude 103°, thus covering almost all its known area. A larger-scale map of the western part of this area in South Dakota, based on the same field work, was published in 1916.[3]

The map herewith presented (fig. 1) is a copy of Lloyd and Hares's map, supplemented on the north by data from a manuscript map by E. T. Hancock, based on his field work of 1914 in the Heart River drainage basin west of Mandan, which has also been used by M. R. Campbell.[4] The tentative northern boundary on Missouri River and east of it (represented by a broken line) is added from observations which I made in 1914 on trips from Mandan to Stanton and from Bismarck to Washburn—the latter in company with E. T. Hancock. The most northern point at which I have collected the characteristic marine fauna of the Cannonball member is on the west bank of Missouri River 1 mile south of Price, in the southern part of T. 142 N., R. 81 W., but rocks of the same general character, mainly dark sandy shales, continue in the low outcrops along the river almost to Fort Clark and are especially well exposed near Washburn.

It is interesting to note in this connection the variations in the boundary between Cretaceous and Tertiary—that is, between Fox Hills and Fort Union—on Missouri River, as shown on the general maps of this region published by F. V. Hayden. On the small maps published in 1857[5] and 1858 the boundary crosses the Missouri at the mouth of Heart River. The map accompanying the report on the geology and natural history of the upper Missouri published in 1863[6] extends the Cretaceous almost up to the present site of Washburn, and the map in the "Final report of the United States geological survey of Nebraska," published in 1872, carries it to Fort Clark. All these localities are considerably north of the actual limits of the Fox Hills sandstone as now known. The mapping was based on collections of marine fossils which Hayden had obtained "near the mouth of Heart River" and "near Fort Clark," consisting of five species formerly assigned to the Fox Hills fauna but now known to have been derived from the Cannonball marine member of the Lance formation.

[1] U. S. Geol. Survey Bull. 541, pp. 243-291, 1914.

[2] The Cannonball marine member of the Lance formation of North and South Dakota and its bearing on the Lance-Laramie problem: Jour. Geology, vol. 23, pp. 523-547, 1915.

[3] Winchester, D. E., Hares, C. J., Lloyd, E. R., and Parks, E. M., The lignite field of northwestern South Dakota: U. S. Geol. Survey Bull. 627, 1916.

[4] Guidebook of the western United States, Part A, Northern Pacific Route: U. S. Geol. Survey Bull. 611, sheet 7, 1915.

[5] Acad. Nat. Sci. Philadelphia Proc., vol. 9, p. 109; vol. 10, p. 158.

[6] Am. Philos. Soc. Trans., new ser., vol. 12, pp. 1-218, 1863.

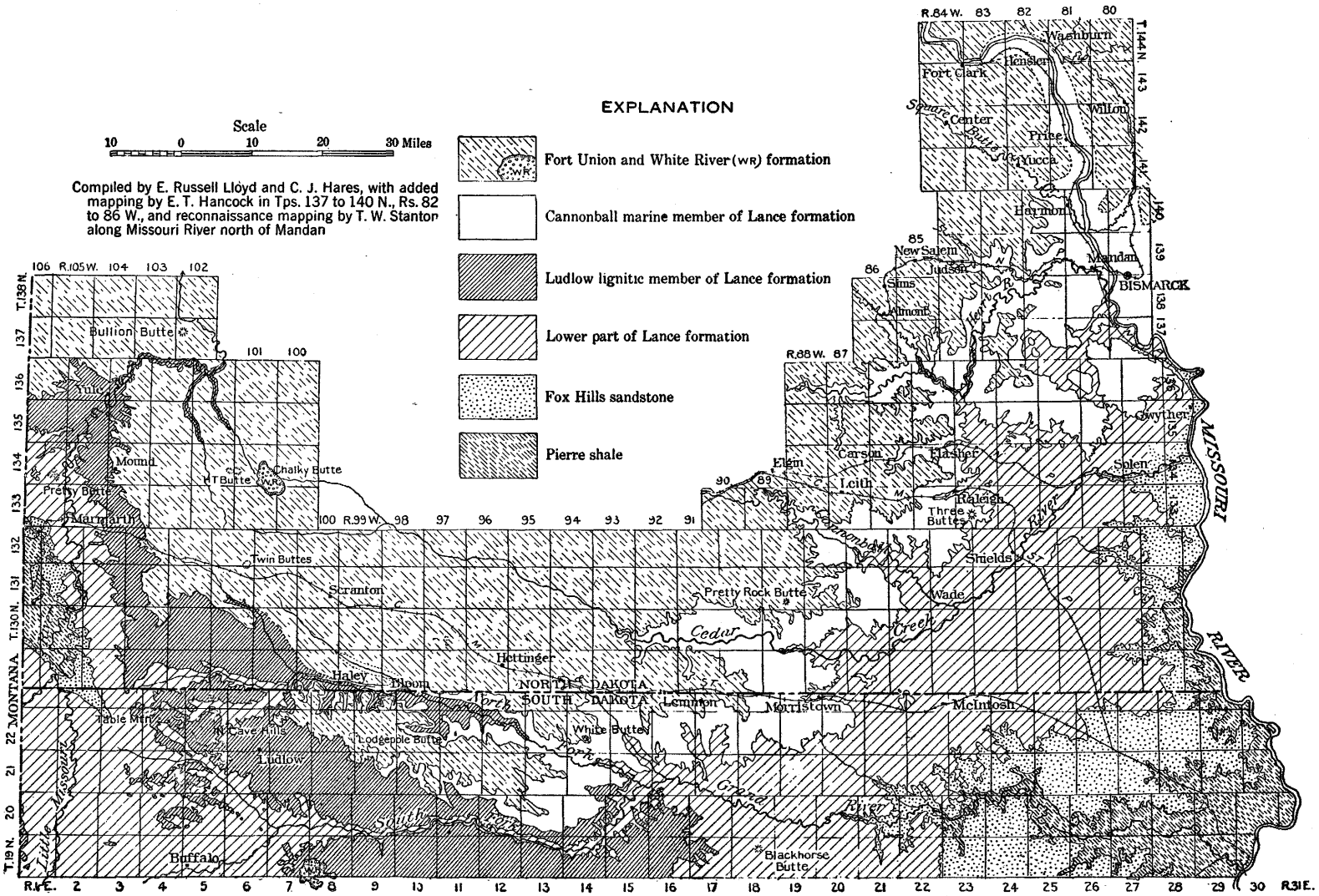

FIGURE 1.—Geologic map of part of western North and South Dakota.

Part of the area covered by the Cannonball marine member was mapped by A. G. Leonard in the Bismarck folio, published in 1911, before the member was distinguished from the rest of the Lance formation. Leonard has also published two small-scale generalized maps of North Dakota,[1] on both of which the boundary between Lance and Fort Union is shown as crossing the Missouri a few miles below Washburn. In the later map Lloyd's mapping of the Cannonball member west of Missouri River is copied and its area is extended to the northern limits of the Lance formation as drawn on the earlier map, but it is not shown on the east side of the Missouri, although it has been mapped by Campbell[2] with an indefinite lower boundary in the neighborhood of Bismarck. Farther east its limits are usually obscured by the heavy mantle of drift.

The Cannonball member is the latest marine deposit known in the Great Plains province and thus adds one more item to the record of the sea's advances and retreats which mark the diastrophic history of the region that includes the Great Plains and the Rocky Mountains. It is intimately associated with some of the continental deposits which lie near the boundary between Cretaceous and Tertiary and concerning whose exact age there has been and still is difference of opinion. For these reasons it will be profitable to describe the fauna of the Cannonball marine member of the Lance formation, to illustrate it fully, to consider its relations to other faunas, and to discuss other facts that may have a bearing on the determination of its age.

In the preparation of this paper I have studied all known collections of animal fossils from the Cannonball member. These consist of (1) types of supposed Fox Hills species described by Meek and Hayden from Heart River and the vicinity of Fort Clark; (2) collections obtained by E. Russell Lloyd and party during the field seasons of 1912 and 1913 in the area extending from the neighborhood of Lemmon, S. Dak., to Mandan, N. Dak., including fossils collected by Lloyd, Knowlton, Berry, and Stanton during a field conference covering part of this area in 1913; (3) collections obtained by C. J. Hares in the upper Grand River valley of North and South Dakota in 1912; (4) collections made by E. T. Hancock while mapping several townships west of Mandan in 1914; (5) collections made by myself in 1914 in the neighborhood of Mandan, near Price on the Missouri, 19 miles north of Mandan, and near Solen on Cannonball River.

[1] The geological map of North Dakota: North Dakota Univ. Quart. Jour., vol. 4, p. 4, 1913; The geological history of North Dakota: Idem, vol. 7, p. 232, 1917.

[2] U. S. Geol. Survey Bull. 611, sheet 7, 1915.

STRATIGRAPHIC RELATIONS.

GENERAL SECTION.

The stratigraphic relations, lithology, and detailed stratigraphy of the Lance formation in western North and South Dakota have been well presented by Lloyd and Hares,[3] from whose paper copious quotations are made below, including the table and detailed sections.

In a large region west of Missouri River in North and South Dakota the Lance formation consists of two distinct parts—a lower nonmarine part containing a flora very similar to if not identical with that of the Fort Union, and an upper marine member containing a fauna closely resembling but not identical with that of the Fox Hill sandstone. This upper part, on account of its peculiar fauna, has been mapped separately and named the Cannonball marine member of the Lance formation. Farther west nonmarine beds bearing lignite and occupying a similar stratigraphic position have been named the Ludlow lignitic member of the Lance.

The general character and relations of the Cretaceous and Tertiary formations exposed in this part of the Dakotas are shown in Table 1. The areal distribution is shown on the map (fig. 1).

CRETACEOUS SYSTEM.

PIERRE SHALE.

The oldest formation exposed in the area covered by the map is the well-known and widely distributed Pierre shale, the upper part (about 300 feet) of which is seen in the valleys of the Missouri and Grand rivers, in the southeast corner of the area, and on the Little Missouri near the western margin. It is a dark-gray marine shale with a characteristic Upper Cretaceous fauna, including *Inoceramus barabini*, *Baculites ovatus*, *B. compressus*, *Placenticeras whitfieldi*, *Scaphites nodosus*, and many others. It is worthy of note, however, that the upper 200 feet of Pierre shale as mapped in Missouri and Grand river valleys does not contain the species just mentioned but is characterized by a Fox Hills fauna, including *Sphenodiscus lenticularis*, *Scaphites conradi*, and several related species of *Scaphites* with many species of littoral pelecypods and gastropods. (See partial list on p. 4.)

[3] Jour. Geology, vol. 23, pp. 523–547, 1915.

TABLE 1.—*Cretaceous and Tertiary formations in western North and South Dakota.*

System.	Series.	Formation.	Character.	Thickness in feet.
Tertiary.	Oligocene.	White River.	Cross-bedded sandstone and fresh-water limestone	140
	Unconformity, angular up to 20° and erosional up to 1,500 feet.			
	Eocene.	Fort Union.	Yellow sandstone, shale, clay, and lignite	1,025
Tertiary?	Eocene?	Lance.	Cannonball marine member. Dark sandy shale, dark shaly limestone, and yellow sandstone, containing marine shells	0–300
			Ludlow lignitic member. Light sandy shale, calcareous sandstone and lignite	0–350
			Somber-colored shale, yellow sandstone, and thin lignite beds	400–525
Cretaceous.	Upper Cretaceous.	Fox Hills.	Sandstone, yellow	25–400
		Pierre.	Dark marine shale	300+

FOX HILLS SANDSTONE.

The Fox Hills sandstone of the eastern part of the area mapped is continuous with the typical exposures of the formation in Fox Ridge between Moreau and Cheyenne rivers, S. Dak. It is made up of gray, yellow, and buff sandstone, locally in two or more distinct beds, separated by banded shale. The whole formation has a maximum thickness of about 150 feet in the Standing Rock and Cheyenne River Indian reservations, but in some localities its thickness is apparently reduced to 25 feet or less. This variation in thickness has been attributed by Knowlton,[1] Calvert,[2] and others to removal of the upper part of the formation by erosion before the overlying Lance formation was laid down. This opinion is supported by direct evidence of local erosion in many places at or near the top of the Fox Hills sandstone, but I have shown in a previous paper[3] that the eroded surface at many localities in this area is within the Fox Hills sandstone and not above it, for the reason that the bed immediately above the irregular surface contains along with a brackish-water fauna several forms of *Scaphites* and other marine Cretaceous invertebrates characteristic of the Fox Hills fauna. Evidence was also given in this paper that the whole Fox Hills sandstone is the product of very irregular deposition such as must occur in the shallowing waters of a retreating sea. The variation in apparent thickness is due in part to the fact that the base of the sandstone varies in position because sands and shales were simultaneously deposited in neighboring localities.

The most common and characteristic species of the Fox Hills marine fauna are as follows:

Pteria linguaeformis Evans and Shumard.
Pteria nebrascana Evans and Shumard.
Cucullaea shumardi Meek and Hayden.
Limopsis striatopunctata Evans and Shumard.
Leda (Yoldia) evansi Meek and Hayden.
Nucula cancellata Meek and Hayden.
Nucula planimarginata Meek and Hayden.
Lucina occidentalis (Morton).
Tancredia americana Meek and Hayden.
Protocardia subquadrata Evans and Shumard.
Callista deweyi Meek and Hayden.
Tellina scitula Meek and Hayden.
Mactra warrenana Meek and Hayden.
Cuspidaria ventricosa (Meek and Hayden).
Lunatia occidentalis Meek and Hayden.
Lunatia concinna Hall and Meek.

[1] Knowlton, F. H., Further data on the stratigraphic position of the Lance formation ("*Ceratops* beds"): Jour. Geology, vol. 19, pp. 362–371, 1911; Cretaceous-Tertiary boundary in the Rocky Mountain region: Geol. Soc. America Bull., vol. 25, pp. 326–327, 1914.

[2] Calvert, W. R., Beekly, A. L., Barnett, V. H., and Pishel, M. A., Geology of the Standing Rock and Cheyenne River Indian reservations: U. S. Geol. Survey Bull. 575, pp. 18–20, 1914.

[3] Stanton, T. W., Fox Hills sandstone and Lance formation ("*Ceratops* beds") in South Dakota, North Dakota, and eastern Wyoming: Am. Jour. Sci., 4th ser., vol. 30, pp. 173–182, 1910.

Lunatia subcrassa Meek and Hayden.
Anchura (Drepanochilus) americana (Evans and Shumard).
Pyropsis bairdi Meek and Hayden.
Fasciolaria (Piestochilus) culbertsoni Meek and Hayden.
Fasciolaria buccinoides Meek and Hayden.
Pyrifusus newberryi Meek and Hayden.
Fusus (Serrifusus) dakotensis Meek and Hayden.
Cylichna volvaria Meek and Hayden.
Haminea minor Meek and Hayden.
Cinulia concinna Meek and Hayden.
Sphenodiscus lenticularis (Owen).
Scaphites conradi (Morton).
Scaphites conradi var. intermedius Meek.
Scaphites abyssinus (Morton).
Scaphites nicolleti (Morton).
Scaphites cheyennensis (Owen).

The upper 200 feet of the Pierre shale as mapped along Missouri River and its tributaries in South Dakota contains the same fauna.

In addition to this purely marine fauna there is the brackish-water fauna already mentioned, which at some localities contains an admixture of marine forms. It is found at the top of the Fox Hills sandstone in an irregular bed that has been assigned by some geologists to the overlying Lance formation, on account of the evidence of erosion at its base. I have considered it the topmost member of the Fox Hills sandstone, because its marine fossils are mostly characteristic Fox Hills species, and have attributed its irregular base and other irregularities to the action of tidal currents; but whether it is assigned to the one formation or the other, the character of its fauna is proof of a gradual transition from marine to nonmarine conditions, the record of which would not have been retained if there had been a long period of erosion after the retreat of the Fox Hills sea. This brackish-water fauna with its associated marine forms includes the species named in the following list, in which * indicates marine species, † species that occur also in the Cannonball marine member of the Lance and in older formations, and ‡ species that occur also in the Ludlow lignitic member of the Lance and in older formations.

‡Ostrea subtrigonalis Evans and Shumard.
‡Ostrea glabra Meek and Hayden.
Anomia micronema Meek.
Modiola meeki (Evans and Shumard)?
Corbicula occidentalis Meek and Hayden.
Corbicula nebrascensis Meek and Hayden.
†Corbicula cytheriformis Meek and Hayden.
Corbicula subelliptica var. moreauensis Meek and Hayden.
*Tancredia americana Meek and Hayden.
*Tancredia? sp.
†Panope simulatrix Whiteaves?
Teredo sp.
Neritina bruneri White.
Neritina (Velatella) baptista White.
Melania insculpta Meek.
Melania wyomingensis Meek.
*Lunatia obliquata Hall and Meek.
†*Lunatia subcrassa Meek and Hayden.
Melampus sp.
*Scaphites conradi (Morton).
*Scaphites conradi var. intermedius Meek.
*Scaphites cheyennensis (Owen).

This fauna through its marine element is directly connected with the Fox Hills fauna and through its brackish-water element tends to connect a brackish-water facies of the Cannonball fauna with the brackish-water faunas of the Laramie, Mesaverde, Judith River, and other Cretaceous formations. In the course of the survey of the Standing Rock and Cheyenne River Indian reservations it was collected at 14 localities and observed at many others scattered over an area extending 75 miles from north to south and 60 miles from east to west, as shown by the following list, in which localities yielding marine species mixed with the predominant brackish-water forms are indicated by †:

†Sec. 25, T. 11 N., R. 18 E., S. Dak.
Sec. 18, T. 13 N., R. 18 E., S. Dak.
†Sec. 2, T. 13 N., R. 19 E., S. Dak.
Sec. 12, T. 13 N., R. 19 E., S. Dak.
Sec. 6, T. 14 N., R. 18 E., S. Dak.
†Sec. 27, T. 14 N., R. 19 E., S. Dak.
Sec. 27, T. 14 N., R. 20 E., S. Dak.
Sec. 19, T. 14 N., R. 20 E., S. Dak.
†Sec. 12, T. 15 N., R. 18 E., S. Dak.
†Sec. 18, T. 17 N., R. 26 E., S. Dak.
Sec. 12, T. 20 N., R. 22 E., S. Dak.
Sec. 27, T. 22 N., R. 24 E., S. Dak.
Sec. 15, T. 22 N., R. 25 E., S. Dak.
Sec. 20, T. 130 N., R. 80 W., N. Dak.

The Cretaceous age of the Fox Hills sand stone is unquestioned, and the doubt as to its exact top involves only the few feet of beds containing the brackish-water fauna. Those who refer the brackish-water deposits to the overlying formation have suggested that the *Scaphites* and other characteristic Fox Hills species locally found in it were eroded from the underlying sandstone and redeposited, but it seems to me, after field examination of sev-

eral of the localities, much more probable that they were carried by the tide up short inlets that were normally inhabited by brackish-water creatures only.

TERTIARY (?) SYSTEM.

LANCE FORMATION.

The overlying rocks referred to the Lance formation are now classified by the United States Geological Survey as of Tertiary (?) age, but it is my opinion that they are Cretaceous. The following description is quoted from Lloyd and Hares:[1]

LOWER PART.

It has been previously stated that the Lance formation in this region consists of three parts—a lower group of shale and sandstone beds of continental origin and two contemporaneous upper members, one of sandstone and shale of marine origin, the other of sandstone, shale, and lignite of nonmarine origin. The lower part of the formation outcrops in a wide belt of country in Morton County, N. Dak. Northward it passes below the flood plain of Missouri River a few miles below Bismarck, and to the west it has been mapped to and beyond the Montana-Dakota State line. It occupies a large area in Bowman and Billings counties, in southwest North Dakota, and in adjacent parts of Montana. Throughout this whole region it is essentially uniform in character, consisting predominantly of somber-colored arenaceous shale intercalated with lenticular beds of brown or buff sandstone. Beds of brown carbonaceous shale, bog iron ore, and thin lignite are conspicuous in most outcrops. All the strata of the lower part of the Lance are lenticular in character, and a section exposed at one locality is different in most of its details from one even a short distance away. Cross-bedding is common, especially in the sandstone. Irregularity of deposition is characteristic. Near Solen on Cannonball River, 9 miles above its mouth, the lower part of the Lance has a thickness of approximately 400 feet and on Little Missouri a thickness of about 525 feet.

The fossils found in the lower part of the Lance in the western Dakotas consist of plant impressions and bones of reptiles. The plant remains are not abundant, but a few good collections have been made from widely separated localities. All of the species belong to the widespread Fort Union flora.[2] The vertebrates include turtles and several genera of dinosaurs,[1] among which is the large-horned *Triceratops*, which is diagnostic of the Lance formation. The ceratopsian remains are especially abundan tnear the base of the formation in the Standing Rock Indian Reservation, but on Little Missouri River several specimens of *Triceratops* have been found near the top of the formation and stratigraphically below the *Ostrea glabra* zone.

[1] Jour. Geology, vol. 23, pp. 527–537, 1915.

[2] For lists of plants and vertebrates collected in the Standing Rock and Cheyenne River Indian reservations see U. S. Geol. Survey Bull. 575, pp. 21, 22, 1914.—T. W. S.

LUDLOW LIGNITIC MEMBER.

The Ludlow lignitic member of the Lance formation occupies a large area in Harding County, S. Dak., and eastward into Perkins County, S. Dak., where it merges with the Cannonball marine member. In the vicinity of Ludlow, S. Dak., its type locality, it consists of 350 feet of loosely consolidated buff and cream-colored calcareous sandstone and shale with interbedded lignite. It contains most of the lignite of South Dakota, and the presence of this lignite is one of the chief criteria for considering it a distinct member of the Lance formation. Its lithologic character in South Dakota is very like and its fossil flora so far as determined is identical with the Fort Union. Its flora is like that of the lower part of the Lance, but its lithology is quite different. On the other hand, in North Dakota its flora has the same affinities as in South Dakota, but lithologically it resembles the lower part of the Lance, except for the presence of the numerous lignite beds. It is this variation in color and lithology of the Lance that renders its separation from the overlying Fort Union so difficult.

The following sections show the lithologic character of the Ludlow lignitic member:

Composite section in secs. 32 and 36, T. 22 N., R. 5 E. Black Hills meridian, S. Dak.

	Ft.	in.
Fort Union formation:		
Sandstone, yellowish, and shale	255	0
Ludlow lignitic member of the Lance formation:		
Lignite		8
Sandstone, somewhat shaly	45	0
Shale, dark	2	0
Lignite	2	4
Sandstone, light colored, grayish, argillaceous	12	0
Sandstone, buff, with ferruginous specks	15	0
Lignite		2
Sandstone, buff, fine grained, muscovitic	11	0
Lignite		3
Sandstone	8	0
Lignite		6
Sandstone, buff	25	0
Shale, bluish	1	0
Shale, carbonaceous		10
Shale, arenaceous	5	0
Lignite		1
Sandstone, buff, soft	5	4
Sandstone	1	0
Shale, arenaceous with carbonaceous streaks	4	0
Sandstone, argillaceous	6	0
Lignite	1	0
Concealed interval	22	0
Sandstone, drab, cross-bedded, ripple-marked	3	0
Shale, arenaceous	4	0
Lignite	1	5
Shale, brown	3	0
Lignite	2	1
Shale, dark		5
Lignite		8
Shale	1	3
Lignite	1	5
Shale, brown	4	0
Lignite	2	3
	446	8

Section on west side of Little Missouri River, sec. 10, T. 135 N., R. 105 W., N. Dak.

	Ft.	in.
Fort Union formation:		
Sandstone, light	15	2
Ludlow lignitic member of Lance formation:		
Shale, dark	24	0
Limestone, arenaceous	2	10
Shale, blue	7	2
Sandstone, gray, friable	4	0
Shale, gray	3	7
Sandstone, argillaceous	1	4
Shale, drab, hard	1	2
Lignite	4	5
Shale, dark, hard	2	10
Shale, light, fossils, leaves	2	10
Lignite	2	6
Shale, carbonaceous	1	8
Sandstone	2	8
Shale	1	8
Sandstone and shale, alternately	2	8
Lignite	1	0
Sandstone and shale	3	0
Lignite		6
Sandstone	4	0
Lignite	1	7
Sandstone, white, hard	3	0
Sandstone in upper part, shale in lower part; *Ostrea glabra* above base (only representative found of Cannonball marine member)	33	11
Lignite	1	11
Sandstone and shale, sandstone in upper part and shale below	27	0
Lignite		10
Shale	11	0
Lignite	3	0
Shale	3	4
Sandstone, hard ledge in upper part	13	2
Lignite	5	3
Shale	1	8
Lignite	1	2
Shale	1	4
Lignite	5	0
Shale	8	6
Lignite	6	11
Shale	4	8
Lignite		6
Shale	7	6
Lignite	5	4
Sandstone	15	4
Shale.		
	250	11

Section along North Fork of Grand River at Bloom, S. Dak.

	Ft.	in.
Fort Union formation (?):		
1. Sandstone, brown and yellow, fine grained, thin bedded, interbedded with lenses of compact bluish-gray limestone.		
Cannonball marine member of the Lance formation:		
2. Sandstone, dark gray, very calcareous; marine fossils *Nucula planimarginata, Callista (Dosiniopsis) deweyi, Pholadomya haresi, Corbula* sp., *Anchura americana* var. *pusilla*[1]	10	0
Ludlow lignitic member of the Lance formation:		
3. Lignite	2	0
4. Shale and sandstone, interbedded	40	0
5. Lignite	1	0
	53	0

NOTE.—No. 1 was considered as Fort Union but very possibly is Cannonball, as indicated by more recent field work in other parts of the field.

Generalized section along North Fork of Grand River between Bloom, S. Dak., and Haley, N. Dak.[2]

	Ft.	in.
1. Sandstone, brown and yellow, fine grained, thin bedded, and lenses of limestone	30	0
2. Sandstone, marine; burrows of *Teredo selliformis, Anchura americana* var. *pusilla*	10	0
3. Shale	1	0
4. Lignite	2	0
5. Shale and sandstone, interbedded. Sandstone in lower part light brown, medium fine grained, micaceous, containing *Halymenites major, Anatina subgracilis, Nucula subplana, Callista (Dosiniopsis) deweyi, Pholadomya haresi*, imprints of pelecypods, and shark teeth	40	0
6. Lignite	1	0
7. Shale	4	0
8. Lignite	2	3
9. Shale.		
	90	3

NOTE.—No. 1 was considered Fort Union but may be Cannonball; No. 2 and part of No. 5 are marine, and Nos. 3, 4, 6, 7, 8, and 9 are considered fresh-water.

CANNONBALL MARINE MEMBER.

The Cannonball marine member of the Lance formation has been traced and mapped in an area extending from near Mandan, N. Dak., to the vicinity of Ralph post office in Harding County, S. Dak., and 4 miles west of Haley, Bowman County, N. Dak. The presence of brackish-water fossils, *Ostrea glabra*, near Yule, on Little Missouri River in Billings County, N. Dak., shows that the sea probably extended some distance farther to the west than its sediments have been mapped. The extent of this member east of Missouri River is unknown.

The marine member is composed predominantly of dark sandy shale or shaly sandstone with a subordinate amount of dark-yellow and gray sandstone. It also contains some thin limestones. All the strata are lenticular in character, and individual beds can be followed for only short distances. The member is typically exposed in the bluffs of Cannonball River in Tps. 132 and 133 N., Rs. 87 and 88 W. The following sections measured in the type area show the character of the strata of the Cannonball marine member and of the strata which underlie and overlie it:

[1] Names of fossils in all the quoted sections are revised in accordance with nomenclature adopted in this paper.—T. W. S.

[2] The last three sections expose the interrelations of the Ludlow lignitic and Cannonball marine members.

Section near base of the Cannonball marine member in south bluff of Cannonball River, sec. 33, T. 132 N., R. 87 W.

	Ft.	in.
1. Sandstone and sandy shale, yellowish gray	23	0
2. Sandstone, yellowish gray, unconsolidated, with thin lenses of shale near the bottom, containing poorly preserved leaf impressions.	22	0
3. Shale, brown, sandy	22	0
4. Shale, bluish brown	2	0
5. Lignite		4
6. Shale, bluish brown	4	0
7. Sandstone, gray, unconsolidated	45+	
8. Concealed to river level	15	0
	133+	

In this section no definite line could be drawn between the lower part of the Lance and the Cannonball member. No. 1 and probably No. 2 belong to the marine member.

Section in south bluff of Cannonball River about three-fourths of a mile west of foregoing section.

	Ft.	in.
1. Sandstone, yellow	25	0
2. Shale, containing poorly preserved plant remains	4	0
3. Sandstone, gray		
	29	0

The sandstone No. 1 in this section appears to be unconformable on the shale. It is probably the lowest bed of the Cannonball member.

Section in bluffs of Cannonball River near Janesburg, N. Dak., T. 132 N., R. 88 W.

	Ft.	in.
1. Sandstone, fine grained, containing "cannonball" concretions	40+	
2. Shale, dark, sandy	10	0
3. Sandstone and sandy shale, light colored, with "cannonball" concretions	21	6
4. Shale, dark, sandy, with *Pedalion lloydi*	4	0
5. Sandstone and shale, light colored, thin bedded; the shale containing indeterminable vegetable remains	30	0
6. Sandstone, consolidated	1	6
7. Shale, light blue	1	6
8. Sandstone and shale, alternating	15	0
9. Shale, dark, carbonaceous	1	0
10. Sandstone and shale, alternating; base concealed by talus at base of slope	5+	
	129+	

No. 4 and the overlying beds of this section are undoubtedly of marine origin; the lowest beds may be nonmarine, but no definite line could be drawn.

Section of part of Cannonball marine member in south bluffs of Cannonball River, E. ½ sec. 5, T. 132 N., R. 88 W.

	Ft.	in.
Shale, sandy, black, and brown, with *Pyrifusus newberryi* (?), fragments of *Crassitellites*, and a coral belonging to an undetermined genus	16	6
Sandstone, yellow, largely consolidated but with lenticular concretions of hard sandstone	31	6
Shale, sandy, dark gray, nearly black	52	0
	100	0

Section of lower part of Fort Union formation and upper part of Cannonball marine member of Lance formation in south bluff of Cannonball River, secs. 31 and 32, T. 133 N., R. 88 W.

	Ft.	in.
Sandstone, yellow; upper part massive, lower part thin bedded and near base interbedded with thin bands of gray shale	30	6
Sandstone, dark gray to black	3	6
Sandstone, yellow, thin bedded, interbedded with gray shale	13	6
Sandstone, gray, concretionary		6
Shale, bluish gray and somber, sandy	52	0
Shale, dark gray	54	6
Sandstone, yellowish gray, unconsolidated	5	0
Sandstone, yellow, hard at top, containing *Lunatia obliquata, Turris cincta, Turris (Surcula) bacata, Fasciolaria lloydi, Pyrifusus* sp., and an undescribed coral	6	0
Shale, sandy, dark gray, grading at top into sandstone	31	6
	197	0

The upper sandstone of this section probably belongs to the Fort Union formation and the remainder to the Cannonball member of the Lance formation.

Sections similar in general character to those given above are exposed in the bluffs of Heart River [1] and on Cedar Creek. The general appearance of the more sandy rocks is very much like that of the Fox Hills sandstone. The shale is very much like the Pierre.

A peculiar feature of both the Fox Hills sandstone and the Cannonball member of the Lance is the abundance of round concretions commonly known as "cannonballs." They are formed by cementation of the sandy shale by the deposition of calcium carbonate. These are true septarian nodules with radiating and concentric veins of calcite. The best examples observed are in a railway cut a few miles west of Raleigh, N. Dak. Where the "cannonballs" are exposed by stream erosion they are mostly weathered and broken to pieces.

The rocks of the Cannonball member weather typically into rounded hills, and in the interstream areas natural rock exposures are very few. In a large part of the area where the member was examined in South Dakota the only evidences that the beds are of marine origin are a few thin beds of nodular fossiliferous limestone, the presence of which is shown by the lines of residual boulders at the borders of level-topped hills. The topography is such, however, that these horizons can be followed for long distances. No definite line could be drawn in the field between the Cannonball marine member and the lower part of the Lance. The contact of the two groups of strata is exposed at only a few places, and in all such cases it seems to be impossible to tell where the beds of nonmarine origin stop and those of marine origin begin. It follows from the foregoing statement that there is no evidence of unconformity at this horizon.

The relationship of the Cannonball member with the underlying lower part of the Lance is well shown in the region northwest of Solen on Cannonball River, N. Dak. In this area the characteristic chaos of badlands formed by

[1] For details of some of these sections see U. S. Geol. Survey Geol. Atlas, Bismarck folio (No. 181), p. 3, 1912.—T. W. S.

the erosion of the sandstone and shale of the lower part of the Lance is bordered on the north by a high, nearly level plateau which is capped by the lower fossiliferous sandstone of the Cannonball member. The top of the plateau is approximately 500 feet above and only about 2 miles distant from the river. The characteristic badland-forming strata of the lower part of the Lance extend up to within about 100 feet of the top of the plateau, but here, as elsewhere, no sharp line of demarkation can be drawn.

Lloyd and Hares make this additional statement about the interrelationships of the Ludlow lignitic member and the Cannonball marine member of the Lance formation:

It has been shown that the Lance formation in a large region immediately west of Missouri River consists of two parts, the upper of which, the Cannonball member, is marine and contains a fauna similar to but not identical with that of the Fox Hills sandstone. The Cannonball member becomes gradually thinner toward the west, and the sea in which it was deposited perhaps did not extend as far west as the Montana line. The oyster beds near Yule in Billings County, N. Dak., first discovered by Leonard and later described by Stanton,[1] may represent the westernmost limit to which the Cannonball sea extended. This region was studied in 1911, and it was found by Hares that the beds containing the oysters are about 700 feet above the base of the Lance.

The zone in which *Ostrea glabra* and *Ostrea subtrigonalis* occur, in Tps. 135 and 134 N., R. 105 W., is considered the westward extension (so far as known at present) of the strata of marine origin, as the oysters are brackish-water animals and consequently must have had some connection with the open sea. The most westerly collection of the Cannonball marine fauna is only 30 miles east of this place, in sec. 21, T. 129 N., R. 100 W., 4 miles west of Haley, and occurs stratigraphically within 100 feet of the T Cross lignite bed, which was traced from T. 134 N., R. 105 W., to the west side of T. 129 N., R. 101 W. The oysters occur about 70 feet above the same lignite bed; it is assumed that the seaward connection was to the east. The oysters also occur about 120 feet below the base of the Fort Union formation, which in the Little Missouri region has the same characteristics (channel conglomerate, light-yellow, somewhat massive sandstone) as it does in the Cannonball River country, where it rests directly on the Cannonball marine member. It appears that the sea in which were deposited some 300 feet of marine sediments transgressed westward across the lignitic strata of the Ludlow member and that the position of its westward limit is underneath the divide between the drainage of Little Missouri and that of Grand and Cannonball rivers. All of the *Triceratops* collected in the Little Missouri country came from below the T Cross lignite bed and the oysters from above it. Calvert, however, states that in Montana "ceratopsian bones were found just above the lowest persistent lignite bed, but there is certainly nothing in the character of the overlying strata to suggest that similar bones do not occur therein up through a stratigraphic distance of perhaps 500 feet."[2] The T Cross lignite bed was mapped to the Montana State line, and it is undoubtedly the same lignite as the "persistent lignite" referred to above.

The presence of numerous lignite beds in the upper part of the Ludlow lignitic member of the Lance is in strong contrast to the undifferentiated lower part of the formation, and the absence of marine fossils in this member is in contrast to the Cannonball marine member. The Ludlow lignitic and the Cannonball marine members are considered to be contemporaneous in age.

It is evident from the above description that the Cannonball marine member rapidly thins toward the west until it is reduced to one or two thin beds which extend as tongues into the predominantly continental deposits of the Ludlow lignitic member, and although the exposures are not sufficient to show the connection it is reasonably certain that one of these tongues is directly connected with the oyster bed near Yule, on the Little Missouri, which must represent a brackish-water estuary or inlet at the western margin of the Cannonball sea.

TERTIARY SYSTEM.

Lloyd and Hares discuss the Fort Union formation and overlying rocks as follows:

FORT UNION FORMATION.

West of Missouri River the Fort Union formation overlies the Cannonball member of the Lance, and on Little Missouri River it overlies the Ludlow lignitic member of the Lance. In this part of the Dakotas a large part of the formation has been removed by erosion, but in Billings County, N. Dak., one of the writers (Hares) has found a thickness of 1,025 feet. The formation consists of calcareous sandstone and shale of continental origin, containing numerous thick persistent beds of lignite and an abundant flora and fresh-water invertebrate fauna. Some of the thick lignite beds have burned extensively, and great numbers of red hills composed of fused and baked rock are characteristic features of the formation. The lower 100 feet of the formation is made up almost wholly of partially consolidated yellow and gray fine-grained sandstone, which is in some localities indistinguishable from the sandstone at the top of the Cannonball member. At numerous other exposures, however, where the upper bed of the Cannonball member is a sandy shale, the contact is easily followed. At one locality on the north bank of Heart River in T. 136 N., R. 88 W., there is an erosion channel from 30 to 50 feet deep in the Cannonball member filled with the channel deposits of a Fort Union stream. Similar channel sandstones at the base of the Fort Union were seen along Little Missouri, near Yule, and at the mouth of Deep Creek, and also on Sand Creek, in Billings

[1] Stanton, T. W., The age and stratigraphic relations of the "*Ceratops* beds" of Wyoming and Montana: Washington Acad. Sci. Proc., vol. 11, p. 249, 1909; Fox Hills sandstone and Lance formation ("*Ceratops* beds") in South Dakota and eastern Wyoming: Am. Jour. Sci., 4th ser., vol. 30, pp. 183–184, 1910.

[2] Calvert, W. R., and others, Lignite in eastern Montana: U. S. Geol. Survey Bull. 471, p. 197, 1912.

County, N. Dak. These strata show evidence of a rapid change in the character of the sedimentation. They consist predominantly of coarse sandstone containing lenses or pockets of conglomerate and of soft clay shale. The conglomerate consists of pebbles derived from the strata of the surrounding region and contain numerous waterworn bones, teeth, fish scales, fragments of silicified wood, and lignite in the form of tree trunks. Among the vertebrate remains are two mammalian teeth which have been identified by Dr. J. W. Gidley, of the U. S. National Museum, as *Euprotogonia* sp., second lower molar of left jaw, and *Pantolamda cavirictus*, upper premolar. Both of these species are found in the Fort Union beds of Sweetgrass County, Mont. The remaining fragments are identified as representing *Champsosaurus*, a crocodile, a turtle, and *Lepisosteus*.

Lenses of conglomerate similar to the one described above were seen at other localities near the base of the Fort Union along Heart River, and in one exposure a bed of conglomerate a few inches thick forms the base of the formation. Along Little Missouri in sec. 31, T. 138 N., R. 102 W., a conglomerate at the base of the Fort Union contains boulders up to a foot in diameter. The unconformity shown in these exposures is such as would be expected in a transition from marine to continental sedimentation.

ROCKS OF POST-FORT UNION AGE.

The rocks of post-Fort Union age in this region embrace (1) small remnants of sandstone, marl, and limestone of the White River formation on the tops of a few high buttes; (2) sand and gravel beds on the tops of high buttes, probably deposited by streams previous to the present cycle of erosion and derived in part from the White River formation; (3) terrace gravel in the valleys of the larger streams from 50 to 250 feet above the present valley floors; and (4) a large number of scattered glacial boulders, the remnants of the drift of one of the earlier glacial epochs. These later rocks occupy small areas and are not shown on the accompanying map.

FAUNAL RELATIONS.

SPECIES COLLECTED.

The following species have been collected in the Cannonball marine member of the Lance formation:

Nodosaria sp.
Cristellaria sp.
Trochocyathus dakotaensis Vaughan, n. sp.
Trochocyathus? neumani Vaughan, n. sp.
Paracyathus lloydi Vaughan, n. sp.
Paracyathus thomi Vaughan, n. sp.
Paracyathus kayserensis Vaughan, n. sp.
Steriphonotrochus leithensis Vaughan, n. sp.
Solemya bilix White.
Nucula planimarginata Meek and Hayden.
Nucula subplana Meek and Hayden?
Leda mansfieldi Stanton, n. sp.
Yoldia scitula Meek and Hayden.
Yoldia evansi Meek and Hayden.
Yoldia thomi Stanton, n. sp.
Cucullaea shumardi Meek and Hayden.
Cucullaea nebrascensis Owen?
Culcullaea solenensis Stanton, n. sp.
Trigonarca? hancocki Stanton, n. sp.
Glycimeris subimbricata (Meek and Hayden).
Pedalion lloydi Stanton, n. sp.
Pteria linguaeformis (Evans and Shumard).
Modiolus schallerensis Stanton, n. sp.
Crenella cedrensis Stanton, n. sp.
Crenella elongata Stanton, n. sp.
Pholadomya haresi Stanton, n. sp.
Anatina subgracilis (Whitfield).
Arctica ovata (Meek and Hayden).
Eriphyla mandanensis Stanton, n. sp.
Crassatellites evansi Meek and Hayden.
Corbicula cytheriformis Meek and Hayden.
Corbicula berthoudi White.
Lucina cedrensis Stanton, n. sp.
Callista (Dosiniopsis) nebrascensis Meek and Hayden.
Callista (Dosiniopsis?) deweyi Meek and Hayden.
Corbula mactriformis Meek and Hayden.
Panope simulatrix Whiteaves?
Teredo selliformis Meek and Hayden.
Teredo globosa Meek and Hayden.
Dentalium pauperculum Meek and Hayden.
Turbonilla cordensis Stanton, n. sp.
Epitonium dakotense Stanton, n. sp.
Lunatia obliquata Hall and Meek.
Lunatia subcrassa Meek and Hayden.
Turritella haresi Stanton, n. sp.
Anchura (Drepanochilus) americana var. pusilla Stanton n. var.
Anchura (Drepanochilus) perveta Stanton, n. sp.
Anchura (Drepanochilus) perveta var. gracilis Stanton, n. var.
Calyptraphorus septentrionalis Stanton, n. sp.
Cantharus (Cantharulus) vaughani (Meek and Hayden).
Pyrifusus (Neptunella) newberryi (Meek and Hayden).
Pyrifusus (Neptunella) gracilis Stanton, n. sp.
Levifusus? tormentarius Stanton, n. sp.
Pyropsis hancocki Stanton, n. sp.
Fasciolaria lloydi Stanton, n. sp.
Fasciolaria? mandanensis Stanton, n. sp.
Fasciolaria? cordensis Stanton, n. sp.
Fasciolaria (Mesorhytis) dakotensis Stanton, n. sp.
Psilocochlis? occidentalis Stanton, n. sp.
Turris lloydi Stanton, n. sp.
Turris cordensis Stanton, n. sp.
Turris? tormentaria Stanton, n. sp.
Turricula janesburgensis Stanton, n. sp.
Turricula textilis Stanton, n. sp.
Turricula bacata Stanton, n. sp.
Turricula cincta Stanton, n. sp.
Turricula? contorta (Meek and Hayden).
Ringicula dubia Stanton, n. sp.
Cylichna scitula Meek and Hayden?
Cylichnella dakotensis Stanton, n. sp.
Lamna cuspidata Agassiz.
Otodus obliquus Agassiz.

In the above list the following five forms suggest brackish-water deposits because the identical or closely related species are known with only brackish-water or fresh-water associates in other formations:

Modiolus schallerensis.
Corbicula cytheriformis.
Corbicula berthoudi.
Panope simulatrix.
Corbula mactriformis.

In the Cannonball collections, however, they are all associated at the same localities with marine species, and in only one small lot (from sec. 22, T. 132 N., R. 86 W., 1 mile west of Schaller, N. Dak.) is there a predominance of *Modiolus*, *Corbicula*, and *Corbula* so as to suggest a brackish-water deposit. There are no oysters except in the extralimital area on Little Missouri River, where the beds containing *Ostrea glabra* Meek and Hayden and *Ostrea subtrigonalis* Evans and Shumard are believed to be contemporaneous with the Cannonball member. With these exceptions the fauna is strictly marine. It includes 2 species of Foraminifera, 6 of corals, 60 of mollusks, and 2 of sharks. The Foraminifera and the corals belong to genera that range from Mesozoic to Recent. The sharks (represented by teeth only) are identified with species that are recorded from Upper Cretaceous, Eocene, and Miocene.

COMPARISON WITH CRETACEOUS FAUNAS.

Of the 60 molluscan forms 33 (including one variety) are described as new and 27 are identified with previously described forms, of which 5 were originally attributed to the Fox Hills sandstone but came from localities now known to belong to the Cannonball marine member of the Lance formation, as follows:

Glycimeris subimbricata.
Arctica ovata.
Teredo selliformis.
Teredo globosa.
Cantharus (Cantharulus) vaughani.

Arctica ovata has since been recorded from the Bearpaw shale, and *Cantharus* (*Cantharulus*) *vaughani* from the Fox Hills sandstone. It will be profitable to group all the 25 species having an outside distribution according to the formations in which they are found. The largest list is in the Fox Hills fauna, as follows:

Solemya bilix.
Nucula planimarginata.
Yoldia scitula.
Yoldia evansi.
Cucullaea shumardi.
Cucullaea nebrascensis.
Pteria linguaeformis.
Callista (Dosiniopsis) nebrascensis.
Callista (Dosiniopsis?) deweyi.
Panope simulatrix.
Dentalium pauperculum.
Lunatia obliquata.
Lunatia subcrassa.
Anchura (Drepanochilus) americana. Represented in Cannonball by var. pusilla.
Cantharus (Cantharulus) vaughani.
Pyrifusus (Neptunella) newberryi.
Turricula? contorta.
Cylichna scitula.

Several of the same species with a few others are found in the Pierre shale, as follows:

Nucula subplana.
Yoldia scitula.
Yoldia evansi.
Pteria linguaeformis.
Anatina subgracilis.
Crassatellites evansi.
Callista (Dosiniopsis) nebrascensis.
Callista (Dosiniopsis?) deweyi.
Dentalium pauperculum.
Lunatia obliquata.
Anchura (Drepanochilus) americana. Represented in Cannonball by var. pusilla.
Pyrifusus (Neptunella) newberryi.

In areas farther west where the Pierre shale is represented by several formations, in part marine, such as the Bearpaw, Lewis, and Claggett shales, and in part continental, such as the Judith River and Mesaverde formations, these equivalents also have several species in common with the Cannonball member. The following species occur in the Bearpaw shale:

Nucula planimarginata.
Nucula subplana.
Callista (Dosiniopsis?) deweyi.
Lunatia subcrassa. Type from Claggett shale.
Anchura (Drepanochilus) americana. Represented in Cannonball by var. pusilla.
Arctica ovata.

The following species occur in the Judith River formation:

Corbicula cytheriformis. Found also in Mesaverde.
Panope simulatrix?

The brackish-water beds in the Laramie formation, which overlies the Fox Hills sandstone in northeastern Colorado, also have

yielded three species found in the Cannonball member:

Corbicula cytheriformis.
Corbicula berthoudi.
Panope simulatrix?

The fauna contains one species, *Corbula mactriformis*, which is found in the basal part of the overlying Fort Union formation associated with fresh-water mollusks. This is the only species in the Cannonball fauna that is known to range into a later formation, presumably because it was the only one that was able to adapt itself to a fresh-water habitat. All the others with an outside distribution are found in older formations of the Upper Cretaceous in the same general region. A considerable proportion of the species described as new are also more or less closely related to Cretaceous species. It is evident, therefore, that a large element in the Cannonball fauna is directly descended without specific change or with only slight change from the preceding Cretaceous faunas of the Rocky Mountain and Great Plains region. These late Cretaceous faunas show a progressive modernization due to the gradual elimination of distinctive Mesozoic generic types and the concurrent introduction of modern generic types which continued through the Tertiary and are still living in the Recent fauna. For example, the strictly Cretaceous *Inoceramus*, *Baculites*, and *Placenticeras*, which are so abundant in the Pierre shale, are not known in the Fox Hills sandstone, and many of the much more diversified gastropods and other new elements in the Fox Hills fauna have so modern an aspect that Meek and Hayden said in one of their early papers: [1]

> Many of the species approximate so closely to Tertiary forms that did we not find them everywhere associated with *Ammonites*, *Scaphites*, and other genera which are known not to have existed later than the Cretaceous epoch, we should at once pronounce the formation in which they occur Tertiary.

The ammonite *Sphenodiscus* and the various forms of *Scaphites* which characterize the Fox Hills fauna and prove it to be Cretaceous were not descendants of earlier species in the Interior province but were immigrants from some other area, probably the Gulf province, which arrived about the beginning of Fox Hills time. They have not been found in the Cannonball marine member of the Lance formation, and the direct evidence of its Mesozoic age that their presence would afford is therefore lacking. The genus *Anchura*, which is a conspicuous element in the Cannonball fauna, may be claimed as a strictly Mesozoic type, though the related genus *Aporrhais* continued on to the present. The Cannonball forms of *Anchura* appear to be direct descendants from those in the Pierre and Fox Hills.

To recapitulate, 40 per cent of the molluscan species in the Cannonball fauna are known in the combined Pierre and Fox Hills, or Montana fauna of the same general region, and 30 per cent of them have been found in the Fox Hills fauna. In earlier statements I have spoken of the Cannonball fauna as a modified Fox Hills fauna, and the relationship is close enough to justify that term, but the fauna clearly belongs to the open sea and was modified after Fox Hills time by the extinction or emigration of the ammonoids and a few other Mesozoic types and by the introduction of a considerable number of new types that are not known in the Fox Hills and Pierre faunas. The modification therefore can not be attributed to isolation and a long time interval under changed conditions, as has been suggested [2] by some who seek an easy explanation of the disagreement in age determinations based respectively on the fossil animals and the fossil plants of the Lance formation.

COMPARISON WITH TERTIARY FAUNAS.

The single species which ranges into the overlying Fort Union formation (*Corbula mactriformis*) has already been mentioned, but as the Cannonball member is marine and the Fort Union and all other known Eocene formations of the Great Plains and Rocky Mountain region do not contain marine deposits, it is necessary to make comparisons with marine Eocene faunas of other areas. The Eocene faunas of the Pacific coast evidently belong to

[1] Acad. Nat. Sci. Philadelphia Proc., vol. 9, p. 113, 1857.

[2] This suggestion has been published by M. R. Campbell (Guidebook of the western United States, Part A, Northern Pacific Route: U. S. Geol. Survey Bull. 611, p. 53, 1915) in the following form: "Although the question is not finally settled, it seems probable that the Cannonball member of the Lance formation is Tertiary and that the Cretaceous fauna which occurs in it is merely a surviving remnant of an old Cretaceous fauna which formerly lived in the open sea but which as this sea became more and more restricted and eventually inclosed by land preserved its old form even into Tertiary time."

a totally different province and offer no basis for specific comparison. In the Gulf Coastal Plain the marine Tertiary faunas are well developed, and those of the lower Eocene (Midway and Wilcox groups), which are the only ones that need be compared with the Cannonball fauna, have been monographed in a preliminary way by G. D. Harris.[1]

These faunas apparently contain no forms that are specifically identical with any of those found in the Cannonball fauna, though there are a few somewhat closely related species and there is some general faunal resemblance caused by the fact that the faunas have a large proportion of genera in common. These common genera were almost all introduced in unquestioned Cretaceous deposits and are present in the Pierre and Fox Hill faunas. As an example the Turritidae may be cited. This family is represented in the Cannonball fauna by a number of forms described as *Turris* and *Turricula*. In both the Midway and Wilcox faunas the family has a still greater development, including several species, especially in the Wilcox, of the same general aspect as some of the Cannonball species. Thus *Turris lloydi* Stanton may be compared with *Pleurotoma nebulosa* Harris, and *Turricula janesburgensis* Stanton with *Pleurotoma nasuta* Whitfield, but the ancestors of these groups are found in the Fox Hills and Pierre faunas. In other molluscan groups *Pholadomya haresi* Stanton may be compared with *P. mauryi* Harris, *Levifusus? tormentarius* Stanton with *L. trabeatus* Conrad, and *Calyptraphorus septentrionalis* Stanton with *C. velatus* Conrad. The genus *Calyptraphorus*, which is represented in the Cannonball collections by a single fragmentary specimen, has heretofore been known in American rocks only in the Eocene ranging from Midway to Jackson, but in India it is apparently present in the Cretaceous (Trichinopoly and Arrialoor groups), because, in my opinion, Gabb was justified in referring *Rostellaria palliata* Forbes to *Calyptraphorus*. The genus *Cylichnella*, represented by *C. dakotensis*, has not been recorded in rocks older than Tertiary. Some of the other genera found in the Cannonball fauna, such as *Leda*, *Yoldia*, *Nucula*, *Cucullaea*, *Glycimeris*, *Pedalion*, *Pteria*, *Modiolus*, and *Crenella*, have been represented by similar types from the Cretaceous to the present time and do not mean much unless specific identity is involved, when they may become important in showing direct connection between faunas.

The Cannonball fauna has the general aspect of a Tertiary fauna on account of the absence of most of the exclusively Mesozoic types and the preponderance of long-lived modern types, but its close relationship with the Cretaceous is shown by the fact that 24 of its species (40 per cent of its known molluscan fauna) are identified with species found in the late Cretaceous formations of the same general region, and 18 of the species (30 per cent) are known in the Fox Hills fauna. This rather close faunal relationship is interpreted to mean that the time interval between the Fox Hills and the Cannonball was not very long.

CONTRAST BETWEEN CRETACEOUS AND EOCENE FAUNAS OF ATLANTIC AND GULF COASTAL PLAIN.

The ammonite genus *Sphenodiscus*, the types of *Scaphites*, and some other fossils found in the Fox Hills sandstone indicate that the Fox Hills is the approximate equivalent of the upper part of the *Exogyra costata* zone, which lies near the top of the Cretaceous in the Atlantic and Gulf Coastal Plain. It will therefore aid in fixing the place of the Cannonball member in the general time scale to compare the faunal relations between it and the Fox Hills, as briefly presented above, with the relations existing between the latest Cretaceous and earliest Eocene faunas of the Coastal Plain. The latter subject is ably discussed by Stephenson,[2] from whose paper the following statement is quoted:

> At no place known between Maryland and the Rio Grande are the Upper Cretaceous deposits immediately below the Eocene contact markedly younger than the upper part of the *Exogyra costata* zone of the eastern Gulf region, nor are the Eocene deposits immediately above the contact older than the Midway. In this connection it should be stated that the Rancocas and Manasquan formations of New Jersey, which carry only a meager fauna, are thought to be somewhat younger than the *Exogyra costata* zone, and the upper part of the Escondido formation of southwestern Texas may be a little younger than that zone, although its fauna is composed of strictly Mesozoic types, of which the genus *Sphenodiscus* is the

[1] The Midway stage: Bull. Am. Paleontology, vol. 1, pp. 17-270, pls. 11-25, 1896; The lignitic stage: Idem, vol. 2, pp. 195-294, pls. 7-20, 1897; vol. 3, pp. 1-128, pls. 1-12, 1899.

[2] Stephenson, L. W., The Cretaceous-Eocene contact in the Atlantic and Gulf Coastal Plain: U. S. Geol. Survey Prof. Paper 90, pp. 155-182, 1915.

most striking example. The time represented by the unconformity at other places throughout the Coastal Plain is therefore approximately equal to or greater than the time represented by the unconformity in the eastern Gulf region. As the faunas above and below the contact are best known in the Gulf region the available data relating to that region form the chief basis for the statements which follow.

During the time represented by the unconformity separating the Cretaceous and Eocene strata of the eastern Gulf region some very important changes took place in the molluscan life of the region. A preliminary study of the faunas has shown that 168 or more species belonging to the subkingdom Mollusca existed in the zone of *Exogyra costata* of the Upper Cretaceous. Of these not a single species is known with certainty to have been found in the basal Eocene or Midway formation. Several species of Cretaceous mollusks have been reported from basal Eocene beds at different places in the Atlantic and Gulf Coastal Plain, but when the records are critically examined more or less uncertainty is found in each record, either as to the correctness of the identifications or as to the authenticity of the localities at which they were reported to have been found.

The 168 species of mollusks in the zone of *Exogyra costata* represent 89 genera. At least 20 of the more common of these genera became extinct before the Midway formation began to be deposited, and these are enumerated in the list which follows. One whole order, the Ammonoidea, which included five or more genera, entirely disappeared.

Genera common in the zone of Exogyra costata (Upper Cretaceous), which became extinct before the deposition of the Midway formation (Eocene).

Breviarca.	Cyprimeria.	Belemnitella.
Nemodon.	Legumen.	Order Ammonoidea:
Gervilliopsis.	Ænona.	Baculites.
Inoceramus.	Linearia.	Scaphites.
Exogyra.	Leptosolen.	Sphenodiscus.
Paranomia.	Perissolax.	Hamites.
Liopistha.	Pugnellus.	Turrilites.

The genus *Trigonia*, which is common in the zone of *Exogyra costata*, does not appear in the Eocene of the Atlantic and Gulf Coastal Plain but occurs rarely in the post-Cretaceous in other parts of the world. One genus, *Hamulus*, belonging to the subkingdom Vermes, or worms, became extinct. Some of the smaller forms of life, such as Foraminifera, Bryozoa, and Ostracoda, have not been studied critically, and it is not known what changes may have taken place among them. However, R. S. Bassler has found that a bryozoan fauna which occurs in the Rancocas, the youngest but one of the Upper Cretaceous formations of New Jersey, reappears in part with certain varietal changes in the Aquia formation (Eocene) in Maryland.

Although practically all the species of mollusks in the Midway formation are different from those found in the underlying Cretaceous, the number of genera that make their first appearance in the Midway is probably less than the number of Upper Cretaceous genera that became extinct in the interval represented by the unconformity. However, using Harris's paper, already cited,[1] as principal authority, the writer has been able to note at least seven common genera in the Midway that are not found stratigraphically below that level in the eastern Gulf region; these are *Chama*, *Venericardia*, *Meretrix*, *Mazzalina*, *Calyptraphorus*, *Mesalia*, and *Enclimatoceras*. Some of these genera are known in the Upper Cretaceous in other parts of the world.

Of the seven genera listed by Stephenson as common in the Midway fauna and not found at a lower level in that region only one, *Calyptraphorus*, has been recognized in the Cannonball fauna (represented by a single broken specimen), and of the 20 genera common in the zone of *Exogyra costata* which became extinct before Midway time only *Nemodon*, *Linearia*, *Belemnitella*, *Scaphites*, and *Sphenodiscus* are known in the Fox Hills fauna, and none of them has been found in the Cannonball fauna. The considerable differences between the Fox Hills fauna and the fauna of the *Exogyra costata* zone are probably due in part to the differences in lithologic facies, in part to geographic separation, and possibly in part to differences in climate. Though both faunas belong to Atlantic waters as contrasted with the Pacific, there was certainly no direct broad connection in late Cretaceous time between the Mississippi embayment and the waters which covered the Great Plains area.

The point to be emphasized in the preceding comparisons is that the connection between the Fox Hills and Cannonball faunas is closer than that between the faunas of the *Exogyra costata* zone and the Midway. Stephenson further discusses the magnitude of the faunal changes in passing from Cretaceous to Eocene in the Gulf region, compares the known floras, and finally concludes his interpretation of the hiatus in the following words:

> It is pretty generally conceded by paleontologists that evolutionary changes have proceeded more rapidly at certain times during the earth's history than at other times, but if this quickening of development is admitted the hiatus, in order to produce the observed changes, must have been of great duration even when measured in terms of geologic time. How much of that time should be classed with the Cretaceous and how much with the Tertiary can not be determined with the available data. It is reasonable to conclude, however, that Cretaceous time did not end with the deposition of the uppermost Cretaceous strata now preserved, nor did Tertiary time begin with the deposition of the lowermost Eocene strata. The line separating the two periods probably lies somewhere toward the middle of the hiatus.

[1] Harris, G. D., The Midway stage: Bull. Am. Paleontology, vol. 1, 156 pp., 15 pls., 1898.

It is my opinion that the fauna of the Cannonball marine member of the Lance formation indicates that the formation belongs within the hiatus discussed by Stephenson and below the line which he postulates as separating Cretaceous from Eocene. It is certainly somewhat younger than the zone of *Exogyra costata* and most probably considerably older than the Midway formation.

PALEOGEOGRAPHIC RELATIONS.

Another line of evidence concerning the age of the Cannonball member is dependent on the geographic location of the Cannonball marine deposits and the geologic history of the region in which they are found. To state the facts bluntly, the Cannonball deposits are in the midst of a great area of marine Cretaceous rocks and a thousand miles from the nearest known marine Eocene rocks. The same facts are graphically presented in figures 2 and 3, which are adapted from Schuchert's paleogeographic maps [1] with the approximate area of the Cannonball member added. The characteristic feature of North American geography in Upper Cretaceous time was the great epicontinental sea which extended from the western part of the Gulf of Mexico across the larger part of the Great Plains and Rocky Mountain regions far into Canada and probably connected with the Arctic Ocean. It began with the deposition of the Dakota sandstone and continued with some variations in area throughout the Colorado and Montana epochs. Figure 2 shows its approximate form within the United States at the time the Pierre shale or lower part of the Montana group was laid down. It was then not quite so extensive as it had been in the Colorado epoch and there were varying areas within it of swamp, estuary, and flood plain with possibly some higher lands during both Colorado and Montana time. Its area in Fox Hills time, though not quite so definitely determined, was probably somewhat smaller than in Pierre time, but Fox Hills deposits are known from southern North Dakota through eastern Montana and eastern Wyoming to middle Colorado east of the Front Range. The Cannonball marine member of the Lance formation is well within the area that had been covered by the epicontinental sea of Pierre and Fox Hills time.

Other marine areas of Upper Cretaceous time covered the Atlantic and Gulf Coastal Plain, with the Mississippi embayment extending up to the mouth of the Ohio, and the narrow Pacific Border region broadening into an embayment in Oregon.

The Eocene map (fig. 3) shows relatively little change from the Cretaceous in the coastal border regions. The form of the Mississippi embayment remains about the same. The other submerged areas of the Atlantic and Gulf Coastal Plain and on the Pacific Border show only minor changes. But the great epicontinental sea of the western interior, which is so conspicuous on all Upper Cretaceous maps, has disappeared. There is no marine Eocene (unless the Cannonball member is Eocene) nor marine Tertiary of any kind between the Coastal Plain and the Pacific Border province; neither is any marine Eocene known between the Mississippi embayment and the Arctic coast.

The comparatively small area in which the Cannonball member has been found lies about a thousand miles from the nearest Coastal Plain Eocene at the head of the Mississippi embayment and about the same distance from the nearest Pacific Border Eocene in Oregon and Washington. No other point in the United States is farther from known marine Eocene. Geographically and historically, therefore, the Cannonball marine member of the Lance formation is connected with the Cretaceous rather than the Eocene.

SUMMARY.

The Cannonball marine member of the Lance formation lies immediately beneath the Fort Union formation and rests on continental deposits of the Lance formation, which in turn overlie the marine Cretaceous Fox Hills sandstone.

Its fauna is strictly marine and includes 2 species of Foraminifera, 6 of corals, 60 of Mollusca, and 2 of sharks. While its molluscan fauna has a modern aspect, on account of the lack of ammonoids and other distinctively Mesozoic groups, it is connected with the preceding late Cretaceous faunas of the same region by the specific identity of 40 per cent

[1] Schuchert, Charles, Paleogeography of North America: Geol. Soc. America Bull., vol. 20, pls. 35, 96, 1908.

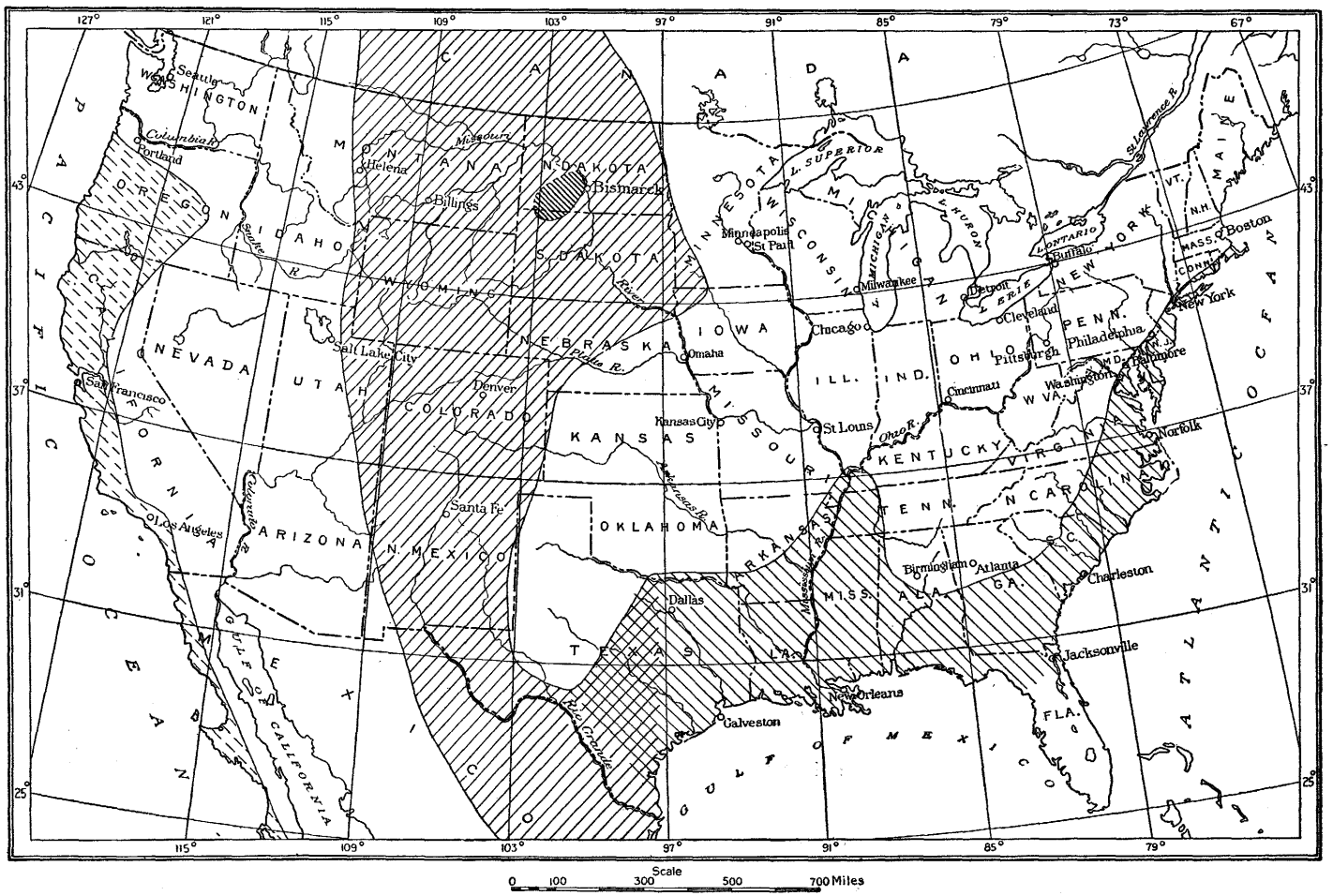

FIGURE 2.—Sketch map showing position of marine Lance deposits with reference to Upper Cretaceous Pierre sea.

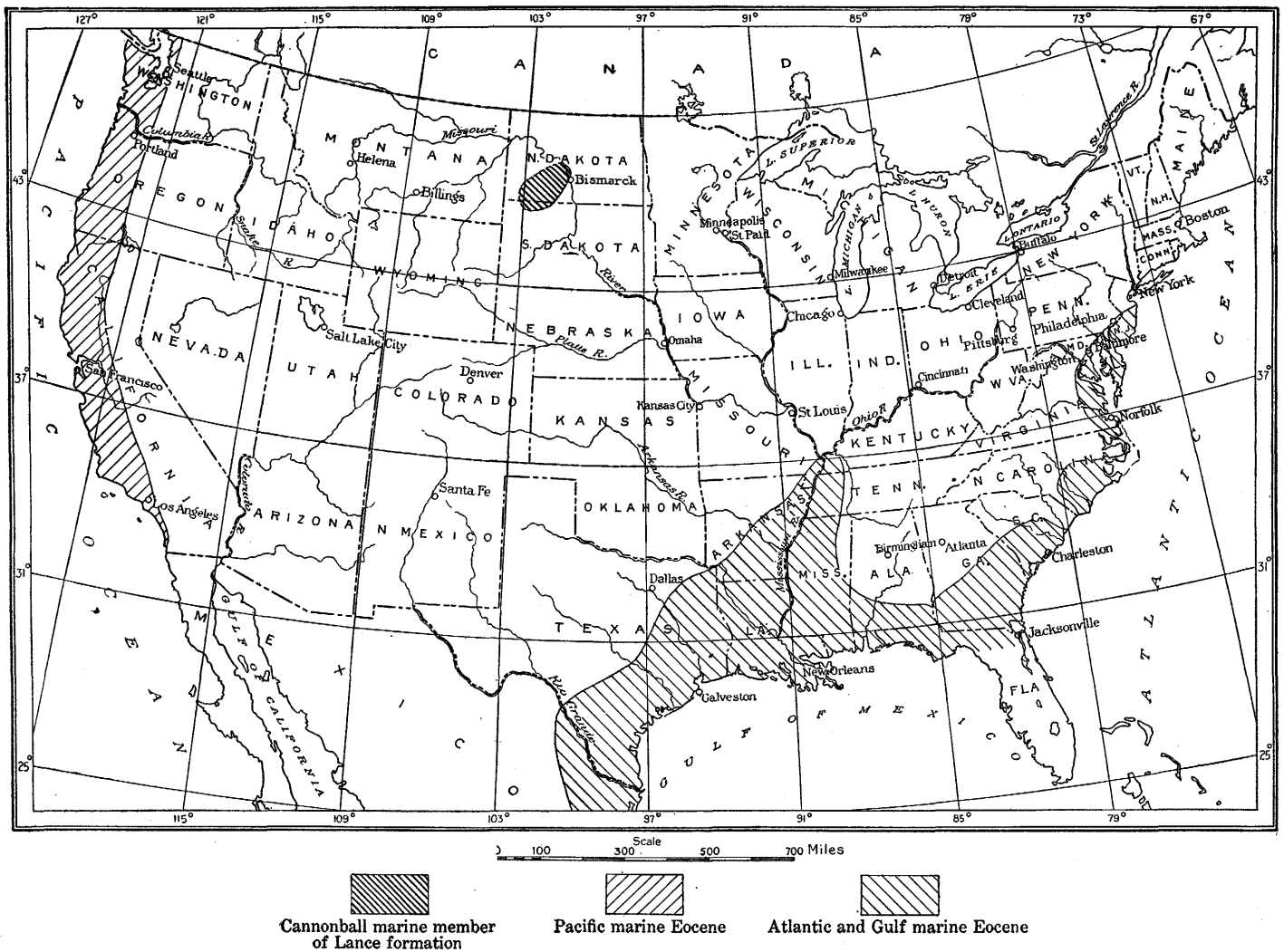

FIGURE 3.—Sketch map showing position of marine Lance deposits with reference to Eocene seas.

of its species. No Eocene species have been identified in it except one from the Fort Union.

Geographically and historically the Cannonball member is much more closely connected with the Cretaceous than with the Eocene, for the reason that it is in the midst of an area that was covered by the sea practically throughout Upper Cretaceous time, while it is a thousand miles distant from recognized marine Eocene deposits.

The conclusion is therefore reached that the Cannonball marine member and consequently the whole of the Lance formation is of Cretaceous age.

In subsequent pages the species will be described and illustrated, so that others may see the paleontologic evidence and form an independent judgment of the validity of the conclusions based upon it.

No attempt is here made to harmonize or explain away the evidence of the flora found in the nonmarine portions of the Lance formation, which has led to a different age determination. Knowlton [1] says:

> The Lance flora embraces about 100 named and described species, as well as a considerable number not yet described. Of these 100 species, over 75 are typical Fort Union species that have never been found in older beds and most of them only in the Fort Union.

As the Fort Union formation is generally accepted as Eocene this close relationship of floras was naturally held to be proof that the Lance formation is Eocene also. It is noteworthy that the Fort Union flora of about 500 species, collected mainly in the Dakotas, Montana, and Wyoming, shows comparatively slight specific relationship with the more southern floras that have been referred to the Eocene. Thus the post-Laramie floras of the Denver Basin (Arapahoe with about 30 species and Denver with nearly 200 species) have about 30 species in common with the Fort Union according to Knowlton.[2] The same author [3] states that the Raton flora of 148 species contains only 10 Fort Union species, and Berry [4] reports only 12 Fort Union species in the Wilcox flora of over 300 species. These statistics indicate that the number of Fort Union species found in other American lower Eocene floras is little if any larger than the number common to the western Cretaceous and Eocene floras [5] as determined by paleobotanists and suggest that the differences between the floras on either side of the "post-Laramie unconformity" are not necessarily due to a long lapse of time. In my opinion the combined evidence from all sources is opposed to the existence of a very long unrepresented interval anywhere between Fox Hills and Wasatch deposition.

Whatever may be the final verdict concerning the exact boundary between Cretaceous and Eocene in the interior of the United States, the Cannonball marine member of the Lance formation and its fauna record an important episode in the history of the region, and their evidence must be given full weight before a correct decision can be made.

DESCRIPTION OF SPECIES.

Phylum PROTOZOA.

Class RHIZOPODA.

Order FORAMINIFERA.

Family LAGENIDAE.

Genus NODOSARIA Lamarck.

Nodosaria sp.

Plate I, figure 13.

A small, slender, slightly curved, strongly costate species of *Nodosaria* resembling *N. zippei* Reuss is represented by five specimens preserved as natural molds in sandy clay shale collected in the Cannonball marine member of the Lance formation at locality 8388, in a railway cut 4 miles southwest of Lark, N. Dak., in the SW. ¼ sec. 15, T. 134 N., R. 86 W.

The figure is made from a gutta-percha squeeze of a small fragment which retains the surface sculpture fairly well. It measures 2.5 millimeters in length and consists of seven chambers. The largest specimen collected is 10 millimeters long and has about 20 chambers.

Genus CRISTELLARIA Lamarck.

Cristellaria sp.

A single specimen of *Cristellaria* about a millimeter in diameter was collected in the

[1] Knowlton, F. H., Cretaceous-Eocene boundary in the Rocky Mountain region: Geol. Soc. America Bull., vol. 25, p. 334, 1914.

[2] Knowlton, F. H., Succession and range of Mesozoic and Tertiary floras: Jour. Geology, vol. 18, p. 114, 1910.

[3] Knowlton, F. H., Fossil floras of the Vermejo and Raton formations of Colorado and New Mexico: U. S. Geol. Survey Prof. Paper 101, p. 239, 1917.

[4] Berry, E. W., Lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 149, 1916.

[5] Knowlton gives the number as 21 or 22: Geol. Soc. America Bull., vol 25, p. 332, 1914.

Cannonball marine member of the Lance formation at locality 8463, in the SE. ¼ sec. 19, T. 136 N., R. 87 W., on Heart River 7 miles southwest of Almont, N. Dak. Unfortunately the specimen was lost while under study, but it resembled *C. mamilligera* Karrer as figured in Geological Survey of New Jersey, Paleontology, volume 4, plate 3, figure 8.

Phylum COELENTERATA.

Six species of corals belonging to the family Caryophylliidae are described by T. W. Vaughan in the accompanying paper (pp. 61–66).

Phylum MOLLUSCA.

Class PELECYPODA.

Family SOLEMYACIDAE.

Genus SOLEMYA Lamarck.

Solemya bilix White.

Plate I, figures 1a and 1b.

Solemya bilix White, U. S. Nat. Mus. Proc., vol. 3, p. 158, 1881; vol. 4, pp. 137, 139, pl. [not numbered], fig. 9, 1882.

Original description:

Shell about two and a half times as long as high, broader anteriorly than posteriorly; both ends rounded, the posterior one more narrowly so than the other; both dorsal and basal margins gently convex or nearly straight; test thin and fragile; valves moderately convex from above downward, the greatest convexity in that direction being near the dorsum; beaks having the usual inconspicuous character common to the genus, situated near posterior end; ligament necessarily short but apparently well developed and resting upon a fulcrum of support of the usual character in each valve. Surface bright and, besides the usual lines of growth, marked by numerous faint radiating lines, which are visible to the unassisted eye but are satisfactorily seen only under a lens, nearly uniformly distributed over the whole surface, but upon the middle portion they are arranged in pairs.

Length, 20 millimeters; height at the broader part, which is in front of the middle, 8 millimeters.

This description is based on a single specimen from a locality about 4 miles north of Golden, Colo., where it was found in strata belonging to the Fox Hills sandstone or the upper part of the Pierre shale. In the second publication cited White records the species as occurring at about the same horizon near Julesburg, Colo., but the collection referred to, consisting of about 50 well-preserved specimens, all considerably smaller than the type, is in the National Museum labeled "Narrows of South Platte River, 50 miles east of Greeley, Colo." They differ from the type only in their smaller size (length 9 to 15 millimeters) and better state of preservation, and they seem to have been correctly identified.

The five specimens collected at three different localities in the Cannonball member range in length from 15 to 24 millimeters. They agree perfectly in form with *S. bilix* and are confidently referred to that species, though none of them shows the surface sculpture well enough to determine whether or not the radiating lines have a paired arrangement on the middle part of the shell. The internal casts among the Colorado specimens, as well as those from North Dakota, fail to show this feature, although they bear numerous very fine radiating lines.

Locality and position: The figured specimen was collected near the top of the hill in the northern edge of Mandan, a short distance west of the courthouse. Other specimens were obtained on Heart River 11 miles north of Flasher and on the west bank of Missouri River 1 mile south of Price and 19 miles north of Mandan, N. Dak., all in the upper part of the Cannonball marine member of the Lance formation.

Family NUCULIDAE.

Genus NUCULA Lamarck.

Nucula planimarginata Meek and Hayden.

Plate I, figures 2 and 3.

Nucula planomarginata Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 8, p. 85, 1856

Nucula planimarginata (Meek and Hayden) Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 101, pl. 15, figs. 8 a, b, and pl. 28, fig. 16, 1876.

Meek's description:

Shell transversely subovate or subelliptic, compressed; posterior or shorter side obliquely truncated above and abruptly rounded or subangular below the middle; anterior or longer side cuneate and rather narrowly rounded; base forming a regular semielliptic curve, not crenate within; dorsum declining gently with a gradual convex curve from near the beaks to the anterior extremity; beaks small, incurved, nearly contiguous, and located about halfway between the middle and the posterior side; surface marked by very fine, irregular, radiating, and minute concentric striae; hinge forming at the beaks an angle of about 110°, having in the adult some 26 or 27 denticles on the longer or anterior side of the beaks and about 10 behind in each valve; lunule-like area behind the beaks lanceovate, flattened along each side, and a little convex in the middle.

Length, 0.95 inch [24 millimeters]; height, 0.66 inch [16.75 millimeters]; convexity, 0.38 inch [9.6 millimeters]

Locality and position: The types came from the Fox Hills sandstone on Moreau River, S. Dak., and near Long Lake, N. Dak. The species has also been collected in the Fox Hills sandstone in northern Colorado west of Greeley, in about the same stratigraphic position on Deer Creek near North Platte River, Wyo., and in the Bearpaw shale on Fish Creek and 5 miles north of Musselshell post office, Mont. The specimens here figured were collected in the Cannonball marine member of the Lance formation in the SW. ¼ sec. 34, T. 23 N., R. 17 E., 9 miles east of Lemmon, S. Dak., and on the west bank of Missouri River 1 mile south of Price and 19 miles north of Mandan, N. Dak. Other specimens were obtained 3 and 6 miles east of Flasher, N. Dak.; 5 miles southeast of Strain, in sec. 21, T. 136 N., R. 82 W., N. Dak.; and in sec. 24, T. 23 N., R. 9 E., one-fourth mile east of Bloom, S. Dak.

Nucula subplana Meek and Hayden?

Plate I, figures 4–7.

Nucula subplana Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 8, p. 85, 1856.
Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 99, pl. 17, figs. 7 a, b, 1876.

Meek's description:

Shell small, broad ovate, approaching subtrigonal, much compressed, with height about four-fifths the length; posterior or shorter side obliquely truncated above and narrowly rounded below; anterior side longer and more broadly rounded; basal margin semiovate in outline, not crenulate within; dorsum declining a little with a slightly convex curve from the beaks anteriorly, and a little concave and sloping abruptly behind; beaks moderately prominent, compressed, and located about halfway between the middle and the posterior or shorter side; teeth of the hinge about 15 in each valve in front of the beaks and a smaller number behind; muscular and pallial impressions faintly marked. (Surface unknown.)

Length, 0.37 inch [9.4 millimeters]; height, 0.26 inch [6.6 millimeters]; breadth, 0.12 inch [3 millimeters].

In the collection from the Cannonball member there are numerous specimens of *Nucula* which are of about the same size as *N. planimarginata* and in the preliminary lists were referred to that species. Closer study and comparison have shown that they differ from *N. planimarginata* in several particulars, being relatively higher, more compressed, and with the posterior end more obliquely truncate, but the two species agree in having the ventral border smooth within and the surface marked only by very fine radiating and concentric lines. In form and outline these specimens agree so closely with the types of *N. subplana* that they are doubtfully referred to that species on the assumption that Meek and Hayden's types are immature specimens.

One of the shells figured, which is of about average size, measures 20 millimeters in length, 16 millimeters in height, and about 8 millimeters in convexity.

Locality and position: The types of the species came from the upper part of the Pierre shale on "Yellowstone River, 150 miles from its mouth," near Glendive, Mont. The larger shells here figured are especially abundant in the upper part of the Cannonball marine member of the Lance formation on the west bank of Missouri River 1 mile south of Price and 19 miles north of Mandan, N. Dak. The form has also been collected in the Cannonball member 7 miles south of Leith, N. Dak.; 7 miles southwest and 8 miles southeast of Lemmon, S. Dak. (fig. 7); 3 and 6 miles east of Flasher, N. Dak.; and 3½ miles west of Haley, N. Dak.; also in the Bearpaw shale on Fish Creek and 5 miles north of Musselshell, Mont.

Family LEDIDAE.

Genus LEDA Schumacher.

Leda mansfieldi Stanton, n. sp.

Plate I, figure 8.

Shell small, transversely sublanceolate, compressed; anterior end broadly rounded; posterior end narrowly subangular; anterior third of basal margin broadly rounded, rest of base nearly straight but bending up in a slight curve to the posterior end; dorsal margin nearly straight and horizontal in front of the beak, descending in a concave curve behind; beaks not conspicuous, very slightly in advance of the middle. Surface marked by very fine concentric lines which are about equal to the interspaces.

Length of type, 10 millimeters; height, 5 millimeters; convexity of both valves, about 2 millimeters. Another specimen with about the same proportions is 13 millimeters long.

The species is named for Mr. W. C. Mansfield, of the United States Geological Survey, who collected the type specimen.

Locality and position: Cut on Northern Pacific Railway in the SW. ¼ sec. 15, T. 134 N., R. 86 W., about 4 miles southwest of Lark,

N. Dak., in bluish shale very near the top of the Cannonball marine member of the Lance formation. It was also found in the lower part of the member in T. 134 N., R. 81 W., about 6 miles northwest of Solen, N. Dak., and 75 feet below the top of the member in the SE. ¼ sec. 10, T. 138 N., R. 83 W., on Heart River about 15 miles southwest of Mandan, N. Dak.

Genus YOLDIA Möller.

Yoldia scitula Meek and Hayden.

Plate I, figures 9 and 10.

Nucula scitula Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 8, p. 84, 1856.
Leda scitula Meek and Hayden, idem, vol 12, p. 185, 1860.
Leda (*Yoldia*) *scitula* Meek and Hayden, idem, vol. 12, p. 428, 1860.
Yoldia scitula Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 110, pl. 28, fig. 9, 1876.

Meek's description:

Shell transversely subovate, gibbous in the central and umbonal regions; anterior extremity rather narrowly rounded; posterior side narrower and more compressed, subangular or very narrowly rounded in outline, the most prominent part being above the middle; base forming a semiovate curve, sometimes very slightly sinuous near the middle; dorsum declining from the beaks; cardinal border of each valve having a distinct marginal groove behind the beaks, which forms, when the valves are united, a lanceolate, escutcheon-like depression; beaks rather obtuse, not oblique, placed a little in advance of the middle; surface marked by regular, fine, distinct, concentric lines, which are nearly equal to the grooves between, and more strongly defined on the middle than toward the extremities of the valves.

Length, 0.40 inch [10 millimeters]; height, 0.21 inch [5.5 millimeters]; convexity, 0.20 inch [5 millimeters].

Meek adds that the pallial sinus seen on internal casts is rather distinct though not deeper than is sometimes seen in the genus *Leda* and that the species is referred to *Yoldia* because the form of the shell agrees more nearly with that group.

A few specimens in the Cannonball fauna agree so closely in size and form with this species that I do not hesitate to refer them to it, although the surface sculpture is not perfectly preserved.

Locality and position: The types came from Moreau River, S. Dak., and Long Lake, N. Dak., where they were found in the Fox Hills sandstone. The species is common in that formation and in the upper part of the Pierre shale. In the Cannonball marine member of the Lance formation it has been collected in sec. 7, T. 22 N., R. 17 E., 8 miles southeast of Lemmon, S. Dak. (fig. 10), and in the SE. ¼ sec. 10, T. 138 N., R. 83 W., on Heart River about 15 miles southwest of Mandan, N. Dak., where it occurs in a brown sandstone 75 feet below the top of the formation.

Yoldia evansi Meek and Hayden.

Plate I, figure 11.

Nucula evansi Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 8, p. 84, 1856.
Leda evansi Meek and Hayden, idem, vol. 12, p. 185, 1860.
Leda (*Yoldia*) *evansi* Meek and Hayden, idem, vol. 12, p. 429, 1860.
Yoldia evansi Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 117, pl. 28, figs. 10 a–c, 1876.

Meek's description:

Shell transversely elongate-subelliptical, depressed, rather compressed, or a little gibbous in the central and umbonal regions; both extremities narrowly rounded, the most prominent part of each being above the middle; basal margin nearly straight, parallel to the cardinal border along the middle, and rounding up gradually in front and behind; dorsal margin nearly straight, provided, behind the beaks, with a shallow groove in each valve; beaks depressed, small, and almost in contact, located a little in advance of the middle of the shell; surface smooth, excepting very obscure traces of fine concentric striae.

Length of largest specimen, 0.77 inch [19.5 millimeters]; height, 0.36 inch [9 millimeters]; convexity, 0.26 inch [6.6 millimeters].

Locality and position: Types from Moreau River, S. Dak., in Fox Hills sandstone. The species is also common in the upper part of the Pierre shale, in the Bearpaw shale, and other equivalents of the upper part of the Pierre. Two small specimens, one of which is figured, were found in the upper part of the Cannonball marine member of the Lance formation in a bluff on the north side of Heart River 1 mile west of Mandan, N. Dak.

Yoldia thomi Stanton, n. sp.

Plate I, figures 12a–12c.

Shell small, transversely elongate subovate, moderately convex, especially in the umbonal region, slightly gaping behind; anterior end narrowly rounded; posterior end more narrowly rounded or subangular; base forming a regular gentle curve; dorsal margin descending from the beaks with a slightly convex curve in front and a slightly concave curve behind; lanceolate escutcheon bounded by a narrow obscure ridge in each valve; beaks prominent, obtuse, median in position; surface almost

smooth, marked only by extremely fine, somewhat irregularly spaced, concentric grooves which are much narrower than the intervening spaces.

Length, 13 millimeters; height, 8 millimeters; convexity of both valves, 6 millimeters.

This species in a general way resembles *Y. scitula* Meek and Hayden, with which it was at first confused, but it is somewhat larger, relatively slightly higher, and less convex, and the surface sculpture is less conspicuous and differs in other details. There are also differences in outline due to more conspicuous beaks and a more symmetrical posterior end.

The specific name is given in honor of Mr. W. T. Thom, jr., of the United States Geological Survey.

Locality and position: On Cannonball River in sec. 28, T. 133 N., R. 88 W., about 7 miles southeast of Kayser, N. Dak., in the upper part of the Cannonball marine member of the Lance formation.

Family PARALLELODONTIDAE.

Genus CUCULLAEA Lamarck.

Cucullaea shumardi Meek and Hayden.

Plate II, figures 1a and 1b.

Arca (*Cucullaea*) *shumardi* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 8, p. 86, 1856.

Cucullaea shumardi Meek and Hayden, idem, vol. 8, p. 285, 1856.

Cucullaea fibrosa Sowerby, Meek and Hayden, idem, vol. 12, p. 428, 1860.

Cucullaea (*Idonearca*) *shumardi* Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 86, pl. 28, figs. 15 a–g; pl. 29, fig. 4, 1876.

This species, which is abundant in the Fox Hills sandstone at a number of localities in the type area of that formation, is represented in the Cannonball fauna by the cast of a right valve, which is figured. At the posterior end it retains a small portion of the shell including part of the hinge and ligamental area. In all the preserved features this specimen agrees with the types of the species, which are well illustrated in Meek's report above cited.

Locality and position: In the NW. ¼ sec. 9, T. 130 N., R. 90 W., about 10 miles southwest of Pretty Rock, N. Dak., in the upper part of the Cannonball marine member of the Lance formation.

Cucullaea nebrascensis Owen?

Cucullaea nebrascensis Owen, Report of a geological survey of Wisconsin, Iowa, and Minnesota, p. 582, pl. 8, figs. 1, 1a, 1852.

Cucullaea (*Idonearca*) *nebrascensis* Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 88, pl. 29, figs. 5 a, b, 1876.

Two small, fragmentary specimens, which in preliminary lists were referred to *C. shumardi*, more probably represent young individuals of *C. nebrascensis*, with which they agree in general form and in details of the hinge. The published descriptions of the species are based on the large mature shells that do not show radiating sculpture, though Meek states that "young individuals are probably provided with radiating costae." The two specimens here recorded are thin shelled, thus indicating immaturity, and are covered in the umbonal region with numerous small, flat radiating ribs which are just visible to the unaided eye.

Locality and position: In the NW. ¼ sec. 9, T. 130 N., R. 90 W., about 10 miles southwest of Pretty Rock, N. Dak., in the upper part of the Cannonball marine member of the Lance formation.

Cucullaea solenensis Stanton, n. sp.

Plate II, figures, 2a, 2b, and 3.

Shell of moderate size, transversely subovate in outline, convex, with prominent incurved beaks; anterior margin forming nearly a right angle with the long hinge line, regularly rounded below; basal margin broadly rounded, strongly crenulate within; posterior margin obliquely subtruncate; ligament area large, marked by very fine longitudinal lines, crossed by three strong, oblique, divaricating grooves. Surface marked by concentric lines of growth and by somewhat stronger but obscure radiating ribs.

Length of best-preserved specimen, 35 millimeters; height from base to top of beak, 30 millimeters; convexity of both valves, about 35 millimeters.

This species, which is represented in the collections by only three specimens, resembles *C. shumardi* in size and general appearance, but it is easily distinguished from that and all other described species from the upper Missouri country by the fact that its ventral margin is

distinctly crenulated within. The crenulations are conspicuous on the casts of all three of the specimens and are also seen on the exfoliated edge of the shell in the specimen represented by figure 3.

Locality and position: Near the top of the high mesa 6 to 7 miles northwest of Solen, N. Dak., in T. 134 N., R. 81 W., about 100 feet above the base of the Cannonball marine member of the Lance formation.

Family ARCIDAE.

Genus TRIGONARCA Conrad.

Trigonarca? hancocki Stanton, n. sp.

Plate II, figures 4 and 5.

Shell very small, subquadrate, very convex, with height and length about equal; dorsal margin straight, nearly as long as the shell; ventral and anterior margins forming a nearly regular curve; posterior margin subtruncate and forming an angle of about 100° with the dorsal margin; beaks prominent, submedian, with a small furrow, more distinctly marked on the cast than on the shell, descending from the point of the beak toward the middle of the ventral margin. Surface marked by fine growth lines and by about 25 relatively strong radiating ribs which are not quite as broad as the interspaces. Hinge and other internal features unknown.

Length, 4 millimeters; convexity of single valve, about 2 millimeters.

This species is represented by only two minute valves, which may be immature individuals of a larger species, though they can not be the young of any of the species of *Cucullaea* or *Glycimeris* here described. As the character of the hinge and of the muscular impressions is unknown, the generic reference is questionable.

The name is given in honor of Mr. E. T. Hancock, of the United States Geological Survey, who collected the types.

Locality and position: In the SE. ¼ sec. 10, T. 138 N., R. 83 W., on Heart River about 15 miles southwest of Mandan, N. Dak., 75 feet below the top of the Cannonball marine member of the Lance formation.

Genus GLYCIMERIS Da Costa.

Glycimeris subimbricata (Meek and Hayden).

Plate II, figures 6a, 6b, and 7.

Pectunculus subimbricatus Meek and Hayden, Acad. Nat. Sc., Philadelphia Proc., vol. 9, p. 146, 1857.

Axinaea subimbricata Meek and Hayden, idem, vol. 12, p. 185, 1860.

Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 95, pl. 28, figs. 14 a–d, 1876.

Meek's description:

Shell subcircular or slightly longer than high, moderately convex, extremities rounded, the posterior side sometimes being a little broader and less regularly rounded than the other; base forming a very nearly semicircular curve, and strongly crenulate within; hinge area rather small, marked by about five to seven distinct grooves; beaks almost central, rather gibbous, obtuse, and neither oblique nor distinctly incurved; hinge a little arched; teeth distinct, lateral ones oblique and curved, the concave sides being turned outward from the middle; muscular impressions rather large but shallow. Surface ornamented by distinct lines of growth, crossed by numerous regular, simple, depressed, radiating costae, about twice as broad as the grooves between.

Length, 1.55 inches [39 millimeters]; height, 1.36 inches [35 millimeters]; convexity of the two valves, 1.03 inches [26 millimeters].

This description is apparently based on a single valve (U.S.N.M. catalogue No. 309), both sides of which are figured, though from the description of the plate it would be natural to infer that Meek's figures 14a and 14d represent different specimens. A much smaller specimen is also figured and described as a young individual of the species, though slight differences are pointed out which suggest the possibility that it may belong to another species. That there is some variation in form and proportions is shown by the specimens now figured from recent collections. One of these (figs. 6a, 6b) is almost an exact duplicate of the type and measures 39 millimeters in length, 36 millimeters in height, and 28 millimeters in convexity. Another specimen (fig. 7) is higher and more convex in proportion to its length, measuring 40 millimeters in length, 42 millimeters in height, and 30 millimeters in convexity of both valves. In other respects all these specimens resemble one another so closely that I have no hesitation in treating them as one species.

The genus *Glycimeris*, usually described as *Pectunculus* or *Axinaea*, forms a somewhat conspicuous feature of the Ripley fauna of the Gulf and Atlantic Coastal Plain, but in the Cretaceous of the region of the Great Plains and Rocky Mountains it has been found at but few localities, and only two other species have been described—*G. wyomingensis* (Meek), from the Mesaverde formation on Cooper Creek, Laramie Plains, and *G. holmesiana* (White), from the same formation at Point of Rocks, Wyo. *G. wyomingensis* does not differ greatly in general appearance from *G. subimbricata*, but it is a heavier, somewhat more convex shell, with relatively broader though less conspicuous radiating ribs.

Locality and position: The published descriptions state that the types came from Heart River in the "upper part of the Fox Hills beds," but it is now known that all the marine deposits on Heart River are in the Cannonball marine member of the Lance formation. The type specimens are catalogued and labeled (probably incorrectly) as from Long Lake, which is a Fox Hills locality. The species has not since been found at any true Fox Hills locality, but it has been found in the Cannonball member at six localities distributed over a considerable area ranging from T. 132 N. to T. 139 N. and from R. 82 W. to R. 88 W. in North Dakota. The specimens figured are from the SE. ¼ sec. 11, T. 136 N., R. 82 W., 5 miles southeast of Strain, N. Dak. (fig. 6), and from sec. 11, T. 132 N., R. 88 W., in the valley of Cannonball River about 7 miles south of Leith, N. Dak. (fig. 7).

Family PERNIDAE.

Genus PEDALION Solander.

Pedalion lloydi Stanton, n. sp.

Plate IV, figures 1a, 1b, and 2.

Perna sp. Stanton, Geol. Soc. America Bull., vol. 25, p. 352, 1914.

Shell of moderate size, compressed, elongate subovate, with acute terminal beak; test very thick, especially near the middle of the hinge; hinge area relatively broad, with numerous shallow cartilage grooves which are slightly broader than the spaces between them; surface marked only by inconspicuous lines of growth.

Height, about 95 millimeters; length, about 49 millimeters; thickness of test in fragment represented by figure 2, 15 millimeters.

The fragmentary material on which this species is based evidently belongs to the genus best known as *Perna* or *Melina*, for which W. H. Dall has revived the earlier name *Pedalion*. The genus ranges from the Triassic to the Recent seas and is represented by several species in American Cretaceous and Tertiary formations. This is the first record of its occurrence in the region of the Great Plains and Rocky Mountains but it is represented by another undescribed species in the Frontier formation of the Wind River region. The species is abundant at the type locality in a layer of soft, friable sandstone about a foot thick. On account of the fragile character of both the shells and the matrix it has not been practicable to collect specimens showing the complete form and the restored outline may not be strictly accurate, but the fragmentary shells in the collection show that it differs in details of outline and other features from all the described American species.

The specific name is given in honor of Mr. E. Russell Lloyd, of the United States Geological Survey, who collected the first specimens.

Locality and position: The types were collected in the lower part of the Cannonball marine member of the Lance formation in sec. 13, T. 132 N., R. 88 W., on the south bank of Cannonball River about 1 mile west of Janesburg, N. Dak. Specimens have also been found a quarter of a mile south of Janesburg, and at another locality about 15 miles east, near Schaller post office.

Family PTERIIDAE.

Genus PTERIA Scopoli.

Pteria linguaeformis (Evans and Shumard).

Plate III, figure 1.

Avicula linguaeformis Evans and Shumard, Acad. Nat. Sci. Philadelphia Proc., vol. 7, p. 153, 1854.
Meek, in Hind, Report on the Assiniboine and Saskatchewan exploring expedition, p. 183, pl. 1, fig. 6, 1859.
Pteria linguiformis (Evans and Shumard) Meek, Check list of invertebrate fossils of North America, Cretaceous and Jurassic, p. 9, 1864; U. S. Geol. Survey Terr. Rept., vol. 9, p. 32, pl. 16, figs. 1 a–d, 1876.
Whitfield, in Newton and Jenney, Geology and resources of the Black Hills of Dakota, p. 384, pl. 7 figs. 2, 3, 1880.
Whiteaves, Contr. Canadian Paleontology, vol. 1, p. 31, 1885.
Pteria petrosa (Conrad) Weller, New Jersey Geol. Survey, Paleontology, vol. 4, p. 429, 1907.

This species, which is so widely distributed in the Pierre shale and the Fox Hills sand-

stone, is very rare in the Cannonball fauna. The specimen figured was collected in the SW. ¼ sec. 30, T. 130 N., R. 88 W., in North Dakota, 7 miles north of Morristown, S. Dak. Another specimen was found on Heart River three-quarters of a mile west of Mandan, N. Dak., in the upper part of the Cannonball marine member of the Lance formation.

Weller treats *P. linguaeformis* as a synonym of *P. petrosa*, which Conrad described in 1853 from an imperfect specimen collected along the Chesapeake & Delaware Canal. *P. petrosa* has been described and figured from New Jersey specimens (also imperfect) by both Whitfield and Weller. Although it is obviously related to the western form, the published figures of *P. petrosa* do not seem to justify the application of the same name to *P. linguaeformis*.

Family MYTILIDAE.

Genus MODIOLUS Lamarck.

Modiolus schallerensis Stanton, n. sp.

Plate III, figure 6.

Shell small, elongate ovate in outline, moderately convex; beak nearly terminal, not conspicuous; dorsal margin straight or very broadly convex; ventral margin distinctly arcuate near the middle; posterior end regularly rounded; anterior end subtruncate; surface marked by numerous fine radiating lines which become coarser and tend to bifurcate toward the posterior end.

Length, 5 millimeters; greatest breadth, 7 millimeters; convexity of both valves, about 6 millimeters.

The species is represented by nine specimens of approximately the same size from a single locality. Their small size suggests that they may be immature. In outline the species resembles *M. meeki* (Evans and Shumard), from the Fox Hills; in sculpture it is more like *M. regularis* (White), from the Laramie.

Locality and position: One mile west of Schaller post office, N. Dak., in the NW. ¼ sec. 22, T. 132 N., R. 85 W., near the base of the Cannonball marine member of Lance formation.

Genus CRENELLA Brown.

Crenella cedrensis Stanton, n. sp.

Plate II, figures 9a–9c.

Shell of moderate size, broadly subovate in outline, very convex, with prominent incurved beaks; short dorsal margin behind the beaks almost straight and descending slightly to its subangular junction with the broadly rounded posterior margin; anterior margin also broadly rounded, base more narrowly rounded; surface marked by numerous fine radiating lines, which are visible under a lens on well-preserved internal casts, and by very fine growth lines and more distinct and somewhat irregular concentric furrows.

Height from beak to base, 14 millimeters; greatest breadth, 12 millimeters; convexity of both valves, 9 millimeters.

This species is related to *C. elegantula* Meek and Hayden, but it is a stouter shell and differs in other details of outline. The radial sculpture also is less distinct, at least on the internal casts.

Locality and position: The types were collected in the Cannonball marine member of the Lance formation on Cedar Creek, N. Dak., in the SW. ¼ sec. 30, T. 130 N., R. 88 W., 7 miles north of Morristown, S. Dak. Another specimen was found near the top of the Cannonball member on Heart River three-quarters of a mile west of Mandan, N. Dak.

Crenella elongata Stanton, n. sp.

Plate II, figures 8a and 8b.

Shell large, elongate subovate in outline, moderately convex, with prominent incurved beaks; dorsal margin descending rapidly with a broad curve into the nearly straight posterior margin; basal margin somewhat narrowly rounded; anterior margin broadly convex below, excavated above under the beak; surface with very fine radiating lines, which are obsolete on the cast and the exfoliated shell, and with finer lines of growth and other concentric markings.

Height from beak to base, 25 millimeters; greatest breadth, 15 millimeters; convexity of both valves, about 14 millimeters.

This species differs from *C. cedrensis* in its larger size, more slender and less convex form, and less pronounced radial sculpture. It is even more slender than *C. elegantula*, from which it differs in all other details.

Locality and position: The type, which is slightly distorted by pressure, was collected in the upper part of the Cannonball marine member of the Lance formation in a bluff on the west bank of Missouri River 1 mile south of

Price and 19 miles north of Mandan, N. Dak. Some small specimens which may be immature individuals of this species were obtained on the north fork of Grand River in the SW. ¼ sec. 11, T. 21 N., R. 14 E., 10 miles south of White Butte, S. Dak.

Family PHOLADOMYACIDAE.

Genus PHOLADOMYA Sowerby.

Pholadomya haresi Stanton, n. sp.

Plate III, figures 2a, 2b, and 3.

Shell small, transversely subovate in outline, very convex in umbonal region of anterior third but narrowing and flattening somewhat rapidly toward posterior end; beaks prominent, approximate, situated about one-third of the length from the anterior end, a subangular umbonal ridge descending from the beaks with a slight forward direction almost to the ventral margin; posterior end slightly gaping and narrowly rounded; anterior end broadly rounded and closed, though the type specimen, probably on account of accidents in preservation, has an apparent anterior gape; surface (of the cast) with about eight relatively strong radiating ribs on the anterior third, with more obscure radiating lines on the middle third, and with moderately strong but irregular concentric sculpture over the entire surface.

Length, 26 millimeters; height, 18 millimeters; greatest convexity of both valves, 18 millimeters. Another fragmentary specimen indicates dimensions about one-third larger.

The species is named for Mr. C. J. Hares, who collected the types. When first examined it was identified as *Pholas* sp. and was so recorded in Lloyd and Hares's paper on the Cannonball marine member of the Lance formation.[1] On further study it seems to be referable to *Pholadomya* and to belong to the same group with *P. semicostata* Agassiz, of the European Lower Cretaceous. In form and sculpture it also has considerable resemblance to *P. mauryi* Harris,[2] from beds of Midway age in Tennessee, but it differs in its more pronounced anterior umbonal ridge, straighter ventral margin, and narrower posterior end. Except in details of sculpture it does not differ greatly from *Pholas cithara* Morton, which is found in several of the Upper Cretaceous formations of New Jersey and in the Ripley of Mississippi. In my opinion that species also is a *Pholadomya*.

Locality and position: The type was collected 3½ miles west of Haley, N. Dak., at the common quarter corner of secs. 21 and 28. T. 129 N., R. 100 W. The only other specimen, which is also figured, was collected on the south bank of North Fork of Grand River a quarter of a mile east of Bloom, S. Dak., in sec. 24., T. 23 N., R. 9 E. The two localities are about 12 miles apart and in the Cannonball marine member of the Lance formation.

Family ANATINIDAE.

Genus ANATINA Lamarck.

Anatina subgracilis (Whitfield).

Plate III, figures 4a, 4b, 5a, and 5b.

Thracia subgracilis Whitfield, Preliminary report on the paleontology of the Black Hills, p. 36, 1877; in Newton and Jenney, Geology and resources of the Black Hills of Dakota, p. 419, pl. 11, figs. 29, 30, 1880.

Thracia sp. Stanton, Geol. Soc. America Bull., vol. 25, p. 352, 1914.

Shell small, transversely subovate, moderately convex, almost equivalve, the portion behind the beaks more compressed and much smaller than the rest of the shell, slightly gaping at posterior end; beaks rather prominent, transversely fissured, directed backward, and situated considerably behind the middle; dorsal margin gently convex in front of the beaks and slightly concave behind; anterior end broadly rounded; posterior end narrower and subtruncate; ventral margin broadly and regularly rounded in the anterior two-thirds, nearly straight and more rapidly ascending in the posterior third; test thin and nacreous; surface marked by somewhat irregular concentric ribs or undulations and by fine lines of growth, all of which are about as conspicuous on the internal cast as on the exterior of the shell itself.

Length of type specimen, 20 millimeters; height, 15 millimeters; convexity of both valves, 7 millimeters. The corresponding measurements of a specimen in the Cannonball fauna are 24, 18, and 9 millimeters, respectively.

In referring this species to *Thracia* Whitfield compared it with *T. gracilis* Meek and Hayden,

[1] Jour. Geology, vol. 23, p. 533, 1915.

[2] Harris, G. D., The Midway stage: Bull. Am. Paleontology, vol. 1, p. 158, pl. 6, fig. 17, 1896.

but the fissured beaks, which he described and figured, and other features preserved differ from those of *Thracia* and agree better with *Anatina*, to which it is here referred. *Thracia gracilis* is apparently a true *Thracia*.

The best preserved of the three specimens found in the Cannonball member agree in every detail with the type of the species except that the type is smaller and its ventral margin, as described by Whitfield, is "constricted or sinuate behind," a feature which is obviously caused by an accidental break.

Locality and position: The type (fig. 4) came from the Pierre shale (probably upper part) on Cheyenne River near French Creek, S. Dak. In the Cannonball marine member of the Lance formation two specimens, one of which is figured, were found 7 miles southwest of Lemmon, S. Dak.; another was obtained in a high bluff in the SW. ¼ sec. 5, T. 129 N., R. 89 W., south of Cedar Creek, N. Dak., and three others 3½ miles west of Haley, N. Dak.

Family PLEUROPHORIDAE.

Genus ARCTICA Schumacher.

Arctica ovata (Meek and Hayden).

Plate IV, figures 4, 5, 6a, and 6b.

Cyprina ovata Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 9, p. 144, 1857.
Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 146, pl. 29, figs. 7 a–c, text fig. 8, 1876.
Whiteaves, Contr. Canadian Paleontology, vol. 1, pt. 1, p. 40, 1885; pt. 2, p. 175, 1889.
Cyprina compressa Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 9, p. 144, 1857.
Cyprina ovata var. *compressa* Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 147, pl. 30, fig. 11, 1876.

Meek's description:

Shell transversely ovate, compressed or moderately convex, rather thin; extremities somewhat narrowly rounded; basal margin semioval; dorsal border declining with a gently convex outline posteriorly and more abruptly in front; beaks not much elevated, rather small, moderately oblique, and located about halfway between the middle and the anterior end; surface marked by distinct lines of growth.

Length, 2.35 inches [57.15 millimeters]; height, 1.95 inches [49.53 millimeters]; convexity, 1.15 inches [29.21 millimeters].

Meek called attention to the very close agreement of the hinge of this species with the hinge of the recent species *A. islandica*, which leaves no doubt concerning the reference to the genus *Arctica*, more commonly called *Cyprina*.

The specimen that was described as a distinct species under the name *Cyprina compressa* (fig. 5) and later classified as a variety of *ovata* does not differ enough from the type to warrant even varietal separation. Meek says: "It agrees with the species in all respects, excepting in the greater elevation and more nearly central position of its beaks, which are also a little less oblique," but even these apparent differences are partly due to incorrect posing of the imperfect internal cast. The outlines of the two specimens are almost exactly of the same shape, and the difference in ratio of height to length is less than 1 per cent. Meek states in his final publication that the two shells were found associated at the mouth of Heart River, but on account of an obvious blunder in the arrangement of the paper containing the original descriptions the type of the variety *compressa* has been credited to the Fox Hills sandstone on Moreau River. The description of *Cyprina compressa* should have followed that of *C. ovata*. Then the statement that the locality and position are "same as last" would have correctly indicated the mouth of Heart River.

Locality and position: The type locality, as above indicated, is at or near the site of the present town of Mandan, N. Dak., and is now known to be in the upper part of the Cannonball marine member of the Lance formation. The species is common in the bluffs on the north side of Heart River 1 mile west of Mandan. The hinge of a left valve represented by figure 4 was obtained near the top of Mitchell Butte, 3 miles east of Flasher, N. Dak. Other localities are the site of old Fort Lincoln, 4 miles south of Mandan; 3 and 5 miles east of Strain, in T. 136 N., R. 82 W.; 6 miles east of Flasher; 7 and 8 miles northwest of Solen; and Heart River 10 miles north of Flasher, all in the Cannonball marine member of the Lance formation.

Whiteaves reports both the typical form and a variety, which he named *alta*, as abundant at many localities in Alberta in the formation now known as the Bearpaw shale. Through the courtesy of the Geological Survey of Canada I have examined five specimens of the variety *alta* from Ross Coulee, South Saskatchewan, and 5 miles above Swift Current, Belly River, St. Marys River, and Bow River, Alberta. The specimens (internal casts) from the first two localities have almost the proportions of typical

C. ovata except that the valves are slightly more convex and the posterior end is not quite so broadly rounded. The other specimens are relatively higher, having the form of Whiteaves's figure of the variety *alta*. All are larger, and most very much larger, than any that have been found in the Cannonball member. I have not been able to see any of the Canadian specimens referred to the typical form of the species.

Family ASTARTIDAE.

Genus ERIPHYLA Gabb.

Eriphyla? mandanensis Stanton, n. sp.

Plate IV, figure 3.

Shell very small, relatively thick, rounded subtrigonal in outline, with length and height almost equal; anterior side rounded below and slightly concave above; posterior side more broadly rounded; base forming a regular curve; beaks prominent, located a little in front of the middle. Surface ornamented by fine growth lines and about seven broad, concentric ribs separated by much narrower grooves. Hinge and other internal characters not seen.

Length and height each, about 5 millimeters; convexity of both valves, about 3 millimeters.

This species is of about the same size as the upper Pierre species *E. gregaria* Meek and Hayden, from which it may be distinguished by its relatively greater height and especially by its much coarser and less numerous concentric ribs.

Locality and position: Near top of bluff on Heart River about a mile west of Mandan, N. Dak., in the upper part of the Cannonball marine member of the Lance formation.

Family CRASSATELLITIDAE.

Genus CRASSATELLITES Kruger.

Crassatellites evansi Hall and Meek.

Plate III, figure 7a–9.

Crassatella evansii Hall and Meek, Am. Acad. Arts and Sci. Mem., new ser., vol. 5, p. 383, pl. 1, figs. 9 a–e, 1856.

Crassatella (Pachythaerus) evansi (Hall and Meek) Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 117, pl. 17, figs. 6 a–d, 1876.

Astarte evansi Whitfield, in Newton and Jenney, Geology and resources of the Black Hills of Dakota, p. 413, pl. 11, fig. 131, 1880.

Cf. *Cytherea missouriana* Morton, Acad. Nat. Sci. Philadelphia Jour., 1st ser., vol. 8, p. 210, pl. 11, fig. 2, 1842.

Meek's description:

> Shell ovate-subtrigonal, rather gibbous, thick; anterior side obliquely truncated and generally a little concave in outline above and abruptly rounded below; base semi-ovate, being usually slightly more prominent before than behind the middle; posterior side longer than the other, sloping from the beaks above, and rounded or vertically subtruncate at the extremity; lunule oval, rather deep; escutcheon narrow lanceolate, defined by an obscure ridge on each side; pallial margins regularly and finely crenate within; beaks prominent, gibbous, and located about halfway between the middle and the anterior extremity. Surface marked by fine, irregular lines of growth, which are sometimes gathered into small, obscure wrinkles near the borders; muscular and pallial impressions strongly marked.
>
> Length, 1 inch [25.4 millimeters]; height, 0.90 inch [22.8 millimeters]; convexity, 0.71 inch [18 millimeters].

The original types described by Hall and Meek were somewhat larger, the measurements recorded being length 1.4 inches, height 0.97 inch, and convexity 0.70 inch. The best-preserved specimen from the Cannonball member measures 33 millimeters in length, 28 millimeters in height, and 19 millimeters in convexity. Other imperfect specimens are somewhat larger.

Although there is slight variation in proportions the 20 specimens representing six localities in the Cannonball member are referred without question to *C. evansi*.

Morton's figure of *Cytherea missouriana* resembles this species closely enough to cause a suspicion that it may be identical, and if the identity could be established the earlier specific name *missouriana* should be used, but with only Morton's obviously inaccurate figure for comparison a change of name is not justified.

Locality and position: The types came from the upper part of the Pierre shale on Cheyenne River at the mouth of Sage Creek, S. Dak., and the specimens figured by Meek came from the same position and nearly the same locality. In the Cannonball marine member of the Lance formation the species was collected in T. 133 N., R. 88 W., about 6 miles south of Kayser, N. Dak. (figs. 7a, 7b); in the NE. ¼ sec. 3, T. 134 N., R. 83 W. (fig. 9); about 20 feet below the top of the plateau 6 miles east of Flasher, N. Dak. (fig. 8); 9 miles southwest of Leith, N. Dak., 7 miles southeast of Kayser, N. Dak.; 7 miles southwest of Pretty Rock, N. Dak.; and on Heart River, about 12 miles south of Almont, N. Dak., on the south line of sec. 20, T. 136 N., R. 86 W.

Family CYRENIDAE.

Genus CORBICULA Megerle.

Corbicula cytheriformis Meek and Hayden.

Plate V, figures 4a and 4b.

Cyrena (Corbicula?) cytheriformis Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 12, p. 176, 1860.

Corbicula cytheriformis Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 520, pl. 40, figs. 5 a–c, 1876.

White, U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, p. 74, pl. 21, figs. 4a–d, 1880; U. S. Geological Survey Third Ann. Rept., p. 437, pl. 22, figs. 1–6, 1883.

Stanton, U. S. Geol. Survey Prof. Paper 98, p. 316, pl. 82, fig. 4, 1916.

Meek's description:

Shell attaining a large size, transversely ovate-subtrigonal or varying to subcircular but always a little longer than high, moderately convex, rather thick and strong; extremities more or less rounded, or the posterior sometimes faintly subtruncated; basal outline forming a semi-ovate curve, the most prominent part of which is generally in advance of the middle; dorsal margin sloping unequally from the beaks, the anterior slope being more abrupt and slightly concave in outline, and the posterior convex; beaks moderately prominent and placed more or less in advance of the middle; surface only marked by lines of growth, without distinct concentric furrows.

Length of a medium-sized rather transverse specimen, 1.20 inches [30.5 millimeters]; height, 1.05 inches [26.67 millimeters]; convexity, 0.77 inch [18.5 millimeters].

The specimens from the Cannonball member agree in every detail with the type, which came from the Judith River formation. (Compare fig. 4a, which is a photograph of the best-preserved shell, with Meek's fig. 5a, which is drawn from the type specimen.) Associated with the figured specimen are numerous others of about the same size and a few that are much larger.

Locality and position: In the Cannonball marine member of the Lance formation the species is common in the NW. ¼ sec. 22, T. 132 N., R. 85 W., 1 mile west of Schaller post office, N. Dak. A few additional specimens were obtained on the site of old Fort Lincoln, 4 miles south of Mandan, N. Dak. The types came from the Judith River formation near Judith, Mont., and the species occurs in the Mesaverde formation of southern Wyoming, in the Black Buttes coal group of the same region, and in the lower part of the Fruitland formation in San Juan County, N. Mex. Closely related forms are also found in the Laramie formation of northeastern Colorado.

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Corbicula berthoudi White.

Plate V, figures 1a–3.

Corbicula berthoudi White, U. S. Nat. Mus. Proc., vol. 5, p. 94, pl. 4, figs. 1–3, 1882; U. S. Geol. Survey Third Ann. Rept., p. 438, pl. 21, figs. 1–3, 1882.

Original description:

Shell very large, subtrigonal in marginal outline, moderately gibbous; front concave immediately in front of the beaks; front margin regularly rounded; basal margin broadly rounded; postero-basal margin abruptly rounded up to the postero-dorsal margin, which latter margin slopes obliquely downward with a gentle convexity from between the beaks; hinge strong; all the teeth well developed, the lateral ones especially being long and large and crenulated upon their edges, as is usual with all the known species of *Corbicula* of the Laramie group; muscular and pallial impressions having the usual characteristics; surface marked with the usual concentric lines.

Length of one of the largest examples in the collections, 62 millimeters; height from base to umbo, 54 millimeters; thickness, both valves together, 44 millimeters.

This fine large species, the largest yet known in North America, has been found only in the Laramie strata east of the Rocky Mountains in Colorado. It is named in honor of Capt. E. L. Berthoud, the first discoverer of the rich shell deposits of the Laramie group in that region.

The locality is given as "valley of South Platte River, northeastern Colorado," but the type specimens in the National Museum are more definitely labeled "15 miles north of Fremonts Orchard, valley of South Platte, Colorado." Fremonts Orchard is presumably the same as Orchard station on the Julesburg branch of the Union Pacific Railroad. This is the only locality from which the species has been recorded, and its presence in the Cannonball fauna was not suspected until careful preparation of the hinges of some specimens that had been referred to *Veniella* (?) showed that they belong to *Corbicula*. Direct comparison of these specimens with the types of *Corbicula berthoudi* showed so close an agreement in size, form, sculpture, and hinge character that I have no hesitation in referring them to the same species, though its associates at the North Dakota localities are all marine while in Colorado they are brackish-water forms.

Locality and position: The specimens figured were collected in the NW. ¼ sec. 11, T. 132 N., R. 88 W., about 7 miles south of Leith, N. Dak., and on the west bank of Missouri River 1 mile south of Price and 19 miles north of Mandan, N. Dak., in the Cannonball marine member of the Lance formation. Other

specimens were obtained in the SE. ¼ sec. 11, T. 22 N., R. 19 E., 4 miles south of Morristown, S. Dak.

Family LUCINIDAE.

Genus LUCINA Bruguière.

Lucina cedrensis Stanton, n. sp.

Plate III, figures 10a–11b.

Lucina occidentalis (Morton). Stanton, Geol. Soc. America Bull., vol. 25, p. 352, 1914.

Shell rather large, subcircular, with height nearly equal to length, moderately convex; anterior, basal, and posterior margins forming a nearly regular subcircular curve; dorsal margin declining slightly in a convex curve behind the beak, concave to the end of the deeply excavated lunule in front; beaks small, nearly median in position; posterior groove bordering the posterodorsal margin, rather obscure; hinge with well-developed cardinal and anterior lateral teeth, and very small posterior lateral tooth; ligament deeply sunken, bordered interiorly by a conspicuous ridge which simulates a third cardinal tooth. Surface marked by very fine, closely arranged concentric lines. Exfoliated specimens also show rather prominent radiating lines on the inner laminae of the shell.

Length of type, 39 millimeters; height, about 36 millimeters; convexity of both valves, about 18 millimeters. A larger specimen from another locality believed to belong to the same species is about 45 millimeters in length, 47 millimeters in height, and 24 millimeters in convexity of both valves.

This species is of about the size of *L. occidentalis* (Morton), and in preliminary lists of the Cannonball fauna it was referred to that species. It may be distinguished from *L. occidentalis* by its greater proportional height, smoother surface, and shorter and much more deeply excavated lunule.

Locality and position: The type (fig. 10) was obtained north of Cedar River in the NW. ¼ sec. 9, T. 130 N., R. 90 W., about 10 miles southwest of Pretty Rock, N. Dak. The other figured specimen and three others were collected in sec. 7, T. 4 N., R. 83 W., near the top of Mitchell Butte, 3 miles east of Flasher, N. Dak. Another specimen possibly belonging to the same species was found in T. 133 N., R. 88 W., about 6 miles south of Kayser, N. Dak. All these localities are in the Cannonball marine member of the Lance formation.

Family VENERIDAE.

Genus CALLISTA Poli.

Callista (Dosiniopsis) nebrascensis (Meek and Hayden).

Plate V, figures 5–10.

Cytherea nebrascensis Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 8, p. 83, 1856.

Dione nebrascensis Meek, Check list of invertebrate fossils of North America, p. 13, 1864.

Callista (Dosiniopsis) nebrascensis Meek (in part), U. S. Geol. Survey Terr. Rept., vol. 9, p. 184, 1876. Probably not the figured specimens.

Original description:

Shell subcircular, much compressed; beaks somewhat elevated, small, a little in advance of the center; ligamentary cavity long and very narrow lanceolate; surface marked with rather faint lines of growth.

Length 0.70 inch [17.78 millimeters]; breadth 0.28 inch [7.11 millimeters]; height 0.60 inch [15.24 millimeters].

The much more compressed form of this shell will serve to distinguish it at once from the last [*C. deweyi*].

Locality and position: Moreau River, No. 5 of the series [that is, Fox Hills].

The type, which is represented by figure 8, has never before been figured. It is labeled in Meek's handwriting "Cretaceous 4 (upper), Cheyenne and Moreau rivers, 343," and is accompanied by another specimen on which is printed "Chey," indicating that it is from Cheyenne River. Whether it came from No. 5, the Fox Hills sandstone, as stated in the original description, or from the upper part of the Pierre shale, as stated on the label and in Meek's final publication, the species is certainly abundant in the upper part of the Fox Hills sandstone on Cannonball River and in neighboring railroad cuts 4 to 5 miles east of Solen, N. Dak.

Most of the more extended description and all of the illustrations in Meek's volume last cited are based on much larger specimens from Deer Creek, on North Platte River in Wyoming, which in Meek's opinion "represent only a more robust growth of one species, *C. nebrascensis*, which was founded upon young or less developed and slightly more compressed individuals; though it is barely possible that they may be distinct." This larger, more convex form had previously been separated by Meek and Hayden [1] as a distinct species under the name *Callista robusta*, and it is my judgment that this name should be revived.

At two localities in the Cannonball marine member of the Lance formation *C. nebrascensis*

[1] Acad. Nat Sci. Philadelphia Proc., vol. 13, p. 443, footnote, 1861.

is a common species. The specimens are not as well preserved as those from the Fox Hills, but so far as can be determined from direct comparison they agree in shape, sculpture, and details of the hinge. The localities are a bluff on the north side of Heart River 1 mile west of Mandan, N. Dak., and the west bank of Missouri River 1 mile south of Price and 19 miles north of Mandan. At the latter locality it is associated with *C. deweyi*. It was also collected 1 mile west of Schaller post office, N. Dak.

The generic reference of this and the following species has been left as Meek placed it, *Dosiniopsis* being treated as a subgenus under *Callista*. All questions concerning the validity and rank of *Dosiniopsis, Callista, Dione, Meretrix,* and other names that have been applied to these and similar shells are for the present held in abeyance, though attention may be called to the fact that Woods [1] recognizes *Dosiniopsis* as a distinct genus and that the hinge of *D. subrotunda* (Sowerby) as figured by him agrees closely in every detail with the hinge of *C.* (*D.*) *nebrascensis*.

Callista (Dosiniopsis?) deweyi (Meek and Hayden).

Plate V, figures 11 and 12.

Cytherea deweyi Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 8, p. 83, 1856.

Meretrix deweyi Meek and Hayden, idem, vol. 12, p. 185, 1860.

Callista deweyi Meek and Hayden, idem, vol. 13, p. 143, 1861.

Dione deweyi Meek, Smithsonian check list of invertebrate fossils of North America, p. 13, 1864.

Callista (*Dosiniopsis?*) *deweyi* Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 182, pl. 17, figs. 15a–e, 1876. Whiteaves, Contr. Canadian Paleontology, vol. 1, pt. 1, p. 42, pl. 6, figs. 4(?), 5, 5a, 1885.

Dosinia missouriana? (Morton) Whitfield, in Newton and Jenney, Geology and resources of the Black Hills of Dakota, p. 416, pl. 11, figs. 25, 26, 1880.

Not *Cytherea missouriana* Morton, Acad. Nat. Sci. Philadelphia Jour., 1st ser., vol. 8, p. 210, pl. 11, fig. 2, 1842, which is probably a *Crassatellites*.

Meek's revised description:

Shell subcircular, or very broad suboval, rather thin, moderately convex; lateral margins rounded, the posterior side being a little broader than the other; dorsum sloping gradually with a slightly convex outline behind the beaks, and concave and more abrupt in front; base semi-oval; escutcheon lanceolate; beaks not very prominent, somewhat gibbous, incurved, nearly touching, and placed a little in advance of the middle; muscular impressions shallow, anterior one narrow oval, posterior one broad ovate; sinus of the pallial impression broad, triangular, its sides converging at an angle of about 35°, extending obliquely forward and upward nearly to the middle of the valves, very slightly obtuse at the immediate extremity. Surface marked by fine, regular, prominent lines of growth.

Length, 0.96 inch [24.38 millimeters]; height, 0.83 inch [21.08 millimeters]; gibbosity, 0.55 inch [13.97 millimeters].

The species originally described from specimens obtained in the Fox Hills sandstone on Moreau River is common in that formation and in the upper part of the Pierre shale and its equivalent. It is especially abundant in the Bearpaw shale of northern Montana and southern Alberta. The measurements given by Meek were taken from a specimen somewhat below the average in size. This type specimen is almost exactly duplicated in size, form, and all other features preserved by the specimens in the Cannonball fauna here figured.

Whitfield tentatively identified this species with *Cytherea missouriana* Morton and referred it to the genus *Dosinia*, but, as Whiteaves [2] remarks, it is not like Morton's figure and it clearly does not belong to *Dosinia*. Morton's figure of *Cytherea missouriana* has a very different outline and shows a deeply excavated lunule and a conspicuous escutcheon, in all these features strongly suggesting *Crassatellites evansi* Meek and Hayden.

Locality and position: In the Cannonball marine member of the Lance formation the species is common on the west bank of Missouri River 1 mile south of Price and 19 miles north of Mandan, N. Dak., where the figured specimens were collected. It was also obtained in sec. 28, T. 133 N., R. 88 W., about 7 miles south of Kayser, N. Dak., and at two localities on the North Fork of Grand River 3½ miles west of Haley, N. Dak., and a quarter of a mile east of Bloom, S. Dak. Imperfect specimens not so positively identified were collected 6 miles east of Flasher, 5 miles southeast of Strain, and 6 miles northwest of Solen, N. Dak., and 1 mile east of Morristown, S. Dak.

[1] Woods, H., Monograph of Cretaceous Lamellibranchia of England, vol. 2, pt. 5, pp. 181, 182, pl. 28 1908.

[2] Op. cit., p. 43.

Family CORBULIDAE.

Genus CORBULA Lamarck.

Corbula mactriformis Meek and Hayden.

Plate VI, figures 1–2b.

Corbula mactriformis Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 8, p. 117, 1856.
Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 528, pl. 43, figs. 7a–f, 1876.
White, U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, p. 80, 1880; U. S. Geol. Survey Third Ann. Rept., p. 442, pl. 18, figs. 12–15.
Whiteaves, Contr. Canadian Paleontology, vol. 1, pt. 1, p. 27, 1885.
Corbula (Potamomya) mactriformis Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 12, p. 432, 1860.

Meek's description:

Shell ovate-subtrigonal, moderately convex; right valve a little shorter, thicker, and more gibbous than the other; anterior side of both valves obliquely subtruncated, slightly concave in outline above and narrowly rounded into the base below; posterior side longer, and narrowing toward the extremity, which is narrowly rounded, or very obscurely subtruncated, base semiovate, being most prominent a little in front of the middle; beaks rather elevated, pointed, and incurved with a forward obliquity; posterior umbonal slopes having an obscure ridge extending obliquely from the beaks to the postero-basal margin; surface ornamented by moderately distinct lines of growth, which are most strongly defined behind the oblique umbonal ridge.

Length, 0.64 inch [16.25 millimeters]; height, 0.54 inch [13.7 millimeters]; breadth, about 0.34 inch [8.6 millimeters].

Locality and position: The types were collected at Fort Clark, N. Dak., and have usually been assigned to the Fort Union formation, though it is now known that the Cannonball marine member of the Lance formation extends up Missouri River about to that point. The species has been collected near the top of the high butte 1 mile south of Price and 19 miles north of Mandan, N. Dak., in supposed basal beds of the Fort Union, where it is associated with *Viviparus leai*, *Campeloma multilineata*, and *Thaumastus limnaeiformis*, and at about the same horizon and with the same associates at several other localities in North Dakota. The specimens here figured are from the Cannonball marine member of the Lance formation in the NW. ¼ sec. 22, T. 132 N., R. 85 W., 1 mile west of Schaller post office, N. Dak., where this species is associated with *Pedalion?* sp., *Modiolus schallerensis*, *Corbicula cytheriformis*, and *Callista (Dosiniopsis) nebrascensis*.

Small specimens of *Corbula* which may be young of this species or possibly represent one or two distinct species were collected at several other Cannonball localities in North Dakota.

Family SAXICAVIDAE.

Genus PANOPE Menard.

Panope simulatrix Whiteaves?

Plate VI, figure 3.

Panopaea simulatrix Whiteaves, Contr. Canadian Paleontology, vol. 1, pt. 1, p. 11, pl. 2, figs. 2, 2a, 1885.
Tellina sp. Stanton, Geol. Soc. America Bull., vol. 25, p. 352, 1914.

Original description:

Shell slightly inequivalve, the umbo of the right valve being a little larger and more tumid than that of the left; valves compressed at the sides, thickest on the anterior umbonal slope and narrowing very gradually to the posterior end but more rapidly to the anterior; posterior termination gaping; lateral outline elliptic ovate, the length being fully twice the maximum height inclusive of the beaks, and the posterior side a little longer, narrower, and more pointed than the anterior. Umbones broad, obtuse, and depressed; beaks small, subcentral, but placed a little in advance of the middle, that of the right valve curved inward and downward with a slight inclination forward, that of the left valve curved inward and a little forward but not downward; ligament apparently short and external. Surface concentrically striated; inner layer of test not nacreous; hinge teeth and muscular impressions not known.

Length of the most perfect example collected (the one figured), 52 millimeters; greatest height of the same, 25 millimeters; thickness of the same, 16.5 millimeters.

The type was obtained in the Edmonton formation of Alberta, and Whiteaves records the species from the approximately equivalent St. Mary River formation. Closely related if not identical forms are found in the Judith River, Laramie, and uppermost Fox Hills or basal Lance beds. The hinge has not been seen on any of these specimens, but a deep, broad pallial sinus has been observed in specimens from both the Judith River and Laramie formations. Neither the hinge nor the pallial line has been seen on the few specimens found in the Cannonball member, but in form and surface features they so closely resemble Whiteaves's species that they are tentatively referred to it, all questions concerning the correctness of the generic reference being left until better material furnishes full details of the hinge and other internal features.

Locality and position: The specimen figured and five other less perfect valves were collected

in the bluff on the north side of Heart River 1 mile west of Mandan, N. Dak. A few imperfect casts were obtained on the west bank of Missouri River 1 mile south of Price and 19 miles north of Mandan, N. Dak., and 8 miles southeast of Lemmon, S. Dak. All these localities are in the Cannonball marine member of the Lance formation.

Family TEREDINIDAE.

Genus TEREDO Linné.

Teredo selliformis Meek and Hayden.

Plate VI, figure 4.

Teredo selliformis Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 12, p. 178, 1869.
Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 262, pl. 17, figs. 19 a–d, 1876.

Meek's description:

Shell subglobose; posterior side narrowly rounded above and provided with a broad angular notch below; anterior ventral side having a very large hiatus, formed by a similar but deeper rectangular notch, which extends from the base nearly halfway up to the beaks and back almost to the middle of the valves; base between the anterior and posterior notches extended downward in the form of a narrow prolongation, which curves under and is the only part of the ventral borders of the two valves that comes in contact; beaks elevated, gibbous, incurved, and located between the middle and the anterior margin. Surface ornamented by small concentric lines, which are curved and deflected parallel to the great irregularities of the free borders and crossed by two radiating grooves, the posterior of which passes from the back part of the beaks obliquely downward and backward to the corner of the posterior notch, and the other, which is more distinct, extends almost directly downward to the extremity of the ventral prolongation.

Length of medium-size specimen, 0.16 inch [4 millimeters]; height, 0.14 inch [3.55 millimeters]; convexity, 0.13 inch [3.3 millimeters].

Locality and position: As originally published, "Fort Clark on the Missouri in formation No. 5," but in Meek's final description the formation is inadvertently given as "Fort Pierre group, or formation No. 5," and the figures are on a plate with Pierre species. The labels in Meek's handwriting read "near Fort Clark." It is now known that the only marine beds on the Missouri between Mandan and Fort Clark belong in the upper part of the Cannonball marine member of the Lance formation, and the specimens of *T. selliformis* must have come from this horizon. The actual type specimen represented by Meek's figures 19a and 19b has been assumed to be lost because none of the specimens in the National Museum are as large as figure 19a, which is said to be of natural size. On measuring the best-preserved shell, however, it was found that its dimensions agree perfectly with the measurements given by Meek, though a third smaller than those of his figure. It is therefore highly probable that this specimen, represented in figure 4, enlarged 4 diameters, is the type. There are several specimens in the type lot, including the tubes which were figured. A collection from a bluff on the east side of Heart River 12 miles south of Almont, N. Dak., consists of numerous slender *Teredo* tubes in which several small shells were found which are identified as immature specimens of *T. selliformis*, as they show a shallow posterior notch in the ventral margin and, on the cast, a well-marked posterior groove—two features which distinguish this species from *T. globosa*. The species was also collected by C. J. Hares in sec. 36, T. 23 N., R. 9 E., near Bloom, S. Dak. This lot was reported as "burrows of a *Teredo*-like shell," but when some of the burrows were broken up identifiable shells were found in some of them.

Teredo globosa Meek and Hayden.

Plate VI, figures 5a and 5b.

Teredo globosa Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 10, p. 53, 1858.
Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 264, pl. 30, fig. 13, text figs. 31, 32, 1876.

Meek's description:

Shell globose-cordate, thin; posterior side rounded or subtruncated, and not very widely gaping; anterior hiatus large, rectangular, extending from the middle of the base halfway up the valves; dorsum rounding posteriorly: umbonal region gibbous; beaks distinctly incurved obliquely forward, located in advance of the middle. Surface ornamented by concentric lines, which follow the curves and angular flexures of the free border and are crossed by an obscure, small groove, descending from the beaks.

Length, 0.23 inch [5.84 millimeters]; height, 0.24 inch [6.1 millimeters]; convexity, 0.22 inch [5.6 millimeters].

This species will be distinguished from the preceding by the absence of a notch or sinus in the border of its posterior side and by having its dorsal margin rounding regularly down behind instead of nearly horizontal. It also differs in having no trace of the obscure, oblique posterior sulcus on internal casts, and in the annular or ringed appearance of its tubes, which are also larger than those of that species.

Locality and position: In original description given as "Square Butte, near Fort Clark, upper part of No. 5"; in later publication "same as last"—that is, Fort Clark. The

horizon of the types must have been in the upper part of the Cannonball marine member of the Lance formation, for the reasons given in relation to *T. selliformis*. Shells that seem to belong to this species, though smaller than the type, have been collected on the hill in the northern edge of Mandan, N. Dak.; in a bluff on the north side of Heart River, 1 mile west of Mandan; and on Mitchell Butte, 3 miles east of Flasher, N. Dak., all in the Cannonball member.

Class SCAPHOPODA.

Family DENTALIIDAE.

Genus DENTALIUM Linné.

Dentalium pauperculum Meek and Hayden.

Plate VI, figures 6 and 7.

Dentalium pauperculum Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 12, p. 178, 1860.

Entalis? pauperculum Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 269, pl. 18, fig. 14, 1876.

Entalis sp. Stanton, Geol. Soc. America Bull., vol. 25, p. 352, 1914.

Meek's description:

Shell small, arcuate, tapering rather gradually; section circular; substance comparatively thick; surface smooth but showing under a magnifier extremely fine obscure lines of growth, which pass around somewhat obliquely.

Length of an imperfect specimen, measuring from the apex, 0.36 inch [9.14 millimeters]; diameter of same at apex, 0.03 inch [0.76 millimeter]; diameter at larger extremity, 0.06 inch [1.52 millimeters].

Although this smooth arcuate little species is not a typical *Dentalium*, the specimens examined, including the type, are not well enough preserved to justify its reference to any of the described subgenera, and as *Entalis* is now usually either treated as a synonym or applied to a group with longitudinal striae it seems best to refer this species again to *Dentalium* until better material is obtained. I have not seen a specimen in which the posterior end is well enough preserved to show whether it has a slit. A slight indication of swelling toward the anterior end with contraction at the aperture suggests that it may be a *Cadulus*.

Meek's figure is misleading because, although said to be of natural size, it is almost twice as long (17 millimeters) as the type specimen (9.14 millimeters). It is also more slender and does not show the maximum curvature. The type has been prepared by removing more of the matrix, and the enlarged figure now given is a photograph.

Locality and position: The type came from the Fox Hills sandstone on Moreau River, S. Dak., associated on the same specimen with *Scaphites cheyennensis*, *Yoldia evansi*, and other typical Fox Hills species. Fragmentary specimens from the upper part of the Pierre shale on Yellowstone River [near Glendive], Mont., were doubtfully referred to the species by Meek. Four specimens, one of which is figured, were obtained 75 feet below the top of the Cannonball marine member of the Lance formation on Heart River in sec. 10, T. 138 N., R. 83 W., about 12 miles southwest of Mandan, N. Dak. They seem to agree with the type in all particulars. A fragmentary imprint, possibly of this species, was collected in the SW. ¼ sec. 15, T. 134 N., R. 86 W., about 4 miles southwest of Lark, N. Dak.

Family PYRAMIDELLIDAE.

Genus TURBONILLA Risso.

Turbonilla? cordensis Stanton, n. sp.

Plate VI, figures 8a and 8b.

Cerithium sp. Stanton, in Lloyd and Hares, The Cannonball marine member of the Lance formation: Jour. Geology, vol. 23, p. 537, 1915.

Shell small and slender, consisting of seven or eight flattened whorls, each of which bears about 13 strong longitudinal ribs crossed by closely arranged, fine, threadlike spiral lines, of which 15 are visible on the penultimate whorl; ribs not quite so broad as the interspaces; base rounded and bearing only the spiral lines; nuclear whorls not preserved; aperture ovate. No columellar plication is visible in the aperture nor on the broken whorl near the apex, so that if present at all it must be very slightly developed, and for this reason the generic reference is questioned.

Height, 11 millimeters; greatest breadth, 3.5 millimeters; height of aperture, 2 millimeters; breadth of same, 1.5 millimeters.

Locality and position: Heart River on the south line of the SW. ¼ sec. 20, T. 136 N., R. 86 W., about 12 miles south of Almont, N. Dak., in the Cannonball marine member of the Lance formation, where the single type specimen is associated with *Crassatellites evansi*, *Lunatia subcrassa*, and *Anchura americana* var. *pusilla*.

Family EPITONIIDAE.

Genus EPITONIUM Bolten.

Epitonium dakotense Stanton, n. sp.

Plate VI, figures 9a and 9b.

Scala? sp. Stanton, Geol. Soc. America Bull., vol. 25, p. 352, 1914.

Shell of moderate size, with about eight well-rounded rather stout whorls, each of which bears about 17 low ribs, which are crossed by an equal number of finer somewhat variable spiral lines; base bounded by a small subangular carina and also bearing fine spiral lines that are not quite as conspicuous as those on the rest of the whorl; no umbilicus; ribs not quite as broad as the interspaces and varying slightly in size, a few of them longitudinally furrowed, probably indicating a rest stage in growth; aperture almost circular with entire peristome.

Height, 28 millimeters; greatest breadth, 15 millimeters; diameter of aperture, 7 millimeters; apical angle, 30°.

This species, which is represented by a single well-preserved specimen, has a superficial resemblance in form and sculpture to the Fox Hills species *Chemnitzia? cerithiformis* Meek and Hayden, from which it may be distinguished even in fragmentary specimens by its more regularly rounded whorls, straighter and slightly broader ribs, and more closely arranged spiral lines. The aperture also is very different in form.

Bolten's generic name *Epitonium* has been revived by Dall [1] for the group usually called *Scalaria* or *Scala*, to which the shell here described obviously belongs.

Locality and position: From a low bluff on Cannonball River in the SW. ¼ sec. 29, T. 133 N., R. 88 W., about 6 miles south of Kayser, N. Dak., in the Cannonball marine member of the Lance formation, associated with *Anchura americana* and a few other forms.

Family NATICIDAE.

Genus LUNATIA Gray.

Lunatia obliquata (Hall and Meek).

Plate VI, figures 10a and 10b.

Natica obliquata Hall and Meek, Am. Acad. Arts and Sci. Mem., vol. 5, p. 389, pl. 3, figs. 1 a, b, 1854.

Natica moreauensis Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 8, p. 64, 1856.

Natica (Lunatia) moreauensis Meek and Hayden, idem, vol. 12, p. 422, 1860.

Lunatia moreauensis Gabb, Synopsis of the Mollusca of the Cretaceous formation, p. 58, 1861.

Lunatia concinna Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 314, pl. 32, figs. 1i a–c, 1876.

Cf. *Lunatia concinna* Hall and Meek, Am. Acad. Arts and Sci. Mem., vol. 5, p. 389, pl. 3, figs. 2 a–d, 1854.

Meek's description:

Shell obliquely rhombic subovate, or subglobose; spire moderate; volutions three and a half to four, convex, and separated by a deep suture; last one comparatively large; surface marked by fine, rather obscure lines of growth, crossed by nearly obsolete, minutely flexuous, revolving striae, only seen on well-preserved specimens; aperture subovate, being straighter on the inner than the outer side; umbilicus small and sometimes showing a slight tendency to develop a small revolving ridge within; inner lip a little thickened and slightly reflected upon the body volution above the umbilicus.

Length of a mature, rather gibbous specimen, 0.90 inch [22.8 millimeters]; breadth of same, 0.76 inch [19.3 millimeters].

This description and the figures published by Meek are drawn from the types of *Natica moreauensis* Meek and Hayden, which Meek referred to *L. concinna* Hall and Meek. Direct comparison of these specimens with shells from the Cannonball marine member of the Lance formation shows very close resemblance in every particular except that the Cannonball specimens are very slightly stouter and none of them is as large as the largest of Meek's specimens. The specimen here figured, which is one of the largest in the collection, is 15 millimeters in length and 15 millimeters in greatest breadth. The recorded dimensions of Hall and Meek's type are length 0.36 inch [9.14 millimeters]; breadth 0.32 inch [8.12 millimeters].

I do not doubt the specific identity of the Cannonball specimens with *Lunatia moreauensis*, but there may be reason for a difference of opinion concerning the name that should be applied to them. Meek's final opinion was that *L. moreauensis* is a synonym of *L. concinna*, though he also called attention to the close relationship with *L. obliquata*, which seemed to differ chiefly in the presence of "an opercular groove along the columella." The types of *L. obliquata* and *L. concinna* are preserved in the American Museum of Natural History, and through the courtesy of Dr. E. O. Hovey, curator of invertebrate paleontology, I have been permitted to examine them and

[1] Dall, W. H., The Miocene of Astoria and Coos Bay, Oreg.: U. S. Geol. Survey Prof. Paper 59, p. 52, 1909.

to compare them with Meek's figured specimens and with the specimens of *Lunatia* from the Cannonball member. My opinion is that the Fox Hills specimens which have been called *L. moreauensis* and *L. concinna* and certain of the Cannonball specimens should be referred to *L. obliquata*. The fact that a single Cannonball specimen shows the opercular groove almost as well developed as in the type of *L. obliquata*, while all the others which agree in other features fail to show it, seems to indicate that this imprint of the operculum is not of specific importance. Meek stated that he had sometimes suspected that the original *L. concinna* should be regarded as belonging to *L. obliquata*, and on the evidence of the description and figures it would be reasonable to make this disposition of the species, as the two types are so nearly alike, and the description of *L. obliquata* stands first on the page. The status of *L. concinna* is further complicated, however, by the fact that the specimen preserved as the type of that species is stated by Whitfield and Hovey[1] to be "a very young individual of a recent form, not a fossil." The state of preservation of the specimen, which appears to be scarcely at all altered, seems to justify this statement, but on the other hand I am assured by W. H. Dall and Paul Bartsch that it does not belong to any recent species represented in the United States National Museum. Furthermore, some undoubted Cretaceous shells are almost as well preserved. Whether this particular shell is a Cretaceous fossil or not it certainly is very closely related to the type of *L. obliquata*.

Locality and position: The original type came from the upper part of the Pierre shale on Sage Creek, S. Dak., and Meek and Hayden's specimens described as *Natica moreauensis* were collected in the Fox Hills sandstone on Moreau River, S. Dak. The species is represented in the collections from 11 localities in the Cannonball marine member of the Lance formation as follows:

Sec. 31, T. 133 N., R. 88 W., about 6 miles south of Kayser, N. Dak. (figured specimens and others).

Secs. 17 and 28 in same township.

Sec. 11, T. 22 N., R. 15 E., 7 miles southwest of Lemmon, S. Dak.

Sec. 9, T. 130 N., R. 90 W., 10 miles southwest of Pretty Rock, N. Dak.

Sec. 17, T. 134 N., R. 81 W., 7 miles northwest of Solen, N. Dak.

Sec. 16, T. 136 N., R. 84 W., on Heart River 10 miles north of Flasher, N. Dak.

Sec. 29, T. 136 N., R. 86 W., 12 miles south of Almont, N. Dak.

Sec. 19, T. 136 N., R. 87 W., 7 miles southwest of Almont, N. Dak.

Sec. 10, T. 138 N., R. 83 W., on Heart River about 12 miles southwest of Mandan, N. Dak.

T. 141 N., R. 81 W., on Missouri River about 1 mile south of Price and 19 miles north of Mandan, N. Dak.

[1] Am. Mus. Nat. Hist. Bull., vol. 11, p. 429, 1901.

Lunatia subcrassa (Meek and Hayden).

Plate VI, figures 11a and 11b.

Natica subcrassa Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 8, p. 87, 1856.

Natica (Lunatia) subcrassa Meek and Hayden, idem, vol. 12, p. 422, 1860.

Lunatia subcrassa Gabb, Synopsis of the Mollusca of the Cretaceous formation, p. 58, 1861.

Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 316, pl. 39, figs. 3 a–c, 1876.

Meek's description:

Shell rather thick, obliquely compressed subglobose or subovate; spire short; volutions three and a half to four, last one comparatively large, sloping obliquely outward and downward almost immediately from the suture above, and rounded below the middle; suture distinct but not deep; aperture large, subovate, being angular above, rounded below, forming a semiovate curve on the outer side, and nearly straight on the inner; outer lip very oblique, being much produced forward above and extending obliquely backward, with a broad and slightly sinuous outline near the middle; inner lip nearly straight, moderately thick, and a little reflexed upon the body volution above the umbilical perforation; surface showing (on slightly weathered specimens) distinct, very oblique lines of growth.

Length, 1.08 inches [27.43 millimeters]; breadth, 0.90 inch [22.86 millimeters]; length of aperture, 0.85 inch [21.59 millimeters]; breadth of same, 0.57 inch [14.47 millimeters].

This shell will be at once distinguished from the foregoing [*L. concinna* and *L. occidentalis*] by its greater thickness, shorter spire, obliquely compressed body volution, and the more oblique outline of its outer lip. Its suture is also less deep than in either of the preceding species, owing to the fact that the volutions do not round into it but slope more immediately below it, nearly in the direction of the general slope of the spire.

The specimen here figured, which is the largest one collected from the Cannonball member, is 27 millimeters long and 25 millimeters broad, with an aperture measuring 22 millimeters long and 14 millimeters wide. It agrees with the types in general form and all other features except that the umbilicus is slightly broader than in the types or any pre-

Lance specimen, although there is some variation in that respect, so that occasional specimens from the Claggett have the umbilicus almost as wide open as it is in the Lance specimens.

Locality and position: The types were collected near Judith, Mont., in rocks long supposed to represent the Fox Hills sandstone but now known to be in the upper part of the Claggett formation. The species is also locally abundant in the same region in sandy beds at the base of the Bearpaw shale immediately overlying the Judith River formation. It has been reported from the Fox Hills sandstone of northern Colorado, and good examples of it have been obtained in the upper part of the typical Fox Hills in Tps. 20 and 21 N., R. 25 E., north of Grand River, N. Dak. In the Cannonball marine member of the Lance formation it has been collected on Heart River three-quarters of a mile west of Mandan (figured specimen), 12 miles south of Almont, in sec. 9, T. 133 N., R. 85 W., and in T. 133 N., R. 88 W., all in North Dakota.

Family TURRITELLIDAE.

Genus TURRITELLA Lamarck.

Turritella haresi Stanton, n. sp.

Plate VI, figure 12.

Turritella sp. Stanton, Geol. Soc. America Bull., vol. 25, p. 352, 1914.

Shell small, slender, with obliquely flattened whorls; sculpture consisting of four rather prominent, minutely tuberculated spiral lines, the lowest of which borders the suture and on the upper whorls may be concealed, while the next one above it is the largest and forms a carina on the last whorl; space above the larger spiral divided by the other spirals into three equal parts, the upper of which is beveled to the suture.

The type specimen, consisting of about nine whorls, is 10 millimeters in length and 3 millimeters in greatest breadth. A crushed specimen supposed to belong to the species is over 20 millimeters long.

In size, general form, and sculpture this little shell resembles the Fox Hills species *Cerithiopsis moreauensis* Meek and Hayden closely enough to suggest relationship, but the points of resemblance are only superficial. *T. haresi* has no anterior canal and apparently there are no plaits or ridges on the columella.

The specific name is given for Mr. C. J. Hares.

Locality and position: In a high bluff south of Cedar Creek, in the NW. ¼ sec. 5, T. 129 N., R. 89 W., N. Dak., in the Cannonball marine member of the Lance formation.

Family APORRHAIDAE.

Genus ANCHURA Conrad.

Anchura (Drepanochilus) americana (Evans and Shumard).

Plate VI, figure 13.

Rostellaria americana Evans and Shumard, St. Louis Acad. Sci. Trans., vol. 1, p. 42, 1857.

Aporrhais americana Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 12, p. 423, 1860.

Anchura (Drepanochilus) americana Meek, Smithsonian check list of North American Cretaceous fossils, p. 19, 1864; U. S. Geol. Survey Terr. Rept., vol. 9, p. 325, pl. 32, figs. 8 a, b, 1876.

This species was included in my preliminary list of the Cannonball fauna [1] as represented by both the typical form and a robust variety. As a result of further study and comparison these two forms are now described respectively as a new variety of *Anchura americana* and as a distinct new species, though it is believed that certainly the variety and possibly the species were directly derived from *A. americana*.

The original types of the species came from Grand and Moreau rivers, S. Dak., presumably from the Fox Hills sandstone. The specimens figured and more fully described by Meek also came from the Fox Hills sandstone on Moreau River, and it is noteworthy that these specimens served as the types of the subgenus *Drepanochilus*, which does not seem to differ from the subsequently described *Dimorphosoma* of Gardner. The species is common in the Fox Hills sandstone, in the upper part of the Pierre shale, and in the Bearpaw shale.

The figure here given for comparison with the new variety *pusilla* is a photograph of a somewhat immature specimen taken from the same lot which furnished the shells figured by Meek.

[1] Geol. Soc. America Bull., vol. 25, p. 352, 1914.

Anchura (Drepanochilus) americana var. pusilla Stanton, n. var.

Plate VI, figures 14 and 15.

Anchura americana (Evans and Shumard) Stanton, Geol. Soc. America Bull., vol. 25, p. 352, 1914.

Shell small, fusiform, consisting of about seven volutions; spire about equal to length of aperture and canal, with rounded volutions; last whorl with a strong carina above the middle and two successively smaller carinae below, the lower of which is sometimes obsolescent; anterior canal short and straight; expanded outer lip with a pointed, slightly upturned process that bears the continuation of the main upper carina to its end, above which the margin is concave, while below it forms a very gentle sigmoid curve or is almost straight to the end of the canal; no posterior canal, though the winglike outer lip extends upward and is applied to part of the penultimate whorl; inner lip moderately thick and connected above with the outer lip; surface marked by numerous small curved ribs crossed by fine, threadlike spiral lines, there being 25 or more of the ribs and from 13 to 17 of the lines visible on each of the larger whorls of the spire. On the last whorl the ribs are gradually reduced to tubercles on the principal carina and the spiral lines are increased by the intercalation of smaller ones until on the outer part of the wing there are about 10 above the upper carina, 6 between that and the middle carina, 4 between the middle and lower carinae, and about 15 below the lower carina.

Height, 11.5 millimeters; breadth of last whorl exclusive of wing, 5 millimeters; apical angle, about 30°.

This little shell agrees with *A.* (*D.*) *americana* in almost every detail except size, and it is therefore regarded as only a dwarfed variety of that species, as the varietal name selected suggests. A comparison of the enlarged figures (14 and 15) of the variety with the natural-size figure (13) of a somewhat immature specimen of the typical form emphasizes the agreement.

Locality and position: The figured types with numerous other specimens were collected near Grand River post office in sec. 12, T. 22 N., R. 12 E., S. Dak. The species has also been collected 9 miles east, 8 miles southeast, and 7 miles southwest of Lemmon, S. Dak.; a quarter of a mile east of Bloom, S. Dak.; 7 miles south of Leith, 12 miles south and 19 miles southwest of Almont, and 6 miles northwest of Solen, N. Dak., all in the Cannonball marine member of the Lance formation.

Anchura (Drepanochilus) perveta Stanton, n. sp.

Plate VII, figures, 1a–3b.

Anchura americana (Evans and Shumard), robust variety, Stanton, Geol. Soc. America Bull., vol. 25, p. 352, 1914.

Shell of medium size, fusiform, consisting of eight or more whorls; spire considerably shorter than combined length of aperture and canal, with strongly rounded whorls tending to become subcarinate; last whorl with three conspicuous carinae, of which the uppermost is largest and extends to the upturned pointed end of the winglike outer lip, and the lowest one is smallest; anterior canal short, narrow, and straight; lower and outer margin of the expanded outer lip forming a broad sigmoid curve, upper margin strongly concave, with varying curvature in different individuals, and extended upward on the spire to the antepenultimate whorl; no posterior canal; inner lip connected above with the outer lip and thickened by a heavy callus, which is especially prominent over the middle and lower carinae, beneath which it is suddenly contracted; outer lip also greatly thickened by an internal deposit on mature specimens; surface of the spire marked by strong oblique or slightly curved ribs crossed by fine, inconspicuous, closely arranged spiral lines, there being about 15 or 16 ribs and 30 or more lines on each larger whorl of the spire. On the last two whorls the ribs are gradually shortened until on the back of the last whorl they are reduced to strong tubercles on the upper carina and cease entirely before the carina reaches the wing.

Height of medium-sized specimen, 29 millimeters; breadth of last whorl exclusive of wing, 13 millimeters, with wing, 21 millimeters; apical angle, about 30°; greatest thickness of outer lip, 4.5 millimeters; callus on inner lip, 3.5 millimeters. Slight variations in the proportions of the shell and in the form of the outer lip are shown by the other two figured specimens.

This species is probably the most abundant gastropod in the Cannonball fauna. In the preliminary lists it was treated as a variety of

Anchura americana in which the whole shell had become more robust, with exaggerated sculpture and thickened callus deposits suggesting the old-age characteristics of an overgrown individual. The type of *A. americana* var. *pusilla* if enlarged a little more than two diameters and with all the sculpture much emphasized would make a similar shell, but closer comparison shows that the two species are not so closely related and *A. perveta* can be easily distinguished by its larger and less numerous vertical ribs, more numerous and less conspicuous spiral lines, and much stronger carinae, as well as by its greater size. Even small young specimens showing only the spire are easily separated by the differences in sculpture.

Locality and position: The type and figured specimens came from Cannonball River in T. 133 N., R. 88 W., about 6 miles south of Kayser, N. Dak., where the species is abundant. It has been recognized in collections from about 15 other localities distributed over most of the area of the Cannonball marine member of the Lance formation from a point 4 miles south of Morristown, S. Dak., to a point on Missouri River 1 mile south of Price and 19 miles north of Mandan, N. Dak. It is not known to range outside of the Cannonball member.

Anchura (Drepanochilus) perveta var. gracilis Stanton, n. var.

Plate VII, figures 4a and 4b.

This variety differs from the type of the species in its more slender form, its straighter outer lip or wing, and its much longer anterior canal, though the last-named feature may be in part due to the accident of preservation. In some specimens of the typical form the canal or beak looks as if it may have been broken or worn off during life. In all other details the variety agrees with the type.

Height of figured specimen, 39 millimeters; breadth of last whorl exclusive of wing, 11 millimeters, with wing about 21 millimeters; apical angle, about 25°. The anterior canal below the expanded outer lip is 9 millimeters in length, which is about twice as long as in the typical form.

Locality and position: The figured specimens and several others were obtained on Cannonball River in the SW. ¼ sec. 29, T. 133 N., R. 88 W., about 6 miles south of Kayser, N. Dak., in the Cannonball marine member of the Lance formation. Several specimens were also collected from the same member on Cedar Creek in the NW. ¼ sec. 9, T. 13 N., R. 90 W., N. Dak.

Family STROMBIDAE.

Genus CALYPTRAPHORUS Conrad.

Calyptraphorus septentrionalis Stanton, n. sp.

Plate VII, figures 5a–5d and 6.

Helicaulax? sp. Stanton, Geol. Soc. America Bull., vol. 25, p. 352, 1914.

Shell of medium size, consisting of about 10 nearly flat whorls which in immature shells are covered by numerous fine, threadlike spiral lines and less conspicuous curved costae, which become obsolete on the later whorls. In the adult a heavy flat callus covers the entire front side of the spire, completely concealing the whorls, and a thinner deposit glazes the dorsal aspect, obscuring but not entirely concealing the sutures and the surface sculpture.

The fragmentary type, consisting of the larger part of the spire, is 33 millimeters in height and 16 millimeters in greatest breadth and has an apical angle of about 25°. A smaller specimen which is believed to represent an immature stage of this species before the callus was developed is 12 millimeters in height and 8 millimeters in greatest breadth. These two specimens from the same locality are the only known examples of the species.

In the preliminary list of the Cannonball fauna this form was doubtfully referred to *Helicaulax*, but further comparison has shown so close a resemblance to *Calyptraphorus velatus* Conrad in form, sculpture, and the nature of the callus which envelops the spire that there can be little doubt that the two species belong to the same genus, even though the form of the aperture is entirely unknown in *C. septentrionalis*. Specifically *C. septentrionalis* may be distinguished even in such fragmentary specimens as are here figured, by its slightly flatter whorls and the much weaker sculpture, particularly the costae of the spire, when not concealed by the callus. If the entire shell were preserved doubtless other differences would be evident.

The occurrence of the genus *Calyptraphorus* in the Cannonball fauna is interesting and im-

portant from the fact that so far as the United States is concerned the genus has been considered characteristic of the Eocene. *C. velatus* was described from specimens found in the Claiborne, but it occurs also in the Jackson and is represented by the variety *compressa* Aldrich in the Midway or lowest Eocene of the Gulf Coastal Plain. This variety is a stouter shell, though its sculpture does not differ greatly from that of *C. septentrionalis*. The other American species, *C. trinodiferus* Conrad and *C. jacksoni* Clark, are found in Eocene formations later than Midway. *Rostellaria palliata* Forbes, a Cretaceous species found in the Trichinopoly and Arrialoor groups of India, has been referred to *Calyptraphorus* by Gabb,[1] and the figures published by Stoliczka[2] make this reference reasonable, although Stoliczka says [3] that it "does not seem to be fully justified for the present," and it is specifically very different from all the American species.

Locality and position: The type of *C. septentrionalis* was found in a bluff on Cannonball River in the SW. ¼ sec. 17, T. 133 N., R. 88 W., about 5 miles southeast of Kayser, N. Dak., in gray shales of the Cannonball marine member of the Lance formation.

Family BUCCINIDAE.

Genus CANTHARUS Bolten.

Cantharus (Cantharulus) vaughani (Meek and Hayden).

Plate VII, figures 7a and 7b.

Fusus vaughani Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 9, p. 138, 1857.

Cantharus? vaughani Meek, Smithsonian check list of North American Cretaceous fossils, p. 22, 1864.

Cantharus (Cantharulus) vaughani Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 377, pl. 32, figs. 5 a, b, text fig. 48, 1876.

Meek's description:

Shell oval-fusiform, rather thick; spire turreted, moderately elevated, composed of six to six and a half convex whorls, which are obliquely a little flattened or very slightly concave above; last turn tapering quite abruptly into the rather narrow, moderately produced canal; suture distinct; surface of each volution ornamented by about fifteen small, equidistant, vertical folds, equaling the depressions between; crossing these are a series of small, rather elevated, regular, revolving bands, less than the intermediate spaces; over the entire surface very fine, obscure, revolving striae may also be seen by the aid of a lens, forming, with the fine lines of growth, a faint textile marking, entirely subordinate to and distinct from the greatly coarser network formed by the crossing of the folds and revolving bands; aperture rather narrow oval; outer lip faintly cross sulcated at the edge within and slightly sinuous above; inner lip united to the outer one above and rather closely connected with the smooth, tortuous, and arcuate columella.

Length, 1.43 inches [36.3 millimeters]; breadth, 0.75 inch [19 millimeters]; apical angle convex, divergence about 54°.

Four or five of the revolving bands on the body whorl and two of those on each turn of the spire are larger than the others and form rather distinct nodes at the points where they cross the folds. Below these four larger bands on the body volution there are about five or more smaller ones, which diminish in size and become more oblique on approaching the canal, while on the obliquely flattened upper part of the whorls there are some three or four much smaller and less prominent bands or lines.

Locality and position: Meek and Hayden's single specimen was collected near the mouth of Heart River, N. Dak., in beds supposed to belong to the Fox Hills sandstone but now known to belong in the Cannonball marine member of the Lance formation. A small specimen has been obtained in the same member in T. 33 N., R. 88 W., about 6 miles south of Kayser, N. Dak., and a very small specimen, 10 millimeters long, which is believed to be a young individual of this species, was collected in the Fox Hills sandstone about 4 miles northwest of Wakpala, S. Dak.

Genus PYRIFUSUS Conrad.

Pyrifusus (Neptunella) newberryi (Meek and Hayden).

Plate VII, figures 8a and 8b.

Fusus newberryi Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 8, p. 66, 1857.

Fusus (Pyrifusus?) newberryi Meek and Hayden, idem, vol. 12, p. 421, 1860.

Pyrifusus newberryi Meek, Smithsonian check list of North American Cretaceous fossils, p. 22, 1864.

Pyrifusus (Neptunella) newberryi Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 346, pl. 31, figs. 6 a–f, text fig. 39, 1876.

Meek's description:

Shell rhombic-subfusiform, rather thick; spire conical, acute at the apex when not eroded; volutions five, obliquely flattened or a little concave above and convex around the middle, where they are ornamented by a row of more or less prominent, vertically elongated nodes, or costae; last turn comparatively large and tapering rather abruptly into the rather short, straight canal below; surface marked by distinct lines of growth, crossed by numerous well-defined, round, threadlike, revolving lines; suture linear; aperture rhombic-obovate, rather obtusely angular above and narrowing more gradually below; outer

[1] Gabb, W. M., Am. Jour. Conchology, vol. 4, p. 142, 1868.

[2] Stoliczka, F., Palaeontologia Indica, Cretaceous fauna of southern India, vol. 2, pl. 2, figs. 18–20, 1868.

[3] Idem, p. 24.

lip beveled; inner lip scarcely distinct from the slightly arcuate columella.

Length, 1.43 inches [36.3 millimeters]; breadth, 0.81 inch [20.57 millimeters]; length of aperture and canal, 0.87 inch [21.1 millimeters]; breadth of aperture, 0.32 inch [8.13 millimeters]; apical angle convex, regular, or even a little concave; divergence variable but usually about 60° to 65°.

This species varies more or less in form, as well as in the prominence of the nodelike costae. In some individuals the spire is more elevated and the body whorl proportionally much narrower than in others. The nodes, or costae, of which about 15 may be counted on the last turn, are usually quite distinct on all the whorls, but in some specimens they become obsolete on the last one. * * * On the upper sloping part of the whorls the revolving lines are in most cases smaller and about equal to the spaces between; farther down, however, they are generally a little larger, rather more distant, and often have between each two of the principal ones a smaller line.

Locality and position: This species was originally described from specimens collected in the Fox Hills sandstone of Moreau River and the Fox Hills, S. Dak. All except one of the specimens later figured by Meek are labeled Moreau River, and the exception (6e of Meek's figures) is one of a lot labeled "Yellowstone, 150 miles above mouth," which doubtless came from the upper part of the Pierre shale a few miles west of Glendive, Mont. In the Cannonball marine member of the Lance formation the few imperfect and immature specimens referred to the species are very similar in form and sculpture to those from the Yellowstone. The best of these, which is figured, was collected by Mr. E. T. Hancock on Heart River in yellowish-brown sandstone 110 feet above water in the SW. ¼ NW. ¼ sec. 6, T. 137 N., R. 83 E., about 15 miles southwest of Mandan, N. Dak. Although much smaller than the type, it agrees well in form and sculpture and is believed to be a young shell.

Pyrifusus (Neptunella) gracilis Stanton, n. sp.

Plate VIII, figures 1a and 1b.

Shell small, fusiform, consisting of about five whorls which are closely appressed, slightly flattened above, and convex around the middle; last whorl tapering gradually into the moderately long canal. Surface ornamented by about 13 short vertical ribs on the middle convex part of each whorl and by numerous fine, threadlike spiral lines; outer lip simple, inner lip inconspicuous; aperture lance-ovate. Height, 26 millimeters; greatest breadth, 12 millimeters; height of aperture and canal, 17 millimeters; breadth of aperture, 5 millimeters; apical angle, about 50°.

This species has about the proportions of *Pyrifusus (Neptunella) intertextus* Meek and Hayden, but it is a smaller shell and differs in details of sculpture.

Locality and position: The type was collected near the top of a bluff on the north side of Heart River three-quarters of a mile east of Mandan, N. Dak., in the upper part of the Cannonball marine member of the Lance formation. Two fragmentary specimens, one of which represents a shell about 38 millimeters high, were obtained at about the same horizon in sec. 11, T. 132 N., R. 88 W., about 7 miles south of Leith, N. Dak.

Genus LEVIFUSUS Conrad.

Levifusus? tormentarius Stanton, n. sp.

Plate VIII, figures 2a, 2b, and 3.

Turris sp. related to *T. contortus* Meek and Hayden, Stanton, Geol. Soc. America Bull., vol. 25, p. 352, 1914.

Shell small, rhombic-subfusiform, consisting of about six rapidly increasing whorls; last whorl forming nearly two-thirds the length of the shell, bluntly bicarinate around the middle, gradually narrowing into the short canal; upper carina, which is also visible on the whorls of the spire just above the suture, with about 20 small nodes to each whorl; lower carina also minutely nodose; upper slope of the whorl concave; outer lip apparently smooth within, broadly sinuous between the suture and the upper carina, as shown by the fine lines of growth; columella slightly twisted below; surface covered by numerous fine, threadlike spiral lines which show a tendency to alternation in size.

Height, 28 millimeters; breadth, 11 millimeters; height of aperture, 12 millimeters; breadth of aperture, 5 millimeters.

This species is apparently congeneric with *Levifusus trabeatus* Conrad and *L. pagoda* (Heilprin), both of which are found in the Midway and Wilcox groups of the Gulf Coastal Plain Eocene. In form and sculpture it especially resembles the variety of *L. trabeatus* figured by Aldrich [1] and by Harris [2] from the Midway of

[1] Aldrich, T. H., Bull. Am. Paleontology, vol. 1, No. 2, pl. 4, fig. 6, 1895.
[2] Harris, G. D., idem, vol. 1, No. 4, pl. 9, fig. 10, 1896.

Alabama, but it differs in having more numerous and smaller nodes on the carina and in lacking internal lirae on the outer lip.

Locality and position: The type was found in the Cannonball marine member of the Lance formation in the SW. ¼ sec. 29, T. 133 N., R. 88 W., on Cannonball River about 6 miles south of Kayser, N. Dak. Another specimen, which is also figured, was found in the same member in the SW. ¼ sec. 34, T. 23 N., R. 17 E., 9 miles east of Lemmon, S. Dak.

Genus PYROPSIS Conrad.

Pyropsis hancocki Stanton, n. sp.

Plate VIII, figure 4.

Shell small, pyriform, consisting of about four rapidly increasing convex whorls; spire low, conical; sutures distinctly impressed; whorls flattened above, the last one faintly tricarinate around the middle and abruptly contracted into the long, slender, slightly curved anterior canal; surface bearing in addition to the carinae slender, somewhat distant vertical ribs (about 15 to the whorl), which tend to be nodose at the intersections with the carinae, and many fine, threadlike spiral lines, of which there are four on the upper surface of the last whorl, three between the upper and middle carinae, and more than a dozen below the lower carina.

Height, 15 millimeters; greatest breadth, 8 millimeters.

This species, which is represented by a single specimen collected by Mr. E. T. Hancock, of the United States Geological Survey, has almost the form and proportions of *Pyropsis whitfieldi* Weller [1] from the Navesink marl, but it is slightly more slender as well as smaller and has relatively finer sculpture.

Locality and position: On Heart River in the SE. ¼ sec. 10, T. 138 N., R. 88 W., about 12 miles southwest of Mandan, N. Dak., in a brown sandstone about 75 feet below the top of the Cannonball marine member of the Lance formation.

[1] Weller, Stuart, New Jersey Geol. Survey, Paleontology, vol. 4, p. 750, pl. 88, figs. 14–16, 1907.

Family FUSIDAE.

Genus FASCIOLARIA Lamarck.

Fasciolaria lloydi Stanton, n. sp.

Plate VIII, figures 11a and 11b.

Fasciolaria buccinoides Meek and Hayden, Stanton, Geol. Soc. America Bull., vol. 25, p. 352, 1914.

Shell small, short fusiform, consisting of about five convex whorls; last whorl gibbous, forming about two-thirds the length of the shell and contracting rather abruptly into the short, slightly curved canal; suture slightly channeled; surface marked by vertical ribs, of which there are 14 on the last whorl, crossed by relatively strong spiral lines, which are slightly narrower than the interspaces and tend to be tuberculated at the intersections with the ribs; 12 spiral lines on the last whorl and only 4 visible on the spire; aperture narrow oval, tapering below; outer lip thin, not crenulate within; columella slightly twisted and bearing two distinct oblique plaits.

Height, 13 millimeters; greatest breadth, 9 millimeters; apical angle, about 60°. A larger specimen is 22 millimeters in height and 13 millimeters in breadth.

This species is closely related to *F. buccinoides* Meek and Hayden, especially the costate variety,[1] with which it agrees in general form and in the character of the two plaits on the columella. Its sculpture also is similar but is relatively coarser. The vertical ribs are longer and better developed, and the spiral lines are coarser and more widely spaced, so that only four of them are visible on the next to the last whorl, as compared with seven in *F. buccinoides*. On account of these differences in the sculpture and the smaller size it has been deemed necessary to recognize this form as a distinct species.

Locality and position: The type was found in sec. 31, T. 133 N., R. 8 W., about 6 miles south of Kayser, N. Dak. The larger specimen above mentioned was collected in sec. 5, T. 22 N., R. 20 E., about 4½ miles southeast of

[1] Meek, F. B., U. S. Geol. Survey Terr. Rept., vol. 9, p. 358, pl. 31, fig. 8c, 1876.

Morristown, S. Dak. Another specimen was obtained in the NW. ¼ sec. 11, T. 132 N., R. 88 W., about 7 miles south of Leith, N. Dak., and a fragmentary specimen in the SW. ¼ sec. 15, T. 134 N., R. 86 W., about 4 miles southwest of Lark, N. Dak., all from the Cannonball marine member of the Lance formation.

Fasciolaria? mandanensis Stanton, n. sp.

Plate VIII, figures 5–7.

Shell rather small, short fusiform, consisting of about six moderately convex whorls, which are somewhat flattened on the upper third especially of the last whorl, which forms about two-thirds of the total length of the shell; canal short and slightly curved; suture distinct; surface marked by prominent vertical ribs, of which there are 16 on the last whorl, crossed by strong spiral lines, which are about equal to the interspaces and of which 6 are visible on the spire and about 20 on the last whorl; aperture narrow oval, tapering below; outer lip thin, rather coarsely crenulate within; columella with two oblique plaits, of which the upper one is the stronger.

Height of most nearly complete specimen, about 30 millimeters; greatest breadth, 15 millimeters; apical angle, about 60°. The other specimen indicates a height of about 35 millimeters and breadth of 17 millimeters.

This species appears to be related to both *F. buccinoides* and *F. lloydi*, but it differs from both sufficiently in details of form and sculpture to justify its recognition as a distinct species.

Locality and position: Represented by only the two figured specimens, which were collected near the top of the bluff on the north bank of Heart River about a mile west of Mandan, N. Dak., in the upper part of the Cannonball marine member of the Lance formation, and a fragment from the NW. ¼ sec. 11, T. 132 N., R. 88 W., about 7 miles south of Leith, N. Dak.

Fasciolaria? cordensis Stanton, n. sp.

Plate VIII, figures 8a–10.

Shell very small, consisting of about five moderately convex whorls, which tend to be slightly shouldered at the top; last whorl with short anterior canal forming nearly two-thirds of the length of the shell; surface marked by numerous fine, closely arranged spiral lines, which are slightly broader than the intervening grooves, and by small, narrow vertical ribs which on the type specimen are fairly well developed on the next to the last whorl but become obsolete on the last whorl; 14 spiral lines on the last whorl and 7 visible on the spire; outer lip thin, smooth within; columella with two distinct oblique plaits, below which there is an incipient fold or denticle that does not continue back inside the shell.

Height, 6 millimeters; greatest breadth, 4 millimeters; apical angle, about 50°.

The type is a very small shell, believed to be an immature individual, which is congeneric with *F. buccinoides* and *F. lloydi* but differs from both in details of sculpture. Two other specimens from the type locality, one of which is figured, have the vertical ribs better preserved.

Locality and position: In the Cannonball marine member of the Lance formation in the SW. ¼ sec. 24, T. 136 N., R. 88 W., on Heart River about 19 miles southwest of Almont, N. Dak. Another specimen (fig. 10), which was collected on Heart River in the SW. ¼ sec. 20, T. 136 N., R. 86 W., about 12 miles south of Almont, differs from the type in its more distinctly shouldered whorls and its lack of vertical ribs and may belong to another species.

Fasciolaria? (Mesorhytis) dakotensis Stanton, n. sp.

Plate VIII, figures 13a–14b.

Fasciolaria (*Piestochilus*) *culbertsoni* Meek and Hayden. Stanton, Geol. Soc. America Bull., vol. 25, p. 352, 1914.

Shell elongate fusiform, consisting of about nine moderately convex whorls; spire produced, about equal in length to the aperture and canal; whorls each with about 15 rather prominent, nearly straight, vertical ribs, which are narrower than the interspaces and on the last whorl do not extend below the middle and tend to become obsolete toward the outer lip; canal nearly straight, moderately produced; columella almost straight, bearing opposite the middle of the aperture three distinct, not very oblique folds or plaits, of which the uppermost is smallest and is separated from the middle one by a slightly narrower interval than that between the middle and the lowest; aperture lance-oval; surface marked by very fine lines of growth parallel to the ribs and by fine, some-

what irregular spiral lines which are considerably broader than the very fine impressed lines separating them.

Height of type, 38 millimeters; greatest breadth, 12 millimeters; apical angle, about 30°. The smaller figured specimen is 15 millimeters in height and 5.3 millimeters in greatest breadth.

This species is closely related to *Fasciolaria? (Mesorhytis) gracilenta* Meek, which was described [1] as the type of the subgenus *Mesorhytis* and was collected from the upper part of the Pierre shale on "Yellowstone River 150 miles above mouth," probably near Glendive, Mont. Apparently Meek failed to label the type of *Fasciolaria (Mesorhytis) gracilenta,* and some years later it was identified as *F. (Piestochilus) culbertsoni.* With this false label it has remained in the collections of the United States National Museum until January, 1918, when it was recognized as the original of Meek's figure and description during the critical study of the Cannonball specimens that had been identified as *Fasciolaria (Piestochilus) culbertsoni,* partly on account of the confusion occasioned by the wrong labeling of *F. (Mesorhytis) gracilenta.* Meek described *Mesorhytis* as nearly agreeing with *Piestochilus* in form but distinguished from it by stronger and less oblique columellar plaits, which are exposed directly opposite the middle of the aperture. In *M. gracilenta* as in *M. dakotensis* there are three strong columellar plaits. The typical costate form of *Piestochilus culbertsoni* has four moderately developed plaits on the columella (seen in two specimens of the type lot), but the larger form, with vertical costae almost lacking, has only one well-developed columellar plait, with an obscure one above it as observed in several broken specimens that show this feature. If this difference should prove to be constant the two forms should not be referred to the same species, and Evans and Shumard's name *haydeni* should then be revived for the larger, noncostate form.

Fasciolaria (Mesorhytis) dakotensis may be distinguished from *F. (M.) gracilenta* by its much finer and less conspicuous spiral sculpture and its less numerous and somewhat stronger vertical ribs.

Some of the Eocene species that have been described as *Mitra* appear to be closely related to *Mesorhytis.* Good examples of these are *Mitra pomonkensis* and *M. potomacensis,* described by Clark and Martin [1] from the Eocene of Maryland. Meek probably had such forms in mind when he said that "*Mesorhytis* occurs in the Cretaceous and, apparently, also in the Tertiary." He further stated concerning the type of *Mesorhytis:*

> I am not at all satisfied with the reference of this shell to the genus *Fasciolaria,* owing to the fact that the plaits of its columella are stronger and much less oblique and occupy so much higher a position than in *Fasciolaria* proper. I do not believe, however, that such shells can be properly referred to any section of *Mitra* or *Turricula,* as is sometimes done.

Locality and position: The type specimen of *Fasciolaria (Mesorhytis) dakotensis* was collected in T. 133 N., R. 88 W., about 6 miles south of Kayser, N. Dak., and the other figured specimen was obtained in the SW. ¼ sec. 17 of the same township. The species is also represented in collections from the west bank of Missouri River 1 mile south of Price, N. Dak.; Heart River in sec. 6, T. 137 N., R. 83 W., sec. 16, T. 136 N., R. 84 W., and sec. 29, T. 136 N., R. 86 W.; sec. 28, T. 133 N., R. 88 W.; river bluff near Janesburg, N. Dak.; sec. 15, T. 134 N., R. 86 W.; sec. 9, T. 130 N., R. 90 W., 10 miles southwest of Pretty Rock, N. Dak.; and sec. 7, T. 22 N., R. 17 E., 8 miles southeast of Lemmon, S. Dak.—all in the Cannonball marine member of the Lance formation.

Family VASIDAE.

Genus PSILOCOCHLIS Dall.

Psilocochlis? occidentalis Stanton, n. sp.

Plate VIII, figures 15a and 15b.

Shell small, pyriform, consisting of about four whorls, the last one comparatively large, very convex on the periphery, flattened and abruptly contracted below into the short, slightly curved canal; columella with three very strong folds, of which the uppermost is the strongest; surface with inconspicuous growth lines and numerous fine, closely arranged spiral lines that are just visible to the unaided eye.

Height, 12 millimeters; greatest breadth, 11 millimeters; height of aperture, 9 millimeters.

This little shell, which is represented by the single type specimen, is unlike anything hitherto

[1] U. S. Geol. Survey Terr. Rept., vol. 9, p. 364, text fig. 45, 1876.

[1] Clark, W. B., and Martin, G. C., Maryland Geol. Survey, Eocene, pp. 132, 133, pl. 21, figs. 10, 11, 1901.

reported from the faunas of the Rocky Mountains or Great Plains. On the suggestion of W. H. Dall it is referred with some doubt to his genus *Psilocochlis*, which it resembles in form and especially in the character of the columellar plaits. The type and only described species of that genus is *Psilocochlis mccalliei*, which was found in rocks of Claiborne age near Hephzibah, Ga. It is much larger than the shell here described and differs in two other important characters in having a distinct umbilicus and a coating of enamel that covers the spire and conceals the sutures. It is possible, of course, that *Psilocochlis? occidentalis* is an immature shell which would develop the enamel coating in the adult stage, but probably well-preserved adult specimens of both species would show that though somewhat related they really belong to distinct genera.

Locality and position: North of Cedar River about 10 miles southwest of Pretty Rock, N. Dak., in the NW. ¼ sec. 9, T. 130 N., R. 90 W., in the Cannonball marine member of the Lance formation.

Family TURRITIDAE.

Genus TURRIS Bolten.

Turris lloydi Stanton, n. sp.

Plate VIII, figure 16.

Turris minor (Evans and Shumard)? Stanton, Geol. Soc. America Bull., vol. 25, p. 352, 1914.

Shell small, slender, fusiform, consisting of about ten subangular whorls, with the spire considerably longer than the aperture and canal; sinus of outer lip comparatively deep and broad, situated on the most convex part of the shell, which also bears about 17 short curved ribs or nodes on each whorl; upper part of whorl somewhat constricted, suture minutely channeled; surface marked by relatively strong spiral lines, of which about 12 are visible on the spire, and by sinuous lines of growth, which are strongest on the upper slope of the whorl just below the suture.

Height, with most of the canal missing, 11 millimeters; breadth, 4.5 millimeters.

This species resembles *Pleurotoma nebulosa* Harris,[1] from the Wilcox group, but it differs in its more numerous ribs and other details of sculpture.

[1] Bull. Am. Paleontology, vol. 3, p. 13, pl. 2, fig. 1, 1899.

Locality and position: The type was collected on Cannonball River in the SW. ¼ sec. 11, T. 132 N., R. 88 W., about 7 miles south of Leith, N. Dak., in the Cannonball marine member of the Lance formation. A smaller specimen was obtained at about the same horizon on Heart River 1 mile west of Mandan, N. Dak.

Turris cordensis Stanton, n. sp.

Plate VIII, figure 12.

Shell small, fusiform, consisting of seven or eight subcarinate whorls, with carina on spire slightly below the middle of visible part of whorl; spire about equal to aperture and canal in height; sinus of outer lip narrow and slitlike, situated on the carina; surface marked by many fine spiral lines, which on the last whorl below the carina tend to alternate in size.

Height, 14 millimeters; breadth, 7 millimeters.

Locality and position: The single type specimen was collected on Heart River in the SW. ¼ sec. 24, T. 136 N., R. 88 W., about 19 miles southwest of Almont, N. Dak., in the Cannonball marine member of the Lance formation.

Turris? tormentaria Stanton, n. sp.

Plate IX, figures 1a and 1b.

Shell of medium size, slender fusiform, consisting of about 10 strongly carinated whorls with the high, narrow carina just above the suture; spire about equal in height to aperture and canal; growth lines not well enough preserved to show form of sinus; surface marked by fine closely arranged spiral lines which tend to become obsolete.

Height, 35 millimeters; breadth, about 11 millimeters.

Locality and position: The single type specimen was collected on Cannonball River in T. 133 N., R. 88 W., about 6 miles south of Kayser, N. Dak., in the Cannonball marine member of the Lance formation.

Genus TURRICULA Schumacher.

Turricula janesburgensis Stanton, n. sp.

Plate IX, figures 2a and 2b.

Shell of medium size, moderately stout fusiform, consisting of seven or more carinated whorls; spire not quite as long as the aperture

and canal; carina with about 14 obliquely elongated nodes or tubercles on each whorl and situated a little above the closely appressed suture on the spire; upper slope of the whorl above the carina concave and marked by the curved growth lines, which indicate the form of the broad, moderately deep sinus of the outer lip; surface also covered with fine, somewhat irregular spiral lines, which tend to alternate in size.

Height, 30 millimeters; breadth, 12 millimeters; height of aperture, 17 millimeters; breadth of aperture, about 5 millimeters.

In general aspect this species resembles *Surcula nasuta* (Whitfield), from the Wilcox group of Alabama, but it is a stouter shell and differs in the details of sculpture.

According to W. H. Dall[1] *Turricula* is the valid name for the generic group usually called *Surcula*, to which this shell apparently belongs.

Locality and position: The type was collected with a smaller specimen from gravel in a bluff on Cannonball River near Janesburg, N. Dak., where it was evidently redeposited from a neighboring exposure of the Cannonball marine member of the Lance formation.

Turricula textilis Stanton, n. sp.

Plate IX, figures 3a and 3b.

Shell resembling *Turricula janesburgensis* in general form and coarser sculpture, but it has a relatively shorter canal, the upper slope of its whorls is more deeply concave, the carina is nearer to the suture, and the spiral sculpture is much finer, with more nearly equal and more closely crowded irregular lines. These differences are believed to justify specific separation, though it is possible that future collections may show enough intermediate forms to prove that the differences are only of varietal value. Only one specimen of each species has been seen.

Height, 24 millimeters; breadth, 10 millimeters; height of aperture, 14.5 millimeters; breadth of aperture, 4 millimeters.

Locality and position: On Cannonball River in T. 133 N., R. 88 W., about 6 miles south of Kayser, N. Dak., in the Cannonball marine member of the Lance formation.

[1] U. S. Nat. Mus. Proc., vol. 54, pp. 315, 332, 1918.

Turricula bacata Stanton, n. sp.

Plate IX, figures 4 and 5.

Shell of medium size, rather stout fusiform, consisting of about six or seven whorls; last whorl with a prominent subangular ridge above the middle bearing about 14 short ribs or nodes, which on the whorls of the spire become a row of beadlike nodes situated just above the appressed suture; slope above the row of nodes slightly concave and bearing the sharply curved growth lines that indicate the form and position of the broad and moderately deep sinus of the outer lip; surface also marked by fine spiral lines, not well preserved on the type, which are mostly much narrower than the interspaces.

Height of type, which lacks both apex and the larger part of the canal, 27 millimeters; breadth, about 24 millimeters.

This species is related to *Turricula janesburgensis*, which differs in its more slender form, more distinctly carinate whorls, and more spinous nodes situated farther from the suture.

Locality and position: The type was collected on Cannonball River in sec. 31, T. 133 N., R. 88 W., about 6 miles south of Kayser, N. Dak. Another fragmentary specimen, which is also figured, was obtained on Heart River in sec. 20, T. 136 N., R. 86 W., about 12 miles south of Almont, N. Dak., both in the Cannonball marine member of the Lance formation.

Turricula cincta Stanton, n. sp.

Plate IX, figures 6a and 6b.

Shell small, fusiform, consisting of about six whorls, with spire about equal in length to aperture and canal; whorls with a narrowly rounded carina, beneath which is an impressed band or sulcus, which is conspicuous on the last whorl but on the spire has its lower margin concealed by the succeeding whorl; carina crenulate; growth lines strongly curved on the upper slope or shoulder of the whorl, showing the form of the sinus; surface also marked by relatively coarse, closely arranged spiral lines, which tend to become obsolete on the upper slope.

Height of imperfect type, 11 millimeters; breadth, 5 millimeters; height of aperture, about 7 millimeters; breadth of aperture, 2 millimeters.

The most distinctive feature of this species is the sulcus or furrow just beneath the carina on the last whorl. It is represented in the collections by only two specimens.

Locality and position: The type was collected in the Cannonball marine member of the Lance formation on Heart River in sec. 29, T. 136 N., R. 86 W., about 12 miles south of Almont, N. Dak. The other specimen was found at about the same horizon on Cannonball River in sec. 31, T. 133 N., R. 88 W., about 6 miles south of Kayser, N. Dak.

Turricula? contorta (Meek and Hayden).

Plate IX, figures 7 and 8.

Fusus contortus Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 8, p. 65, 1856.

Pleurotomaria contorta Meek and Hayden, idem, vol. 12, p. 185, 1860.

Turris contortus Meek and Hayden, idem, p. 422.
Meek, Smithsonian check list of North American Cretaceous fossils, p. 22, 1864.

Turris (Surcula?) contortus Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 385, pl. 31, figs. 7 a–c, text fig. 49, 1876.

Meek's description:

Shell rather short fusiform; spire turreted, moderately elevated but not quite equaling the length of the aperture and canal; volutions five and a half to six, distinctly concave above, and convex around the middle, where they are each ornamented by about eleven oblique, flexuous, elongated nodes, or costae, equaling the sinuosities between; last turn prominent around the middle and tapering obliquely into the rather short, nearly straight canal below; suture distinct; aperture narrow subovate, angular above, most convex on the outer side, and tapering into the canal below; outer lip broadly prominent in outline along the middle, somewhat contracted below, and again curving backward into the broadly rounded, rather deep sinus between the angle of the volutions and the suture above; surface marked by fine but distinct lines of growth, which are crossed by numerous rather small, threadlike, revolving lines.

Length, 1.09 inches [27.68 millimeters]; breadth, 0.55 inch [13.97 millimeters]; length of aperture and canal, 0.7 inch [17.78 millimeters]; breadth of aperture, 0.24 inch [6.1 millimeters]; slope of spire nearly straight, with divergence of about 42° in adult examples.

This species as represented in the six specimens of the type lot shows some variation in the strength of the sculpture, especially of the vertical ribs. Those with more subdued sculpture, such as the one depicted by Meek's text figure 49, are very similar to the specimens from the Cannonball fauna, some of which as indicated by imperfect specimens are about one-fourth longer than the measured type. *Turris (Surcula) ostrarupis* Harris,[1] from the Midway formation, seems to be a related species.

Locality and position: The types of the species were collected in the Fox Hills sandstone on Moreau River, S. Dak. The specimens now figured were collected in the Cannonball marine member of the Lance formation on Heart River 10 miles north of Flasher, N. Dak., in the SW. ¼ sec. 16, T. 136 N., R. 84 W. Other specimens were obtained on Heart River in the NW. ¼ sec. 6, T. 137 N., R. 83 W.; in sec. 20, T. 136 N., R. 86 W., about 12 miles south of Almont, N. Dak.; and in T. 133 N., R. 88 W., about 6 miles south of Kayser, N. Dak., all in the Cannonball marine member.

Family RINGICULIDAE.

Genus RINGICULA Deshayes.

Ringicula dubia Stanton, n. sp.

Plate IX, figures 9a, 9b.

Cinulia sp. Stanton, Geol. Soc. America Bull., vol. 25, p. 352, 1914.

Shell small, globose, consisting of three or four rapidly increasing convex volutions; spire short; sutures distinct, slightly channeled; aperture auriform, narrow above and broadly rounded below, without any anterior canal or emargination; outer lip greatly thickened, bearing on its inner surface a single relatively prominent denticle which is located below the middle of the aperture and opposite the space between the columellar plaits; inner lip thickened throughout and rather broad and flat below; columella with two strong transverse plaits; surface smooth.

Height and breadth, each 3 millimeters; height of aperture, 2 millimeters.

This little shell has the globose form of a *Cinulia* and like that genus lacks an anterior canal or notch, but its two strong columellar folds, denticulate outer lip, and smooth surface seem to ally it more closely to *Ringicula*, to which it is now tentatively referred. Possibly it should be made the type of a new genus or subgenus, because it lacks the anterior notch or canal that seems to be present in all described species of *Ringicula* and is usually considered an important feature.

[1] Bull. Am. Paleontology, vol. 1, p. 192, pl. 17, fig. 13, 1896.

Locality and position: The type was collected in the Cannonball marine member of the Lance formation near Heart River in the SW. ¼ sec. 24, T. 136 N., R. 88 W., about 19 miles southwest of Almont, N. Dak. Other specimens were obtained in the same member on Heart River about 1 mile west of Mandan, N. Dak., and in the SE. ¼ sec. 10, T. 138 N., R. 83 W., about 12 miles southwest of Mandan; in the SE. ¼ sec 8, T. 136 N., R. 83 W., 5 miles east of Flasher, N. Dak.; and in the SE. ¼ sec. 21, T. 136 N., R. 82 W., 5 miles east of Strain, N. Dak.

Family SCAPHANDRIDAE.

Genus CYLICHNA Lovén.

Cylichna scitula Meek and Hayden?

Plate IX, figure 10.

Cylichna scitula Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 12, p. 178, 1860. Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 276, pl. 31, figs. 3 a, b, 1876.

Meek's description:

Shell small, rather solid, narrow subelliptical, approaching subcylindrical; summit truncated and occupied by a comparatively large umbilicoid depression; aperture very narrow, arcuate, widening little below; umbilical region slightly impressed; inner lip reflexed and twisted, so as to form a small indistinct fold at its base; surface marked by fine, obscure lines of growth, which are crossed by impressed transverse striae separated by spaces about two or three times their own breadth near the middle of the outer whorl but becoming much more closely crowded toward the extremities.

Length, 0.24 inch [6.1 millimeters]; breadth, 0.14 inch [3.55 millimeters]; widest part of aperture, 0.07 inch [1.78 millimeters]; breadth of same near upper extremity, only 0.02 inch [0.5 millimeter].

The above description is drawn from a specimen found in the Fox Hills sandstone on Moreau River, S. Dak. A *Cylichna*-like shell found in the Cannonball marine member of the Lance formation agrees so well with *C. scitula* in size, form, and sculpture that it is tentatively referred to that species, though it is slightly distorted by pressure and its true generic character is not determinable because the inner lip and columella are not visible. This specimen is figured. A much smaller specimen is probably the young of the same species. Four other fragmentary specimens representing as many localities are too poorly preserved for specific identification.

Locality and position: The figured specimen was collected near Heart River in the SE. ¼ sec. 10, T. 138 N., R. 83 W., N. Dak., about 75 feet below the top of the Cannonball marine member of the Lance formation. The small specimen was obtained in the SE. ¼ sec. 21, T. 136 N., R. 82 W., 5 miles southeast of Strain post office, N. Dak. The other undetermined *Cylichna* specimens were collected on Heart River in sec. 8, T. 136 N., R. 84 W.; in the SW. ¼ sec. 30, T. 130 N., R. 88 W., 7 miles north of Morristown, S. Dak.; in sec. 7, T. 22 N., R. 17 E., 8 miles southeast of Lemmon, S. Dak.; and on Heart River, 1 mile west of Mandan, N. Dak.

Genus CYLICHNELLA Gabb.

Cylichnella dakotensis Stanton, n. sp.

Plate IX, figures 11a and 11b.

Shell of moderate size, subcylindrical, with rather broadly rounded base; apex subtruncate, with narrow umbilicoid depression; aperture very narrow above, slightly broadened below; inner lip thickened and reflexed at the base; columella with two distinct folds; surface marked by numerous fine, impressed spiral lines, which are finer and more closely arranged on the middle third than toward the ends.

Height about 15 millimeters; breadth 8 millimeters.

The genus *Cylichnella*, which is distinguished from *Cylichna* by the presence of two folds on the columella, is represented by a number of recent and Tertiary species. The Cretaceous forms referred to *Cylichna* are often not well enough preserved to show the folds, and it may be that some of them really belong to *Cylichnella*. *C. dakotensis* may be distinguished from *Cylichna scitula* by the finer and more closely arranged spiral striae, especially on the middle part of the shell, even when the internal features are not visible. It is also larger and more nearly cylindrical.

Locality and position: The type was collected in the Cannonball marine member of the Lance formation on Heart River about 12 miles south of Almont, N. Dak., in the SW. ¼ sec. 20, T. 136 N., R. 86 W. A smaller specimen doubtfully referred to this species was obtained from the same member on Heart River in the SW. ¼ sec. 16, T. 136 N., R. 84 W., 10 miles north of Flasher, N. Dak.

Phylum VERTEBRATA.

Class PISCES.

Subclass ELASMOBRANCHII.

Family LAMNIDAE.

Genus LAMNA Cuvier.

Lamna cuspidata Agassiz.

Plate IX, figures 12 and 13.

Lamna cuspidata Agassiz, Poissons fossiles, t. 3, p. 289, pl. 35, figs. 1–5; pl. 37a, fig. 59, 1843.
Fowler, New Jersey Geol. Survey Bull. 4, p. 43, figs. 12–15, 1911.
Odontaspis cuspidata (Agassiz) Eastman, Maryland Geol. Survey, Eocene, p. 105, pl. 14, figs. 1a, 1b, 6a, 6b, 1901.

NOTE—For more complete synonymy of this and the following species see U. S. Geol. Survey Bull. 179, and the Eocene and Miocene volumes of the Maryland Geological Survey.

Ten shark teeth representing as many localities in the Cannonball marine member of the Lance formation seem to be referable to *Lamna cuspidata*, which is reported from the Cretaceous, Eocene, and Miocene of both New Jersey and Maryland.

Locality and position: The figured specimens came from Heart River 11 miles north of Flasher, N. Dak., in sec. 8, T. 136 N., R. 84 W., and in a railway cut 1 mile east of Morristown, S. Dak. Other specimens were found 5 and 6 miles east of Flasher, in secs. 3 and 4, T. 134 N., R. 83 W.; on Heart River 12 miles south of Almont, N. Dak., in sec. 29, T. 136 N., R. 86 W.; on the west bank of Missouri River 1 mile south of Price and 19 miles north of Mandan, N. Dak.; in secs. 20 and 21, T. 136 N., R. 82 W.; in sec. 31, T. 135 N., R. 83 W.; and in sec. 10, T. 138 N., R. 83 W.

Genus OTODUS Agassiz.

Otodus obliquus Agassiz.

Plate IX, figure 14.

Otodus obliquus Agassiz, Poissons fossiles, t. 3, p. 267, pl. 31, pl. 36, figs. 22–27, 1843.
Eastman, Maryland Geol. Survey, Eocene, p. 106, pl. 15, figs. 1–4c, 1901.
Otodus lanceolatum (Morton) Fowler, New Jersey Geol. Survey Bull. 4, p. 57, figs. 23–25, 1911.

A specimen, which is figured, agrees very well with the figure of a specimen of *Otodus obliquus* from the Eocene of Maryland. The species is reported in the Eocene and Miocene of Maryland and in the Cretaceous, Eocene, and Miocene of New Jersey.

Locality and position: In the Cannonball marine member of the Lance formation near the top of Mitchell Butte, in sec. 7, T. 134 N., R. 83 W., about 3 miles east of Flasher, N. Dak. A smaller, less perfect specimen was obtained in sec. 24, T. 136 N., R. 68 W.

PLATES I–IX.

PLATE I.

Solemya bilix White (p. 19).

FIGURE 1a. Left side of specimen from Mandan, N. Dak.
1b. Dorsal view of same.
U. S. N. M. catalogue No. 32380.

Nucula planimarginata Meek and Hayden (p. 19).

FIGURE 2. Gutta-percha squeeze from mold of left valve, × 2.
U. S. N. M. catalogue No. 32381.
3. Gutta-percha squeeze from mold of right valve, natural size.
U. S. N. M. catalogue No. 32382.

Nucula subplana Meek and Hayden (p. 20).

FIGURE 4. Internal cast of left valve, natural size.
5. Internal cast of right valve, natural size.
6. Squeeze from mold of right valve, natural size.
U. S. N. M. catalogue No. 32383.
7. Right side of a small internal cast from another locality, natural size.
U. S. N. M. catalogue No. 32384.

Leda mansfieldi Stanton (p. 20).

FIGURE 8. Type specimen, × 2.
U. S. N. M. catalogue No. 32385.

Yoldia scitula Meek and Hayden (p. 21).

FIGURE 9. Left valve of type from Fox Hills sandstone, × 2.
U. S. N. M. catalogue No. 302.
10. Right valve of specimen from Cannonball member, × 2.
U. S. N. M. catalogue No. 32386.

Yoldia evansi Meek and Hayden (p. 21).

FIGURE 11. Cast of small right valve, × 2.
U. S. N. M. catalogue No. 32387.

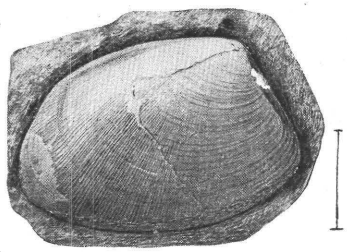
Yoldia thomi Stanton (p. 21).

FIGURE 12a. Left valve of type, × 2.
12b. Dorsal view of both valves of same, × 2.
12c. Interior of left valve of same, × 2.
U. S. N. M. catalogue No. 32388.

Nodosaria sp. (p. 18).

FIGURE 13. Gutta-percha squeeze from small mold, × 4.
U. S. N. M. catalogue No. 32389.

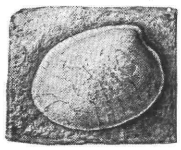
1a



2

3

1b



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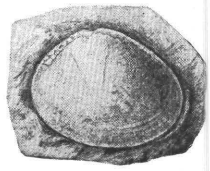

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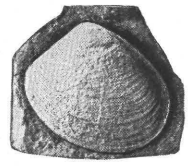

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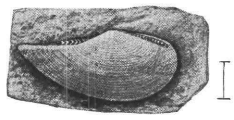

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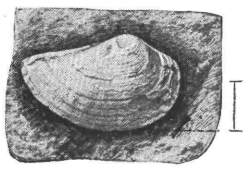

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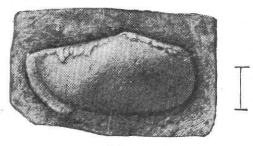

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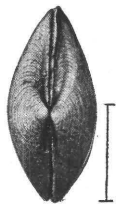

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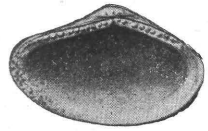

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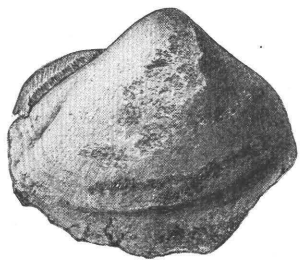
FAUNA OF THE CANNONBALL MARINE MEMBER OF THE LANCE FORMATION.



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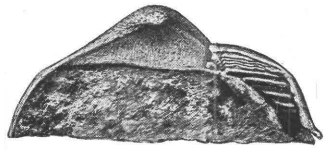

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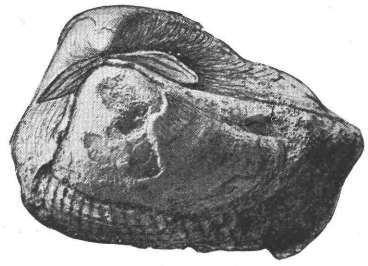

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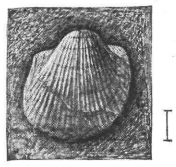

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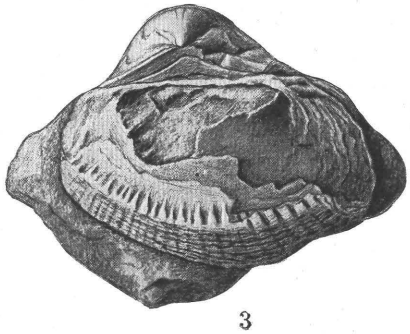

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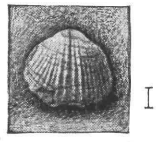

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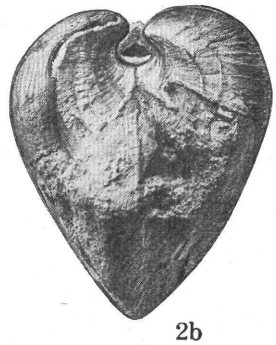

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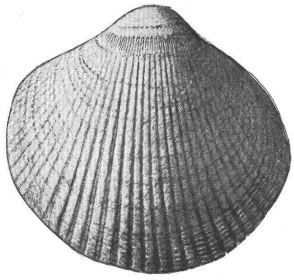

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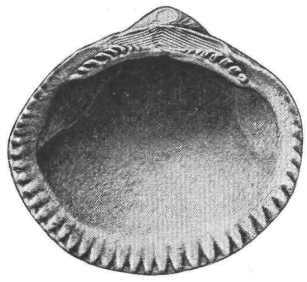

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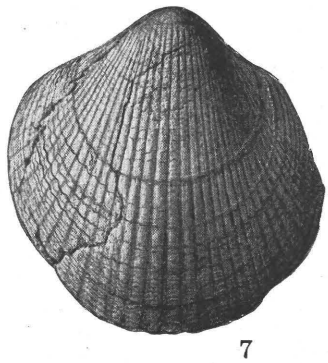

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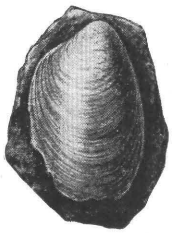

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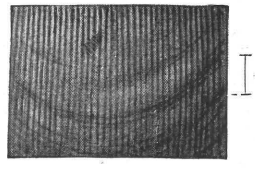


9c

FAUNA OF THE CANNONBALL MARINE MEMBER OF THE LANCE FORMATION.

PLATE II.

Cucullaea shumardi Meek and Hayden (p. 22).

FIGURE 1a. Cast of right valve retaining bit of shell near posterior end.
1b. Hinge view of same.
U. S. N. M. catalogue No. 32390.

Cucullaea solenensis Stanton (p. 22).

FIGURE 2a. Left side of an imperfect, somewhat distorted specimen.
2b. Posterior view of same.
U. S. N. M. catalogpe No. 32391.
3. Left side of another specimen showing character of crenulations of free margin.
U. S. N. M. catalogue No. 32392.

Trigonarca? hancocki Stanton (p. 23).

FIGURE 4. Right valve (type), × 4.
5. Left valve of another specimen, × 4.
U. S. N. M. catalogue No. 32393.

Glycimeris subimbricata (Meek and Hayden) (p. 23).

FIGURE 6a. Left valve of typical form.
6b. Hinge and interior of same.
U. S. N. M. catalogue No. 32394.
7. Larger, more convex, left valve.
U. S. N. M. catalogue No. 32395.

Crenella elongata Stanton (p. 25.)

FIGURE 8a. Side view of type.
8b. Profile view of same.
U. S. N. M. catalogue No. 32396.

Crenella cedrensis Stanton (p. 25).

FIGURE 9a. Right valve of type.
9b. Profile view of both valves of same.
9c. Sculpture near middle of right valve, × 4.
U. S. N. M. catalogue No. 32397.

PLATE III.

Pteria linguaeformis (Evans and Shumard) (p. 26).

FIGURE 1. Small left valve.
U. S. N. M. catalogue No. 32398.

Pholadomya haresi Stanton (p. 20).

FIGURE 2a. Right side of type.
2b. Dorsal view of same.
U. S. N. M. catalogue No. 32399.
3. Anterior view of another specimen from squeeze of natural mold.
U. S. N. M. catalogue No. 32400.

Anatina subgracilis (Whitfield) (p. 26).

FIGURE 4a. Left side of type from Pierre shale.
4b. Dorsal view of same.
U. S. N. M. catalogue No. 12253.
5a. Left side of larger specimen from Cannonball member.
5b. Dorsal view of same.
U. S. N. M. catalogue No. 32401.

Modiolus schallerensis Stanton (p. 25).

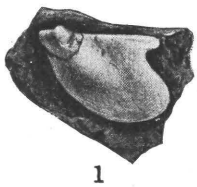
FIGURE 6. Left valve (type), × 2.
U. S. N. M. catalogue No. 32402.

Crassatellites evansi Meek and Hayden (p. 28).

FIGURE 7a. Left side of a large well-preserved specimen.
7b. Dorsal view of same.
U. S. N. M. catalogue No. 32403.
8. Small left valve enlarged to show details of sculpture.
U. S. N. M. catalogue No. 32404.
9. Hinge of small specimen, × 2.
U. S. N. M. catalogue No. 32405.

Lucina cedrensis Stanton (p. 30).

FIGURE 10a. Left valve (type).
10b. Hinge and interior of same.
U. S. N. M. catalogue No. 32406.
11a. Left side of large imperfect specimen.
11b. Profile view of same.
U. S. N. M. catalogue No. 32407.



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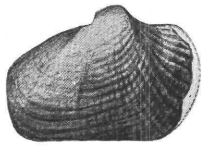

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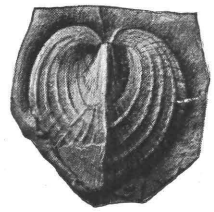

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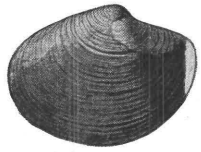

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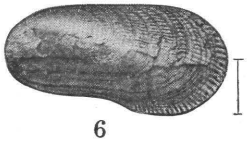

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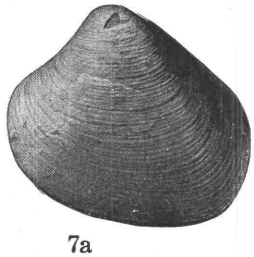

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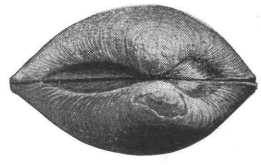

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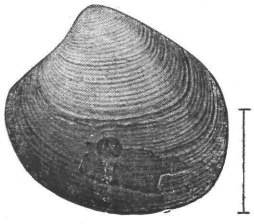

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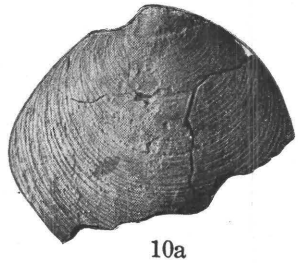

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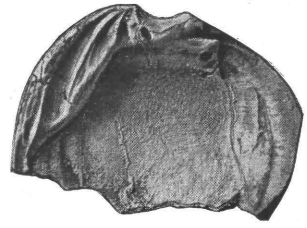

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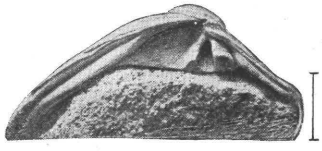

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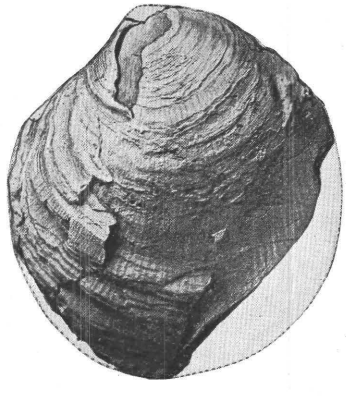

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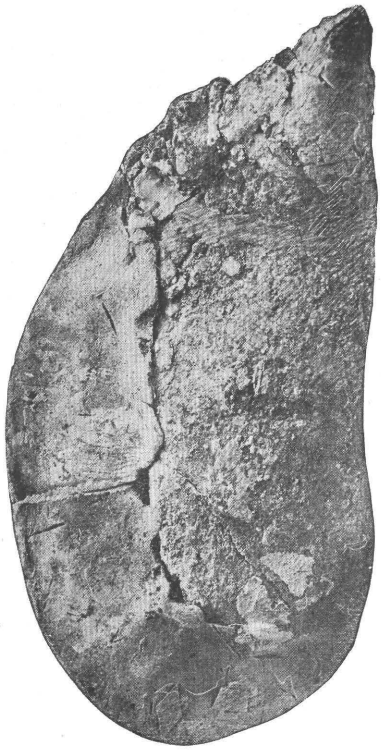
FAUNA OF THE CANNONBALL MARINE MEMBER OF THE LANCE FORMATION.



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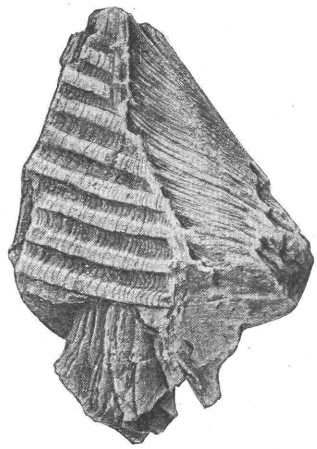

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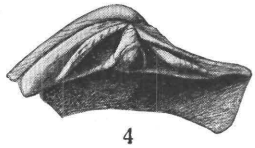

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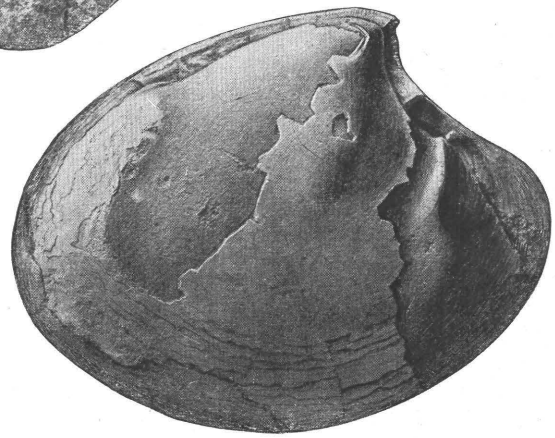

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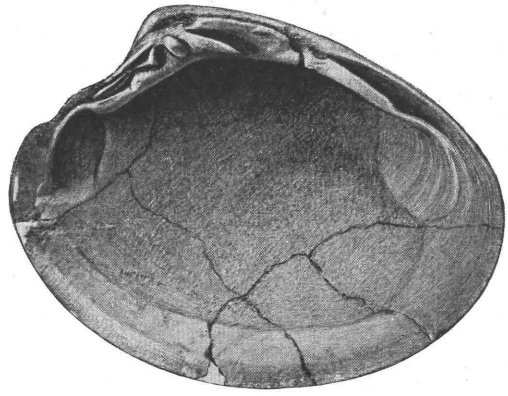

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FAUNA OF THE CANNONBALL MARINE MEMBER OF THE LANCE FORMATION.

PLATE IV.

Pedalion lloydi Stanton (p. 24).

FIGURE 1a. Small right valve, partly restored.
1b. Interior of same showing part of hinge.
2. Fragment showing part of hinge of left valve.
U. S. N. M. catalogue No. 32408.

Eriphyla? mandanensis Stanton (p. 28).

FIGURE 3. Type, × 2.
U. S. N. M. catalogue No. 32409.

Arctica ovata Meek and Hayden (p. 27).

FIGURE 4. Hinge of left valve.
U. S. N. M. catalogue No. 32410.
5. Type of variety *compressa*, cast of right valve.
U. S. N. M. catalogue No. 306b.
6a. Type of species. Small right valve.
6b. Hinge and interior of same.
U. S. N. M. catalogue No. 306.

PLATE V.

Corbicula berthoudi White (p. 29).

FIGURE 1a. Imperfect left valve.
1b. Hinge of same.
U. S. N. M. catalogue No. 32411.
2. Hinge of a right valve.
U. S. N. M. catalogue No. 32412.
3. Cast of a left valve.
U. S. N. M. catalogue No. 32413.

Corbicula cytheriformis Meek and Hayden (p. 29).

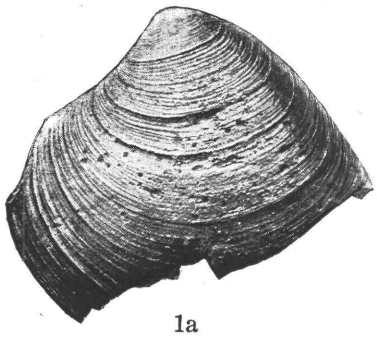
FIGURE 4a. Small left valve.
4b. Hinge and interior of same.
U. S. N. M. catalogue No. 32414.

Callista (Dosiniopsis) nebrascensis (Meek and Hayden) (p. 30).

FIGURE 5. Large right valve from Fox Hills sandstone.
6. Hinge and interior of medium right valve from same formation.
7. Small left valve from same formation.
U. S. N. M. catalogue No. 32415.
8a. Left side of Meek and Hayden's type specimen from Pierre shale or Fox Hills sandstone.
8b. Dorsal view of same.
U. S. N. M. catalogue No. 343.
9. Imperfect right valve from Cannonball member.
U. S. N. M. catalogue No. 32416.
10. Squeeze from mold of left valve from Cannonball member.
U. S. N. M. catalogue No. 32417.

Callista (Dosiniopsis) deweyi (Meek and Hayden) (p. 31).

FIGURE 11. Squeeze from mold of right valve.
12. Cast of right vlave.
U. S. N. M. catalogue No. 32418.



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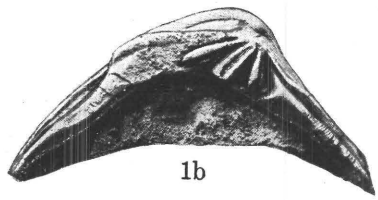

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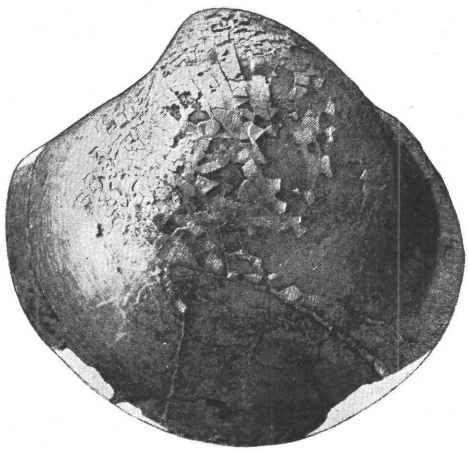

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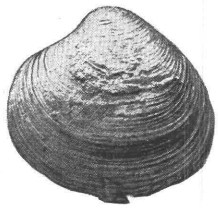

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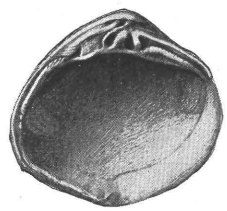

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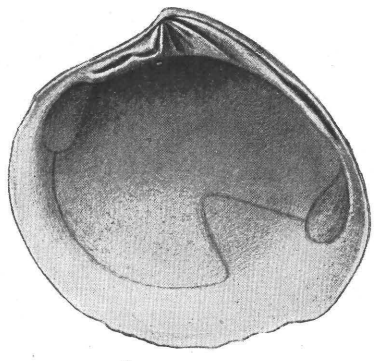

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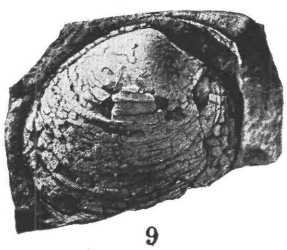

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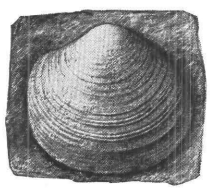

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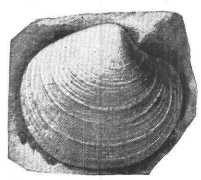

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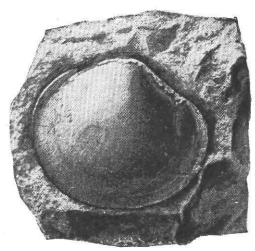

12

FAUNA OF THE CANNONBALL MARINE MEMBER OF THE LANCE FORMATION.


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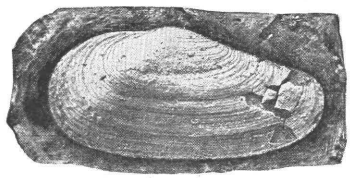
2b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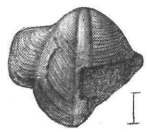
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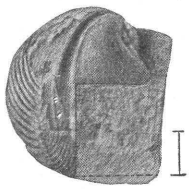
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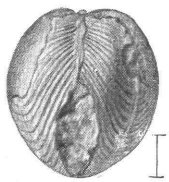
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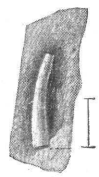
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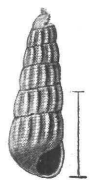
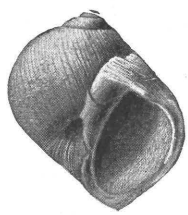

8b


9a


9b


10a


10b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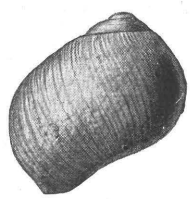
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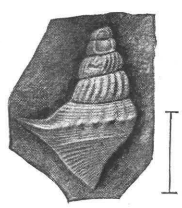
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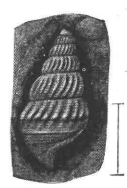

15

FAUNA OF THE CANNONBALL MARINE MEMBER OF THE LANCE FORMATION.

PLATE VI.

Corbula mactriformis Meek and Hayden (p. 32).

FIGURE 1. Small left valve.
2a. Right side of an internal cast.
2b. Dorsal view of same.
U. S. N. M. catalogue No. 32419.

Panope simulatrix Whiteaves? (p. 32).

FIGURE 3. Left valve.
U. S. N. M. catalogue No. 32420.

Teredo selliformis Meek and Hayden (p. 33).

FIGURE 4. Right valve (type), × 4.
U. S. N. M. catalogue No. 421.

Teredo globosa Meek and Hayden (p. 33).

FIGURE 5a. Right valve of type, × 4.
5b. Posterior view of type, × 4.
U. S. N. M. catalogue No. 422.

Dentalium pauperculum Meek and Hayden (p. 34.)

FIGURE 6. Type specimen from Fox Hills sandstone, × 2.
U. S. N. M. catalogue No. 311.
7. Specimen from Cannonball member, × 2.
U. S. N. M. catalogue No. 32421.

Turbonilla? cordensis Stanton (p. 34.)

FIGURE 8a. Dorsal view of type, × 2.
8b. Aperture view of same, × 2.
U. S. N. M. catalogue No. 32422.

Epitonium dakotense Stanton (p. 35).

FIGURE 9a. Aperture view of type, natural size.
9b. Dorsal view of same.
U. S. N. M. catalogue No. 32423.

Lunatia obliquata Hall and Meek (p. 35).

FIGURE 10a. Aperture view of large specimen from Cannonball member, natural size.
10b. Dorsal view of same.
U. S. N. M. catalogue No. 32424.

Lunatia subcrassa Meek and Hayden (p. 36).

FIGURE 11a. Aperture view of a large specimen, natural size.
11b. Dorsal view of same.
U. S. N. M. catalogue No. 32425.

Turritella haresi Stanton (p. 37).

FIGURE 12. Aperture view of type, × 2.
U. S. N. M. catalogue No. 32426.

Anchura (Drepanochilus) americana (Evans and Shumard) (p. 37).

FIGURE 13. Dorsal view of immature specimen from Fox Hills sandstone, natural size.
U. S. N. M. catalogue No. 274.

Anchura (Drepanochilus) americana var. pusilla Stanton (p. 38).

FIGURE 14. Dorsal view of type, × 2.
15. Aperture view of another specimen which lacks the wings, × 2.
U. S. N. M. catalogue No. 32427.

PLATE VII.

Anchura (Drepanochilus) perveta Stanton (p. 38).

FIGURES 1a, 1b. Opposite views of type specimen.
2a, 2b, 3a, 3b. Similar views of two other specimens showing variations in form and sculpture.
U. S. N. M. catalogue No. 32428.

Anchura (Drepanochilus) perveta var. gracilis Stanton (p. 39).

FIGURES 4a, 4b. Opposite views of type specimen.
U. S. N. M. catalogue No. 32429.

Calyptraphorus septentrionalis Stanton (p. 39).

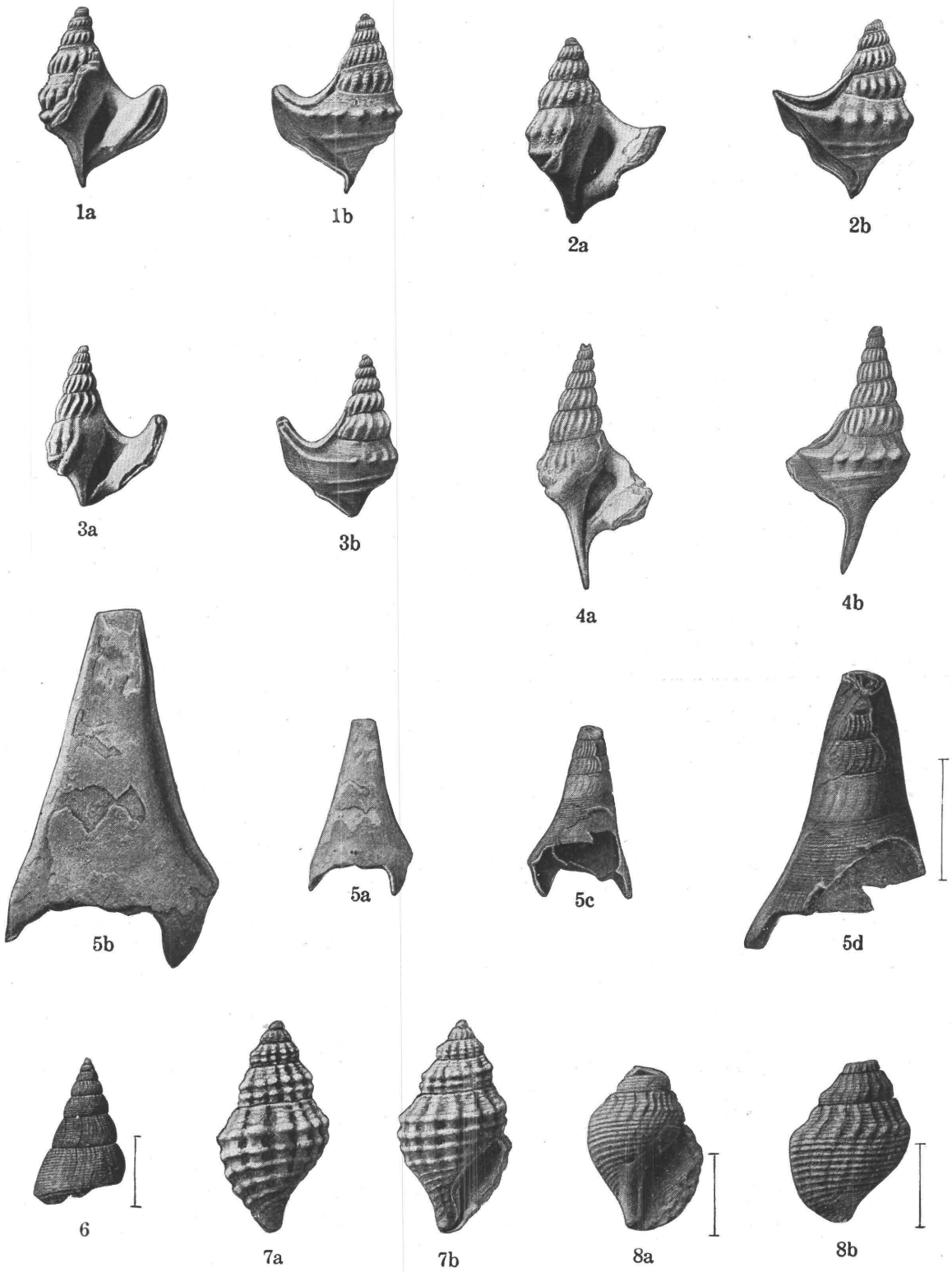
FIGURES 5a, 5b, 5c, 5d. Opposite views of fragmentary type specimen, natural size and × 2.
6. Spire of immature specimen, × 2.
U. S. N. M. catalogue No. 32430.

Cantharus (Cantharulus) vaughani (Meek and Hayden) (p. 40).

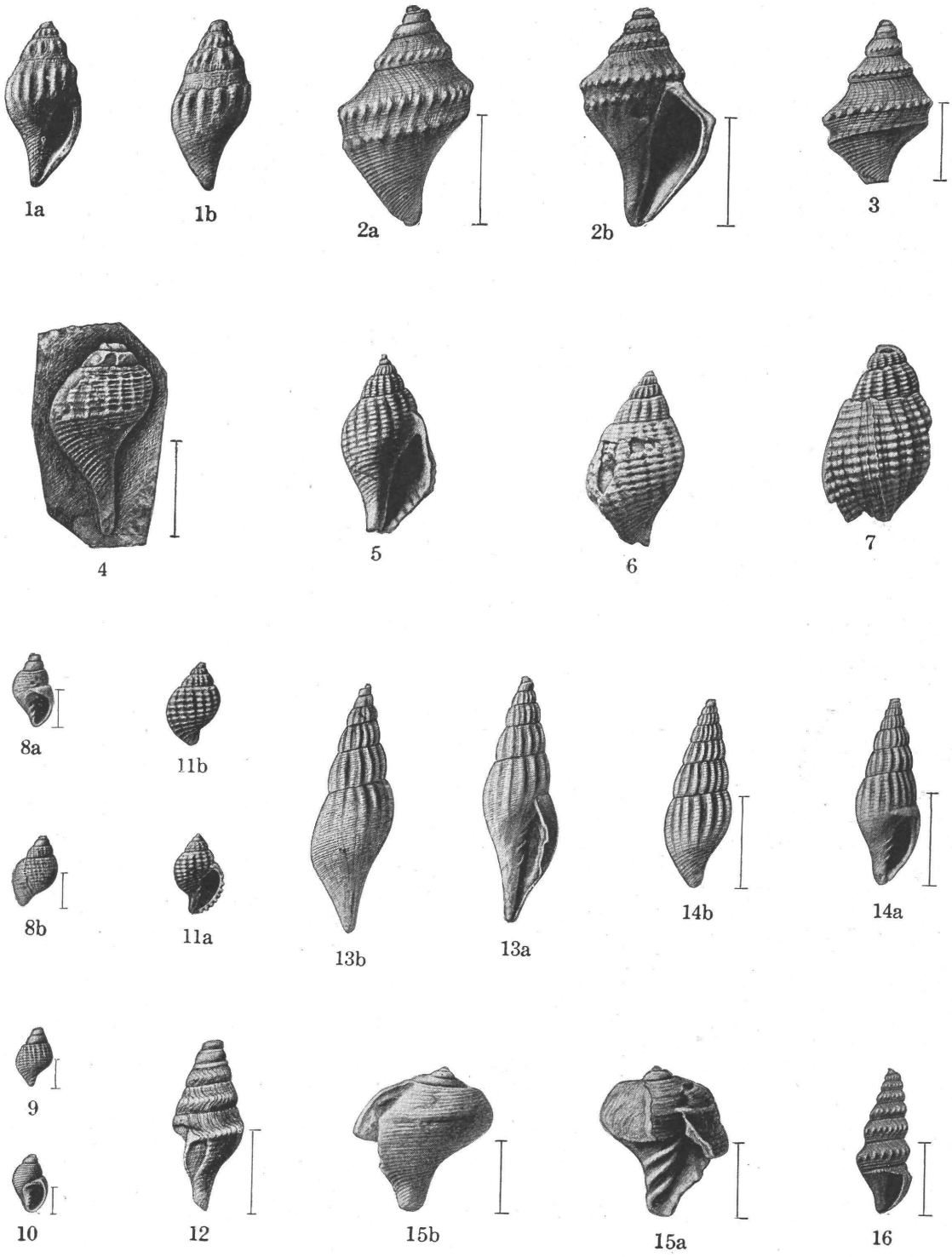
FIGURES 7a, 7b. Opposite views of type specimen, natural size.
U. S. N. M. catalogue No. 255.

Pyrifusus (Neptunella) newberryi (Meek and Hayden) (p. 40).

FIGURES 8a, 8b. Opposite views of a small specimen, × 2.
U. S. N. M. catalogue No. 32431.



FAUNA OF THE CANNONBALL MARINE MEMBER OF THE LANCE FORMATION.



FAUNA OF THE CANNONBALL MARINE MEMBER OF THE LANCE FORMATION.

PLATE VIII.

Pyrifusus (Neptunella) gracilis Stanton (p. 41).

FIGURES 1a, 1b. Opposite views of the type, natural size.
U. S. N. M. catalogue No. 32432.

Levifusus? tormentarius Stanton (p. 41).

FIGURES 2a, 2b. Opposite views of the type, × 2.
U. S. N. M. catalogue No. 32433.
3. Dorsal view of another specimen, × 2.
U. S. N. M. catalogue No. 32434.

Pyropsis hancocki Stanton (p. 42).

FIGURE 4. Dorsal view of the type, × 2.
U. S. N. M. catalogue No. 32435.

Fasciolaria? mandanensis Stanton (p. 43).

FIGURE 5. Aperture view of type, natural size.
6. Dorsal view of same.
U. S. N. M. catalogue No. 32436.
7. Dorsal view of larger fragmentary specimen.
U. S. N. M. catalogue No. 32437.

Fasciolaria? cordensis Stanton (p. 43).

FIGURES 8a, 8b. Opposite views of type, × 2.
9. Dorsal view of specimen with better-preserved vertical ribs, × 2.
U. S. N. M. catalogue No. 32438.
10. Aperture view of specimen doubtfully referred to this species, × 2.
U. S. N. M. catalogue No. 32439.

Fasciolaria lloydi Stanton (p. 42).

FIGURES 11a, 11b. Opposite view of type specimen, natural size.
U. S. N. M. catalogue No. 32440.

Turris cordensis Stanton (p. 45).

FIGURE 12. Type specimen, × 2.
U. S. N. M. catalogue No. 32441.

Fasciolaria (Mesorhytis) dakotensis Stanton (p. 43).

FIGURES 13a, 13b. Opposite views of type, × 2.
U. S. N. M. catalogue No. 32442.
14a, 14b. Opposite views of a small specimen, × 2.
U. S. N. M. catalogue No. 32443.

Psilocochlis? occidentalis Stanton (p. 44).

FIGURES 15a, 15b. Opposite views of type, × 2.
U. S. N. M. catalogue No. 32444.

Turris lloydi Stanton (p. 45).

FIGURE 16. Aperture view of type, × 2.
U. S. N. M. catalogue No. 32445.

PLATE IX.

Turris? tormentaria Stanton (p. 45).

FIGURES 1a, 1b. Opposite views of type, natural size.
U. S. N. M. catalogue No. 32446.

Turricula janesburgensis Stanton (p. 45).

FIGURES 2a, 2b. Opposite views of type, × 2.
U. S. N. M. catalogue No. 32447.

Turricula textilis Stanton (p. 46).

FIGURES 3a, 3b. Opposite views of type, × 2.
U. S. N. M. catalogue No. 32448.

Turricula bacata Stanton (p. 46).

FIGURE 4. Dorsal view of type, natural size.
U. S. N. M. catalogue No. 32449.
5. Aperture view of another imperfect specimen, natural size.
U. S. N. M. catalogue No. 32450.

Turricula cincta Stanton (p. 46).

FIGURES 6a, 6b. Opposite views of the type, × 2.
U. S. N. M. catalogue No. 32451.

Turricula? contorta (Meek and Hayden) (p. 47).

FIGURE 7. Aperture view of medium specimen, natural size.
8. Dorsal view of smaller specimen.
U. S. N. M. catalogue No. 32452.

Ringicula dubia Stanton (p. 47).

FIGURES 9a, 9b. Opposite views of the type, × 4.
U. S. N. M. catalogue No. 32453.

Cylichna scitula Meek and Hayden? (p. 48).

FIGURE 10. Dorsal view of small specimen, × 3.
U. S. N. M. catalogue No. 32454.

Cylichnella dakotensis Stanton (p. 48).

FIGURES 11a, 11b. Opposite views of type specimen, × 2
U. S. N. M. catalogue No. 32455.

Lamna cuspidata Agassiz (p. 49).

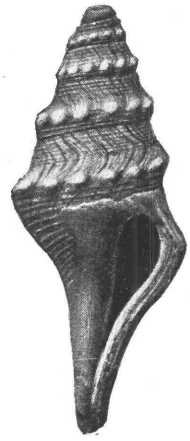
FIGURE 12. Outer face of small tooth, natural size.
U. S. N. M. catalogue No. 32456.
13. Inner face of smaller tooth, × 2.
U. S. N. M. catalogue No. 32457.

Otodus obliquus Agassiz (p. 49).

FIGURE 14. Inner face of tooth, natural size.
U. S. N. M. catalogue No. 32458.

1a

1b



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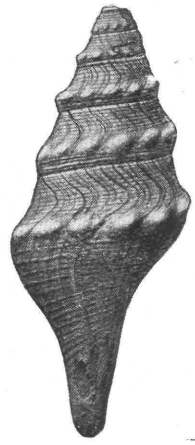

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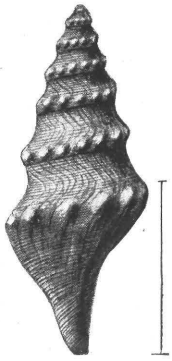

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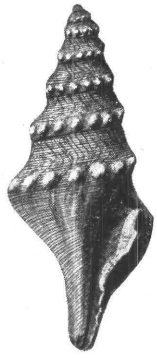

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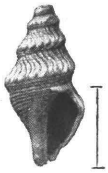

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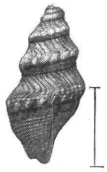


6b

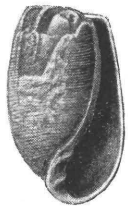
7

8

9a

9b

10



11a

11b

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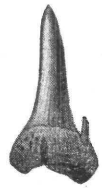

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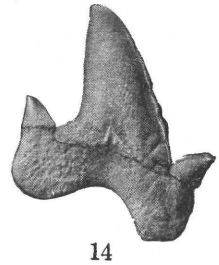

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FAUNA OF THE CANNONBALL MARINE MEMBER OF THE LANCE FORMATION.

CORALS FROM THE CANNONBALL MARINE MEMBER OF THE LANCE FORMATION.

By THOMAS WAYLAND VAUGHAN.

INTRODUCTION.

Mr. T. W. Stanton has submitted to me for description a small lot of corals from the Cannonball marine member of the Lance formation. The species, all of which belong to closely related genera of the family Caryophylliidae, are as follows:

Trochocyathus dakotaensis Vaughan, n. sp.
Trochocyathus? neumani Vaughan, n. sp.
Paracyathus lloydi Vaughan, n. sp.
Paracyathus thomi Vaughan, n. sp.
Paracyathus kayserensis Vaughan, n. sp.
Steriphonotrochus leithensis Vaughan, n. sp.

As several of the species have considerable resemblance to one another, a synopsis of some of the differences may aid in identification.

Synopsis of differential characters of species of corals here described.

Corallum short, height less than 8 millimeters, costae unequal:
  Height less than longer diameter of calice, corallum straight, smaller costae indistinct or obsolete, *Trochocyathus dakotaensis.*
  Height slightly greater than longer diameter of calice, corallum curved, smaller costae well developed, distinct..... *Trochocyathus? neumani.*
Corallum elongate, exceeds 8 millimeters in height, costae equal:
  Corallum straight, inversely subconical:
    Calice shallow, depth about 1.75 millimeters, *Paracyathus kayserensis.*
    Calice about 3.5 millimeters deep:
      Pali very distinct..... *Paracyathus lloydi.*
      No pali, but rounded, more or less twisted lobes on inner edges of long septa, *Steriphonotrochus leithensis.*
  Corallum slightly curved in plane of shorter calicular axis, form subflabellate, greater transverse axis of calice longer than in any of the other species.
    Calice 5.5 millimeters deep... *Paracyathus thomi.*

All the species are easily separable on external characters except *Paracyathus lloydi* and *Steriphonotrochus leithensis*, which are distinguishable chiefly by the differences in their septal margins. The type of *P. lloydi* is more compressed than *S. leithensis*, but this difference may not be original.

These corals afford no basis for an inference as to the precise age of the sediments in which they were embedded, for they might be either of Tertiary or Cretaceous age.

DESCRIPTION OF SPECIES.

Family CARYOPHYLLIIDAE Verrill.

Genus TROCHOCYATHUS Milne Edwards and Haime.

Trochocyathus dakotaenis Vaughan, n. sp.

Plate X, figures 1–1b.

Description of holotype: Corallum short, turbinate, straight; transverse outline elliptical; basal scar of attachment rather large. Height, 5.5 millimeters; greater diameter of the calice, 8 millimeters; lesser diameter of the calice, 6.5 millimeters; basal scar, 3.5 by 2 millimeters in diameter; depth of calice, about 2 millimeters.

Wall rather stout, externally costate. Costae alternately distinct, well developed, and small or obscure. There are 24 large costae, all of which extend to the margin of the basal scar; low, triangular in profile; edges rather sharp, rather irregularly beaded. The small costae are low and thin; on each side of each of them there is a small raised line nearly equal in thickness and height to the costa but without any corresponding septum.

Septa in four complete cyles; the primaries and secondaries are of the same thickness and length and reach the columella; the tertiaries are thinner and extend to or almost to the columella; the quaternaries are still thinner, are fused to the sides of the tertiaries, and usually reach about two-thirds the distance from the wall to the columella. Interseptal loculi open. Septal margins not very prominent; those of the largest septa exsert 1 millimeter; those of tertiaries and quaternaries low, subequal. Granulations on septal faces rather small, rather tall, and obtuse on the ends.

Pali appear to be in two crowns. A perfectly preserved narrow palus, rounded above,

stands before one secondary septum, and although the inner ends of the septa are broken, there appear to have been wide pali before the tertiary septa.

Columella rather small, papillate.

Locality and geologic occurrence: Station 7962, river bluff in the SW. ¼ sec. 17, T. 133 N., R. 88 W., about 5 miles southeast of Kayser, N. Dak.; collected by W. T. Thom, jr., September 18, 1912. Cannonball marine member of the Lance formation.

Type: U. S. N. M. catalogue No. 32374.

Trochocyathus? neumani Vaughan, n. sp.

Plate X, figures 2–2c.

Description of holotype: Corallum short, subturbinate, curved, asymmetric; transverse outline subelliptical; basal scar large, covered, irregular in shape. Height on outside curvature of corallum, 7.5 millimeters; height on inside curvature, 6 millimeters; greater diameter of calice, 6.5 millimeters; lesser diameter of calice, 5 millimeters; depth of calice in plane of longer calicular diameter, about 2 millimeters.

Wall rather thin between the distal ends of the septa, externally rather strongly costate. Costae correspond to all septa; distinct almost to the tip of the base; rather thick; their sides steep, interspaces narrow; edges obtuse, beaded; the beads with their longer axes transverse to the costal courses; every other or every fourth costa somewhat more prominent than the intermediate costae.

Septa about 45; the fourth cycle seems almost but not quite complete, but the holotype is not in perfect condition and there may be a few more septa than were counted; the normal number is probably four complete cycles. Primaries and secondaries equal or subequal; tertiaries thinner; quaternaries shorter and thinner than the tertiaries. Septal margins very slightly exsert.

Palar characters indefinite, a condition which explains the doubtful identification of the genus of the species.

Columella small.

Locality and geologic occurrence: Station 7964, sec. 31, T. 133 N., R. 88 W., about 6 miles south of Kayser, N. Dak.; collected by L. M. Neuman, September 23, 1912. Cannonball marine member of the Lance formation.

Type: U. S. N. M. catalogue No. 32375.

For reasons made obvious in the foregoing description the genus of this species can not be positively determined, but its costal characters and form show that it is distinct from any of the other corals collected in the Cannonball marine member of the Lance.

Genus PARACYATHUS Milne Edwards and Haime.

Paracyathus lloydi Vaughan, n. sp.

Plate X, figures 3–3b.

Description of holotype: Corallum somewhat compressed, inversely conical, straight; transverse outline elliptical; base rather sharp-pointed. Height, 13.5 millimeters; greater diameter of calice, 10.25 millimeters; lesser diameter of calice, 7 millimeters; depth of calice, 3.5 millimeters.

Wall at its upper edge thin between the distal ends of the septa. Costae correspond to all septa; they are low, rounded in profile and equal or subequal, separated by narrow intercostal grooves; their sides and edges granulate, the granulations elongate transversely to the costal courses.

Septa 50 in number, four complete cycles and two quinaries; primaries and secondaries equal, appreciably but not greatly thicker than the members of the higher cycles, extending to or almost to the columella; tertiaries and quaternaries decidedly thin and shorter than the members of the lower cycles; quaternaries seem to join the tertiaries about two-thirds the distance from the wall to the columella. Interseptal loculi relatively wide in upper part of the calice, wider than the thickness of the septa. The septa are not nearly so thick, only half or less than half as thick as the corresponding costae. Septal margins not prominent, exsert only about 0.5 millimeter. Granulations on the septal faces tall, rather crowded, nipple-shaped or subcylindrical.

Pali well developed and conspicuous. The widest form a crown before the tertiary septa; these stand up almost half the depth of the calice above the bottom of the calicular fossa, are rounded above, and are a little less than 0.5 millimeter wide. Narrower pali seem to be present before the secondary and primary septa, and these are not sharply differentiated from the columellar papillae.

The top of the columella is sunken in a deep, rather narrow fossa; its upper surface is papillate; the papillae are small and rodlike, and are not sharply differentiated from the innermost palar crowns.

Locality and geologic occurrence: Station 7961, in the NE. ¼ SW. ¼ sec. 5, T. 132 N., R. 88 W., about 9 miles southwest of Leith, N. Dak.; collected by W. T. Thom, jr., September, 1912. Cannonball marine member of the Lance formation.

Type: U. S. N. M. catalogue No. 32376.

Paracyathus thomi Vaughan, n. sp.

Plate X, figures 4–4d.

Description of holotype: Corallum subflabellate; slightly curved in the plane of the shorter transverse axis of the calice; transverse outline elliptical; base with a distinct, elongate, but not very large scar of attachment. Height, 13.5 millimeters, measured with calicular margin in a horizontal plane. As the corallum has been slightly crushed the measurements of calicular diameters at the calicular margin are not as they would be in an undamaged specimen, but they are as follows: Greater diameter, 12.5 millimeters; lesser diameter, 7.75 millimeters. At a height of 8.5 millimeters above the base the diameters are as follows: Greater diameter, 10 millimeters; lesser diameter, 7.75 millimeters. The greater diameter normally is between 1.25 and 1.30 times as long as the lesser diameter. Basal scar 3 millimeters long and 1 millimeter wide. Depth of calice, 5.5 millimeters.

Wall rather thin at its upper edge. Costae well developed, thicker than the width of the intercostal furrows, subequal in thickness and height, edges subacute, sides granulate. Although the costae are somewhat thicker than the corresponding septa inside the calicular cavity, the difference between the thickness of septa and costae is not so pronounced as in *Paracyathus lloydi*.

Septa 58 in number, four complete cycles and 10 quinaries; primaries and secondaries equal or subequal, considerably thicker than the members of the higher cycles, extending to the columella; tertiaries and quaternaries thinner and shorter than the members of the lower cycles; there are no obvious septal groups; of the quinaries it can only be said that they are small. Interseptal loculi open and rather wide in the upper part of the calice, slightly wider than the thickness of the larger septa, much wider than the thickness of the smaller septa. Septa not greatly different in thickness from their corresponding costae. Margins only moderately exsert, taller ones project about 1.2 millimeters. Granulations on the septal faces rather crowded and rather tall, nipple-shaped or subcylindrical.

There are before the tertiary septa rather wide, very thin, curly pali, which stand fairly high up in the calice; pali before the secondary and primary septa are not so definite, but there are on the lower part of the inner edges of at least some of these septa processes or curly lobes that appear to grade into the columellar papillae, as is usual in species of *Paracyathus*.

The columella is at the bottom of a deep, narrow fossa; it is rather small, and its upper surface is finely papillate, the columellar papillae not sharply distinguishable from the innermost small pali.

Locality and geologic occurrence: Station 7961, in the NE. ¼ sec. 5, T. 132 N., R. 88 W., about 9 miles southwest of Leith, N. Dak.; collected by W. T. Thom, jr., September, 1912. Cannonball marine member of the Lance formation.

Type: U. S. N. M. catalogue No. 32377.

Paracyathus kayserensis Vaughan, n. sp.

Plate X, figure 5–5b.

Description of holotype: Corallum inversely conical, straight; transverse outline broadly elliptical; basal scar distinct. Height, 9.5 millimeters; greater diameter of the calice, 7.5 millimeters; lesser diameter of the calice, 6.75 millimeters; basal scar, about 1.25 millimeters in diameter; depth of calice, about 1.75 millimeters.

Wall rather strong but not especially thick, externally costate. Costae distinct but not prominent, correspond to all septa, equal; intercostal grooves narrow; costal edges subacute; faces with some granulations.

Septa 48 in number, four complete cycles; primaries and secondaries equal, a little thicker than the tertiaries and quaternaries; the quaternaries seem as a rule to fuse to the sides of the

included tertiary septum. Interseptal loculi wide, much wider than the thickness of the septa. The septa are thin, not nearly so thick as the corresponding costae. Septal margins not at all exsert. Granulations on the septal faces unequally distributed and of unequal height; some are tall and slender, others low and conical.

Wide, rather thin, more or less sinous pali before the tertiary septa; before the primaries and secondaries apparently there are narrow, small pali which are not sharply distinct from the columellar papillae.

Columella rather large, about 1.5 by 2 millimeters in diameter, upper surface papillate, the papillae rather small.

Locality and geologic occurrence: Station 7965, in T. 113 N., R. 88 W., about 6 miles south of Kayser, N. Dak.; collected by W. T. Thom, jr., September 23, 1912. Cannonball marine member of the Lance formation.

Type: U. S. N. M. catalogue No. 32378.

Genus STERIPHONOTROCHUS Vaughan.

Steriphonotrochus leithensis Vaughan, n. sp.

Plate X, figures 6–6b.

Description of holotype: Corallum inversely conical, straight, transverse outline broadly elliptical; base a rounded tip on which a few septa are visible. Height, 13.5 millimeters; greater diameter of the calice, 9 millimeters; lesser diameter of the calice, 8.5 millimeters; depth of calice, about 3.5 millimeters.

Wall not very thick, externally costate. Costae distinct but low, equal, separated by narrow intercostal grooves, edges rather obtuse but not flat.

There are 48 septa, four complete cycles; all septa equal or subequal at the wall and at least 22, probably one or two more, extend to the columella—that is, the primary, secondary, and most or all of the tertiary septa reach the columella; the quaternaries are shorter. Although the septa are not weak, their thickness at the wall is less than the width of the interseptal loculi, and they are not so thick as the corresponding costae. Septal margins slightly exsert, about 0.75 millimeter. There are no clearly differentiated pali in the holotype of this species, but beginning about 1.25 millimeters below the top of the septal arches and continuing to the periphery of the columella there are on the inner edges of all the long septa curly lobes—there are about six of these lobes within a distance of about 3 millimeters measured along the septal margin; therefore a lobe and an interlobar space are about 0.5 millimeter across on an average. Some of the lobes are curled so that the measure perpendicular to the septal plane exceeds that parallel to it. These lobes are smooth edged and resemble the lobes on the inner ends of some septa in some species of *Paracyathus;* they do not resemble the septal dentations of *Montlivaltia, Antillia,* etc. Septal faces with low granulations.

Columella well developed, of moderate size, almost 2 millimeters in diameter; upper surface finely papillate; papillae not sharply distinguishable from the innermost septal lobes.

Locality and geologic occurrence: Station 7963, north of the NW. ¼ sec. 11, T. 132 N., R. 88 W., about 7 miles south of Leith, N. Dak.; collected by W. T. Thom, jr., and L. M. Neuman, September 20, 1912. Cannonball marine member of the Lance formation.

Type: U. S. N. M. catalogue No. 32379.

PLATE X.

Trochocyathus dakotaensis Vaughan, n. sp. (p. 61).

FIGURE 1. Corallum, × 2.
1a. Costae, × 4.
1b. Calice, × 4.
U. S. N. M. catalogue No. 32374.

Trochocyathus? neumani Vaughan, n. sp. (p. 62).

FIGURE 2, 2a. Two views of the corallum, each × 2.
2b. Costae of edge, × 4.
2c. Calice, × 4.
U. S. N. M. catalogue No. 32375.

Paracyathus lloydi Vaughan, n. sp. (p. 62).

FIGURE 3. Corallom, × 2.
3a. Costae, × 4.
3b. Calice, × 4.
U. S. N. M. catalogue No. 32376.

Paracyathus thomi Vaughan, n. sp. (p. 63).

FIGURES 4, 4a, 4b. Three views of the corallum, each × 2.
4c. Costae, × 4.
4d. Calice, × 4.
U. S. N. M. catalogue No. 32377.

Paracyathus kayserensis Vaughan, n. sp. (p. 63).

FIGURE 5. Corallum, × 2.
5a. Costae, × 4.
5b. Calice, × 4.
U. S. N. M. catalogue No. 32378.

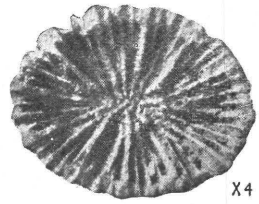
Steriphonotrochus leithensis Vaughan, n. sp. (p. 64).

FIGURE 6. Corallum, × 2.
6a. Costae, × 4.
6b. Calice, × 4.

U. S. N. M. catalogue No. 32379.


X2
1

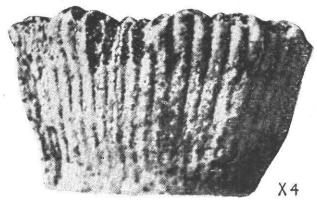

X4
1a

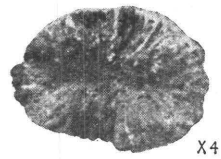

X4
1b

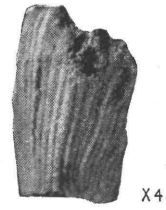

X2
2

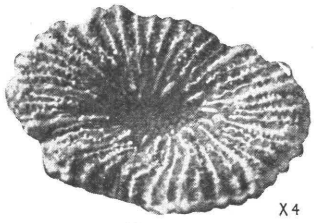

X2
2a

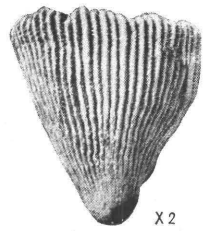

X2
3


X4
3a


X4
2c

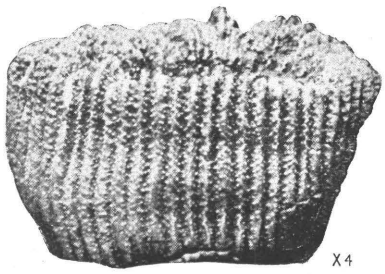

X4
2b

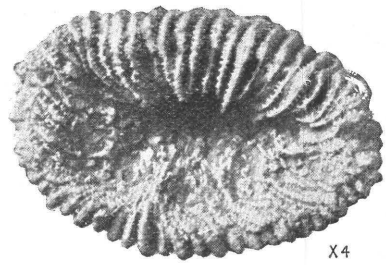

X4
3b


X2
4


X2
4a


X2
4b

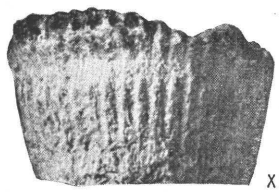

X4
4c

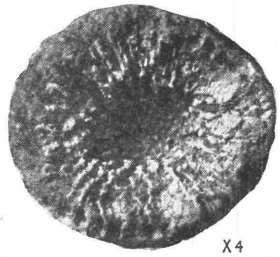

X4
4d

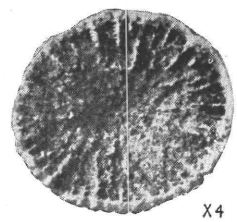

X4
5a


X2
5


X2
6


X4
6a


X4
6b


X4
5b

CORALS OF THE CANNONBALL MARINE MEMBER OF THE LANCE FORMATION.