

3. NONMARINE CRETACEOUS INVERTEBRATES OF THE SAN JUAN BASIN.

By T. W. STANTON.

In the San Juan Basin of New Mexico and southwestern Colorado the formations that have yielded marine Cretaceous faunas are, beginning at the base, the Mancos shale, the Mesaverde formation, the Lewis shale, and the Pictured Cliffs sandstone. The fossils obtained below the middle of the Mancos shale belong to the fauna of the Colorado group; those obtained above that line belong to the fauna of the Montana group.

East of the mountains, in the Denver Basin and more northern areas, the Montana group consists of the thick Pierre shale at the base and the thinner Fox Hills sandstone above. The faunas of these two formations are closely related, but each has its own distinctive species.

It might naturally be inferred from purely stratigraphic and lithologic considerations that the Pictured Cliffs sandstone should be correlated with the Fox Hills sandstone, for each is the latest marine sandstone in its respective section. The direct faunal evidence, however, does not support this correlation. Although the known fauna of the Pictured Cliffs sandstone consists of only a few species and, taken as an assemblage, agrees with the known stratigraphy in indicating late Montana age, it lacks all the strictly characteristic Fox Hills forms and includes some which are not known elsewhere above the Pierre shale. The fauna itself, therefore, suggests for the Pictured Cliffs sandstone an age slightly older than the Fox Hills.

Overlying the Pictured Cliffs sandstone with apparent conformity in the San Juan Basin and underlying the Puerco formation is a group of nonmarine sediments, coal bearing in the lower part, which in many previous reports have been referred more or less doubtfully to the Laramie formation. The rocks occupying this interval are fully described and a considerable area of them is mapped in the accompany-

ing stratigraphic paper by C. M. Bauer,¹ who recognizes in them three formations—the Fruitland formation containing all the coal beds at the base, the Kirtland shale in the middle, and the Ojo Alamo sandstone at the top. The vertebrate fauna and the flora of these formations are described and discussed by C. W. Gilmore² and F. H. Knowlton,³ respectively. The invertebrates, which form the subject of the present paper, nearly all come from the Fruitland formation. Of the 27 species discussed only two, *Unio pyramidatoides* and *U. baueri*, were collected in the Kirtland shale, and none was found in the Ojo Alamo sandstone. A few collections from southern Colorado a short distance north of the area mapped by Mr. Bauer have been included in the discussion because they are obviously from the equivalent of the Fruitland formation.

The general facts concerning the stratigraphic range and relationships of the invertebrate species may be most easily presented in tabular form, as shown on page 310.

The list of species shows that the nonmarine invertebrates of the Fruitland formation include both a fresh-water fauna and a brackish-water fauna. The latter is mostly confined to several thin bands in the lower half of the formation, though many of the collections show both fresh-water and brackish-water forms commingled. The *Corbula* and the *Neritina* especially are found with so many fresh-water associates at several localities that the suggestion is justified that they may have ranged into fresh waters, like some of their living congeners. The fresh-water fauna is especially notable for the greatly varied development of the genus *Unio* and for the abundance and considerable variety of the gastropods.

¹ U. S. Geol. Survey Prof. Paper 98-P.

² U. S. Geol. Survey Prof. Paper 98-Q.

³ U. S. Geol. Survey Prof. Paper 98-S.

Stratigraphic range of nonmarine invertebrates of the San Juan Basin.

	Fruitland.	Kirtland.	Mesaverde.	Judith River.	Fox Hills.	Laramie of north-eastern Colorado.	Lance.	"Lower Laramie" of southern Wyoming.	"Laramie" of southern Utah.
<i>Ostrea glabra</i> Meek and Hayden.....	x		x	x	x	x			
<i>Anomia gryphorhynchus</i> Meek.....	x		x	x		x			
<i>Anomia gryphæiformis</i> n. sp.....	x								
<i>Modiola laticostata</i> (White).....	x		x						
<i>Unio holmesianus</i> White.....	x						x	x	r
<i>Unio amarillensis</i> n. sp.....	x						r	r	r
<i>Unio pyramidatoides</i> Whitfield?.....		x					x		
<i>Unio gardneri</i> n. sp.....	x						r		
<i>Unio reesidei</i> n. sp.....	x								r
<i>Unio brachyopisthus</i> White.....	x						x	x	
<i>Unio baueri</i> n. sp.....		x							
<i>Unio neomexicanus</i> n. sp.....	x						r		
<i>Unio brimhallensis</i> n. sp.....	x						x?		
<i>Unio</i> sp. cf. <i>U. primævus</i> White.....	x			r					
<i>Corbicula cytheriformis</i> (Meek and Hayden).....	x		x	x		r	x		
<i>Corbula chacoensis</i> n. sp.....	x		r	r		r	r		
<i>Panopæa simulatrix</i> Whiteaves?.....	x								
<i>Teredina neomexicana</i> n. sp.....	x						r	r	
<i>Neritina baueri</i> n. sp.....	x								
<i>Neritina</i> (<i>Velatella</i>) sp.....	x						r	r	
<i>Campeloma amarillensis</i> n. sp.....	x			r			r		
<i>Tulotoma thompsoni</i> White.....	x		x			x	x	x	
<i>Melania insculpta</i> Meek?.....	x		x		x	x	x		
<i>Goniobasis? subtortuosa</i> Meek and Hayden.....	x			x					
<i>Physa reesidei</i> n. sp.....	x					r			
<i>Physa</i> sp.....	x								
<i>Planorbis</i> (<i>Bathyomphalus</i>) <i>chacoensis</i> n. sp.....	x								r

NOTE.—In this table "x" indicates the identical species named in the same horizontal line and "r" indicates a closely related form.

The distribution of the species as exhibited in the table may seem at first glance to indicate that the Fruitland fauna is about as closely related to the Mesaverde and Judith River faunas (which are approximately contemporaneous with each other) as it is to the Lance and Laramie faunas. A closer analysis of the table, however, will show that most of the species occurring or represented by related forms in the Mesaverde and Judith River are long-lived brackish-water species which range at least as high as the Laramie. *Melania insculpta* belongs to this class, for like all the other American Cretaceous species referred to *Melania* it is invariably associated with brackish-water forms. The only two Fruitland species with an outside distribution which do not elsewhere range into the higher formations are *Modiola laticostata*, from the Mesaverde, and *Goniobasis? subtortuosa*, from the Judith River.

With the fresh-water species, especially those belonging to the genus *Unio*, the case is different. The majority of the identical and closely related species are found in the Laramie, the so-called "Lower Laramie" of southern Wyoming, and the Lance and do not range below these formations. It is my opinion, therefore, that the invertebrate evidence as a whole favors the assignment of the Fruitland formation to an epoch considerably later than Mesaverde and Judith River and possibly somewhat earlier than Lance. If due weight is given to the known stratigraphic relations and to the faunal evidence from the underlying formations, the Fruitland can hardly be older than Fox Hills, and the sequence from the base of the Fruitland up to the top of the Ojo Alamo, which is conformable, according to Mr. Bauer, may include the equivalents of everything from the Fox Hills to the Lance inclusive.

***Ostrea glabra* Meek and Hayden var.**

Plate LXXIX, figures 1-3.

The New Mexican specimens referred to the widespread and long-lived species *Ostrea glabra* show scarcely perceptible differences from the variety from the Mesaverde formation at Point of Rocks, Wyo., described under the name *O. wyomingensis*. The species was originally described from the Judith River formation, but it also ranges into the Fox Hills, Laramie, and Lance formations.

Locality and position: The specimens here figured are from Bauer's locality 12, in Amarillo Canyon, 10 miles south of Jewett (locality 9279), in the Fruitland formation, 37 feet above its base. It was also collected from the same horizon 12 miles south of San Juan River and 2 miles east of Chaco River. Another lot provisionally identified as *O. subtrigonalis* Evans and Shumard, from Coal Creek, 37 miles south of Farmington, N. Mex., may be only young specimens of this species.

***Anomia gryphorhynchus* Meek.**

Plate LXXIX, figures 7 and 8.

Anomia? *gryphorhynchus* Meek, U. S. Geol. Survey Terr. Fifth Ann. Rept., p. 375, 1872.

Anomia gryphorhynchus White, U. S. Geol. Survey Terr. Twelfth Ann. Rept., pt. 1, p. 57, pl. 25, figs. 1a-c, 1880; U. S. Geol. Survey Third Ann. Rept., p. 16, pl. 12, figs. 12-15, 1883.

The New Mexican specimens of *Anomia gryphorhynchus* agree very well with the type lot from the Mesaverde formation at Point of Rocks, Wyo., especially with those individuals which have very fine radiating striæ, barely visible without lens, though many of the Wyoming shells have no sculpture other than concentric growth lines. The species also occurs in the Laramie of Crow Creek, Colo., and in the Black Buttes coal group at Black Buttes station, Wyo.

An average specimen measures 20 millimeters in height and 18 millimeters in length.

Locality and position: In the lower part of the Fruitland formation 3 miles northwest of Fruitland, N. Mex. (locality 3475), where it is associated with *Modiola laticostata*, *Corbicula*, and other forms.

***Anomia gryphæiformis* Stanton, n. sp.**

Plate LXXIX, figures 4-6.

Shell small, of variable outline, but usually much higher than long, very convex and with strongly incurved beaks, so that the general aspect is that of a small *Gryphæa*. Surface marked by conspicuous, threadlike radiating ribs, usually about 30 in number, varying considerably in size but relatively somewhat coarse compared with the size of the shell. Lower valve not seen.

The form varies considerably, as in all species of this genus, but most of the specimens seen resemble the one represented by figures 4 and 5, which measures 20 millimeters in height, 14 millimeters in length, and 12 millimeters in convexity of single valve. Another specimen representing nearly the extreme in variation is subcircular in outline, measuring 18 millimeters in height and length and 9 millimeters in convexity of single valve.

The coarser sculpture, smaller size, more slender convex form, and more conspicuous beaks distinguish this species from *A. micro-nema* Meek, which is probably its nearest relative in the western Cretaceous.

Locality and position: The types were collected by J. H. Gardner in the SE. $\frac{1}{4}$ sec. 19, T. 34 N., R. 4 W., in Colorado, from beds that are doubtless equivalent to the Fruitland formation. Other specimens came from Beaver Creek in T. 35 N., R. 6 W., in a neighboring part of southwestern Colorado.

***Modiola laticostata* (White).**

Plate LXXIX, figures 9 and 10.

Volsella (*Brachydontes*) *laticostata* White, U. S. Geol. and Geog. Survey Terr. Bull., vol. 4, p. 708, 1878; U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, p. 59, pl. 25, fig. 4a, 1880; U. S. Geol. Survey Third Ann. Rept., p. 423, pl. 13, fig. 2, 1883.

The type of this species is from the Danforth Hills, near White River Indian Agency, Colo., where it occurs in beds now referred to the Mesaverde. It is incomplete at both ends, but in form and sculpture it agrees perfectly with some of the larger and much better preserved specimens from New Mexico here referred to the species. The two examples figured show

that the species varies in breadth and curvature, but the variation in these particulars is even greater than they indicate.

Locality and position: All the New Mexican examples are from the lower part of the Fruitland formation near Fruitland. The two figured were collected by the late Robert Forrester and labeled "Fruitland" (locality 7077). Other lots were collected by Schrader and Shaler 3 miles northwest of Fruitland, a quarter of a mile southeast of the Bruce mine (locality 3475), and by Gardner at Thurling's limekiln, 4 miles north of Fruitland (locality 4002).

***Unio holmesianus* White.**

Plate LXXX, figures 1-7.

Unio holmesianus White, U. S. Geol. and Geog. Survey Terr. Bull., vol. 3, p. 604, 1877; U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, p. 67, pl. 22, figs. 4a-e, 1880; U. S. Geol. Survey Third Ann. Rept., p. 433, pl. 17, figs. 2-6, 1883.

The published descriptions and figures of this striking species are full and accurate except in some minor details of sculpture, which are not well preserved on the types and were slightly misinterpreted by the artist, as may be seen by comparing the original figures with the photographs of the same specimens as reproduced in figures 1 and 2. The radiating ridges on the posterior part of the larger specimen are in part due to accidental distortion and are not conspicuous on any other adult shell in the type lot.

The strong beak sculpture, which is the characteristic feature of the species, covers the umbonal region of the shell for a distance of 16 to 20 millimeters from the apex. It consists near the apex of sharp, slightly undulating concentric ridges which are almost parallel with the growth lines, but within a short distance these ridges become more wavy and develop a deep V-shaped sinus with its apex in the broad umbonal furrow that lies just in advance of the posterior umbonal ridge. Subordinate sinuses are developed on the anterior portion of some shells. The anterior part of the shell thus becomes covered with strong undulating ridges which run from the anterior margin obliquely backward and downward to the umbonal furrow. The rather narrowly rounded umbonal ridge is usually crossed by several short transverse ridges that are almost at right angles to

the main sculpture of the front part of the shell, where the continuation of this second system of ridges is sometimes faintly shown. Small irregular radiating lines with varying development on different individuals diverge from the umbonal ridge, some passing to the posterior margin and others toward or to the basal margin, thus extending farther on the adult shell than the other elements of beak sculpture. Well-preserved shells also show a threadlike raised line running from the beak down the crest of the umbonal ridge and a similar line midway between it and the posterior margin.

The dimensions given by White (length 45 millimeters, height 42 millimeters) are about the average for an adult shell.

Geographic and stratigraphic distribution: The specimen from which this species was originally described was found near the base of the coal-bearing rocks near Black Buttes station, Wyo. The beds at this locality have at different times and by different geologists been assigned to the Wasatch, the Laramie, the Lance, and a horizon intermediate between the Laramie and Lance. My own opinion is that the beds should be correlated with the lower part of the Lance. *Unio holmesianus* has also been collected from the Lance formation on Lance Creek, Wyo., and Fish Creek, Mont., from beds of approximately the same age near Belfry, Mont., and from the "Lower Laramie" as mapped by Veatch 3 miles west of Carbon, Wyo. A closely similar if not identical form described by Whitfield under the name *U. browni* was obtained from the "Hell Creek beds," now referred to the Lance formation on Snow Creek, 130 miles northwest of Miles City, Mont.

In the San Juan Basin of New Mexico and Colorado the species has been found only in the Fruitland formation, which in the past has sometimes been tentatively referred to the Laramie. It was collected by C. M. Bauer's party from his localities 4, 14, 17, 18, and 77, which are, respectively, 40 feet above the base of the formation, 1 mile south of Fruitland (locality 9268); 115 to 140 feet above the base (locality 9270), 140 feet above the base (locality 9271), and 150 feet above the base (locality 9272) in Amarillo Canyon, 10 miles south of Jewett; and 200 feet above the base near Hunter's store, 30 miles south of San Juan River (locality 9293). One broken specimen from locality 9271 showing

beak sculpture is represented by figure 5. The material from the above-named localities is ample for identification, but the specimens are less perfect than those selected for figuring from the collection of J. H. Gardner from the Ignacio quadrangle, Colo. The specimens represented by figures 3 and 4 were collected 8 feet above "B" coal in sec. 16, T. 35 N., R. 7 W. (locality 6071), and those shown by figures 6 and 7, 300 feet below the top of the "Laramie" in sec. 19, T. 35 N., R. 8 W. (locality 6063). For comparison with these figures new illustrations of White's types are given in figures 1 and 2. The smaller shell is the original type, on which the first description was based.

***Unio amarillensis* Stanton, n. sp.**

Plate LXXX, figures 8 and 9.

Shell small, moderately convex, subquadrate to subcircular in outline, with height and length nearly equal; beaks rather prominent, near middle of hinge line; dorsal margin descending rapidly and slightly excavated in front of the beak, very gently convex behind it; anterior and ventral margins regularly rounded; posterior margin subtruncate; surface strongly sculptured for a distance of about 10 millimeters from the apex of the beak, the sculpture consisting at the apex of concentric ridges each with a deep V-shaped sinus on the umbonal ridge and a shallower one near the middle, but within a short distance these sinuses fade out into the smooth surface of the shell and only the obliquely descending anterior and posterior portions of the ridges are developed. Beyond the distance of 10 millimeters from the beak the shell bears only fine lines of growth except on the short posterior slope, where there are five to seven rather strong plications that descend obliquely from the faintly marked umbonal ridge to the posterior margin. Height of type, which may be immature, 27 millimeters; length 29 millimeters.

This specimen belongs in the group of *U. holmesianus*, though in sculpture it shows relationship with *U. verrucosiformis* Whitfield and *U. letsoni* Whitfield, both of which differ from it in form and in having a line of nodes down the middle of the valve.

Locality and position: The type lot consists of three valves from Bauer's locality 14, in Amarillo Canyon, 10 miles south of Jewett, N. Mex. (locality 9270), 115 to 140 feet above the base of the Fruitland formation. Five specimens from the Lance formation on the divide between Lance and Lightning creeks, Wyo. (U. S. N. M., catalogue No. 23364), are believed to belong to this species, though they are slightly larger and their beak sculpture is not perfectly preserved.

***Unio pyramidatoides* Whitfield?**

Plate LXXX, figures 12 and 13.

Unio pyramidatoides Whitfield, Am. Mus. Nat. Hist. Bull., vol. 23, p. 624, pl. 41, figs. 1-5, 1907.

The imperfect specimens doubtfully referred to *Unio pyramidatoides* have very nearly the same form as *U. holmesianus* White, but they are very much larger and thicker than that species, and the beak sculpture, so far as it is still discernible on the eroded beaks, while of the same general type is not so strong and does not extend over so much of the shell. In all these features of size and sculpture they are more like *U. pyramidatoides*, though fuller collections of better-preserved material may prove that they belong to a distinct species.

The larger specimen figured measures 70 millimeters in height and about 72 millimeters in length. A slightly crushed specimen from Yellow Jacket Creek, Colo., measures 73 millimeters in height and 76 millimeters in length.

Locality and position: The figured specimens were obtained at Bauer's locality 32, 17 miles south of San Juan River and 6 miles east of Chaco River, N. Mex. (locality 9276), in the Kirtland shale 150 feet above its base. Another specimen believed to belong to the same species comes from either the Kirtland shale or the Fruitland formation on Yellow Jacket Creek in T. 34 N., R. 5 W., Colo.; and two small examples, which may be young shells of the species, were found 140 feet above the base of the Fruitland formation in Amarillo Canyon, 10 miles south of Jewett, N. Mex. (locality 9271). Whitfield's types came from beds now referred to the Lance formation on Snow Creek, 130 miles northwest of Miles City, Mont. The species has also been recognized in the Lance on Fish Creek, Mont.

Unio gardneri Stanton, n. sp.

Plate LXXX, figures 10 and 11.

Shell small, subcircular in outline, very convex; beaks prominent, strongly incurved, somewhat flattened, situated near the middle of the hinge line; anterior, ventral, and posterior margins forming a nearly regular curve; dorsal margin straighter. Surface strongly sculptured for a distance of about 20 millimeters from the apex of the beak, the sculpture consisting primarily of concentric ridges on which two deep V-shaped sinuses develop—one on the posterior umbonal ridge and the other near the median line of the shell. Within a short distance these ridges break up into oblique, more or less curved lines of nodes, and there are also developed two radiating lines of irregular tubercles, one down the middle of the shell and the other on the posterior umbonal ridge, and behind this ridge a number of small irregular curved ribs that extend from it toward but not to the posterior margin. The rest of the surface shows only lines of growth.

Height of type specimen 38 millimeters; length 43 millimeters; convexity of single valve 14 millimeters.

This species belongs to the group of *Unio letsoni* Whitfield, of the Lance formation, from which it differs in being more convex, in having two lines of tubercles instead of one, and in having much less conspicuous sculpture on the posterior portion of the shell.

The species is named for Mr. James H. Gardner, who collected the type.

Locality and position: Sec. 19, T. 35 N., R. 8 W., Ignacio quadrangle, Colo. (locality 6063), about 300 feet below the top of the "Laramie," probably in the upper part of the Fruitland formation.

Unio reesidei Stanton, n. sp.

Plate LXXXI, figure 1.

Shell rather small, broadly subelliptical in outline, strongly convex; beaks very inconspicuous, situated about one-third the length of the shell behind the front; anterior margin forming a regular curve from the beak to the ventral margin, which is more broadly curved; dorsal margin behind the beak gently convex, and posterior margin slightly subtruncate. Beak sculpture not preserved on the specimens studied. Surface in advance of the incon-

spicuous umbonal ridge marked only by fine lines of growth; posterior portion, comprising about two-fifths of the total surface, marked by 8 or 9 distinct but somewhat irregular radiating plications decreasing in size from the umbonal ridge backward and upward.

Height of figured type 46 millimeters; length (restored) 62 millimeters. A small specimen measures 39 millimeters in height, 49 millimeters in length, and 33 millimeters in greatest convexity of both valves united.

The species is named for Mr. J. B. Reeside, jr., of the United States Geological Survey.

In general features of form and sculpture this species suggests *U. gonionotus* White, from the "Laramie" of Sevier Cliffs, 10 miles above Panguitch, Utah, but it is easily distinguishable by its stouter form and the smaller size and different shape of the posterior plications.

Locality and position: The type specimen was obtained at Bauer's locality 48, 25 miles south of San Juan River and 6 miles east of Chaco River, N. Mex. (locality 9288), about 150 feet above the base of the Fruitland formation. Other specimens were collected at Bauer's locality 21, 12 miles south of the San Juan and 2 miles east of the Chaco (locality 9281) at about the same horizon.

Unio brachyopisthus White.

Plate LXXXI, figures 2 and 3.

Unio brachyopisthus White, in Powell, Geology of the eastern portion of the Uinta Mountains, p. 126, U. S. Geol. and Geog. Survey Terr., 2d div., 1876; U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, p. 64, pl. 22, figs. 2 a, b, 1880; U. S. Geol. Survey Third Ann. Rept., p. 433, pl. 16, figs. 7, 8, 1883.

This species, originally described from specimens found in the coal-bearing rocks at Black Buttes station, Wyo., is widely distributed in the so-called "Lower Laramie" of southern Wyoming and in the Lance formation in the eastern part of the State. It varies considerably in outline, even at the original locality, and the small type specimen is relatively shorter and higher than the average. In the San Juan Basin it is represented by the typical form (fig. 3) at Yellow Jacket Creek, Colo. (locality 7079), and by a more elongate form (fig. 2) at Bauer's locality 18, in Amarillo Canyon, 10 miles south of Jewett, N. Mex. (locality 9272), 150 feet above the base of the Fruitland formation.

Unio baueri Stanton, n. sp.

Plate LXXXI, figure 6.

Shell of medium size, subovate in outline, convex and thick; beaks prominent, situated in the anterior third of the shell; dorsal margin in front of the beak descending steeply into the broadly rounded front margin; postero-dorsal margin nearly straight and forming an obtuse angle with the subtruncate posterior margin; ventral margin very broadly convex. Beak sculpture not preserved on the type. The rest of the shell marked by irregular broad, rounded radiating plications which are strongest just behind the umbonal ridge and are separated by much narrower shallow furrows.

Height of type 57 millimeters; length 89 millimeters; convexity of single valve about 35 millimeters.

The species is named for Mr. C. Max Bauer.

Locality and position: At Bauer's locality 32, about 17 miles south of San Juan River and 6 miles east of Chaco River, N. Mex. (locality 9276), 150 feet above the base of the Kirtland shale.

Unio neomexicanus Stanton, n. sp.

Plate LXXXI, figures 4 and 5.

Shell small to medium, obliquely ovate in outline, moderately convex; beaks moderately prominent, at anterior end of shell; front margin descending abruptly with very slight curvature from the beaks for three-fourths of the height and then curving backward more rapidly to join the nearly straight (slightly convex) ventral margin; posterior end obliquely subtruncate above and broadly rounded below. A rather prominent rounded umbonal ridge extends obliquely from the beak to the postero-ventral margin, and in front of this is a broad, shallow depressed area. Beak sculpture not well preserved but apparently confined to a small area and consisting of irregular concentric ridges. The crest of the umbonal ridge bears a threadlike elevated line, especially in the umbonal region, and a similar line is midway between this and the postero-dorsal margin. The rest of the shell shows only fine lines of growth.

Height 39 millimeters; length 60 millimeters; convexity of single valve 19 millimeters.

Unio neomexicanus is related to *U. proavitus* White, which is found in the coal-bearing

rocks at Black Buttes, Wyo., and in the Lance formation on Lance Creek, eastern Wyoming. The Wyoming species differs in details of outline and has much more prominent beaks.

Locality and position: Represented by two left valves from the Fruitland formation, 150 feet above its base, at Bauer's locality 48, 25 miles south of the San Juan and 6 miles east of Chaco River, N. Mex. (locality 9288).

Unio brimhallensis Stanton, n. sp.

Plate LXXXI, figure 7; Plate LXXXII, figure 1.

Shell large, transversely broad ovate, gently convex; beaks prominent, situated about one-fourth the length of the shell from the front; dorsal margin deeply excavated in front of the beaks and almost straight behind them; anterior and posterior margins broadly and almost equally rounded; ventral margin more broadly rounded. Surface marked only by ordinary lines of growth on the anterior half of the valve. The rest of the surface not preserved except traces of faint radial sculpture near the dorsal margin behind the beaks.

The types are two imperfect valves, one of which shows the front part of the shell and the other preserves the outline of the posterior part. The better specimen measures 93 millimeters in height and has a convexity of about 30 millimeters and an estimated length of about 130 millimeters.

This species or a closely similar form is represented by a cast retaining part of the shell from the Lance formation between Lance and Lightning creeks, eastern Wyoming. The specimen measures 102 millimeters in height and 140 millimeters in length.

Locality and position: On Brimhalls Wash at Bauer's locality 48, about 25 miles south of San Juan River and 6 miles east of Chaco River, N. Mex. (locality 9288), 150 feet above the base of the Fruitland formation.

Unio sp.

Plate LXXXII, figures 2 and 3.

cf. *Unio primævus* White, U. S. Geol. and Geog. Survey Terr. Bull., vol. 3, p. 599, 1877; U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, p. 70, pl. 29, figs. 3 a, b, 1880; U. S. Geol. Survey Third Ann. Rept., p. 432, pl. 14, figs. 4, 5, 1883.

Several small, poorly preserved specimens evidently represent a distinct species of *Unio* that may be compared with the Judith River

form *U. primævus* White, from which it differs in its more anterior beaks, more angular and prominent posterior umbonal ridge, and probably in details of sculpture. These differences are probably of specific value, but on account of distortion and other accidents of preservation it is impossible to give a full, accurate specific description or even to decide whether all the specimens here grouped together belong to a single species. For similar reasons *U. primævus*, with which these specimens are compared, is in the same uncertain status.

Of the two specimens figured the smaller one, which is only an exfoliated fragment showing the umbonal region, is believed to represent nearly the normal form. The larger one is obliquely compressed so that the posterior area behind the umbonal ridge is much shortened.

Locality and position: The smaller specimen was obtained from the Fruitland formation about 150 feet above its base at Bauer's locality 48, 25 miles south of San Juan River and 6 miles east of Chaco River (locality 9288); the larger one 40 feet above the base of the same formation at Bauer's locality 4, 1 mile south of Fruitland, N. Mex. (locality 9268). Another specimen was found 140 feet above the base of the Fruitland formation at Bauer's locality 21, 12 miles south of San Juan River and 2 miles east of the Chaco.

***Corbicula cytheriformis* Meek and Hayden.**

Plate LXXXII, figure 4.

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

Corbicula cytheriformis Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 520, pl. 40, figs. 5a-c, 1876; White, U. S. Geol. Survey Terr. Twelfth Ann. Rept., pt. 1, p. 74, pl. 21, figs. 4a-d, 1880; U. S. Geol. Survey Third Ann. Rept., p. 437, pl. 22, figs. 1-6, 1883.

In the brackish-water fauna that is found in the lower part of the Fruitland formation the genus *Corbicula* is abundant at certain localities, especially in the neighborhood of Fruitland. Several species may be represented by more or less distorted and imperfect material. The form here figured, however, agrees in every particular with the types of *C. cytheriformis* from the Judith River formation of Montana. The species is widely distributed in the Mesa-verde formation and also ranges up into the Lance formation.

Locality and position: The specimen figured came from Bauer's locality 36, 120 feet above the base of the Fruitland formation, 18 miles south of San Juan River and 3 miles east of Chaco River, N. Mex. (locality 9286), where it is associated with *Corbula chacoensis*, *Neritina baueri*, *Viviparus*, *Campeloma amarillensis*, and *Tulotoma thompsoni*.

***Corbula chacoensis* Stanton, n. sp.**

Plate LXXXII, figures 5 and 6.

Shell of medium size, subtriangular in outline, moderately convex; beaks prominent, situated slightly in advance of the middle of the hinge line; dorsal margin descending steeply before and behind, the two portions making an angle of about 110°; anterior end and ventral margin broadly rounded; posterior end narrowed and obliquely subtruncate; surface marked only by numerous fine concentric growth lines until the shell has attained about three-fourths the dimensions of a full-grown individual, after which strong concentric corrugations are developed on the ventral part of the shell and the convexity becomes relatively greater.

Height 16 millimeters; length 22 millimeters; convexity of the two valves 12 millimeters.

The species is related to *Corbula subtrigonalis* Meek and Hayden, from which it differs in its more nearly equilateral form and other details of outline and in the much stronger corrugations at the later stages of growth.

Locality and position: The type came from the lower part of the Fruitland formation at Bauer's locality 25, about 13 miles south of San Juan River and 1 mile east of Chaco River, N. Mex. (locality 9284). The collection from this place contains 18 individuals in addition to the figured type. The species is abundantly represented, mostly by immature individuals, half a mile north of this locality, and it was collected at several other localities ranging from 18 to 28 miles south of San Juan River.

***Panopæa simulatrix* Whiteaves?**

Panopæa simulatrix Whiteaves, Contr. Canadian Paleontology, vol. 1, p. 11, pl. 2, figs. 2, 2a, 1885.

Several casts obtained at Bauer's locality 51, in the Fruitland formation 120 feet above its base, 28 miles south of San Juan River, and 6 miles east of Chaco River, N. Mex. (locality 9290), represent either this species or one closely

related to it. Whiteaves's species occurs in Canada and Montana in the Judith River formation, and a closely similar if not identical form is found near the top of the Fox Hills sandstone in South Dakota.

***Teredina neomexicana* Stanton, n. sp.**

Plate LXXXII, figures 7-10.

cf. *Xylophomya laramiensis* Whitfield, Am. Mus. Nat. Hist. Bull., vol. 16, pp. 73-76, pls. 28, 29, 1902.

Shell small, subglobose, broadly gaping in front and behind and with the posterior ends of the valves prolonged into a tapering, somewhat tortuous shelly tube several times the length of the valves themselves; anterior gape, which is formed by a rectangular notch in each valve, closed by a shield-shaped plate or callus with median furrow or suture; posterior end of valve broadly subangular. Surface marked by distinct growth lines parallel to the margins, by a narrow umbonal furrow corresponding in position to an internal rib or thickening, extending from the beak to the ventral margin, and by a less conspicuous furrow extending from the beak to the lateral angle of the anterior gape. One of the types shows fragments of an umbonal accessory valve.

Height of best-preserved type, 12 millimeters; length of valve, 12 millimeters; convexity of united valves, 12 millimeters.

A tube associated with the types and believed to belong to the same species indicates dimensions nearly twice as great.

This burrowing shell seems to be referable to the genus *Teredina* Lamarek, though it is also certainly congeneric with the Lance species for which Whitfield proposed the new name *Xylophomya*. Through the courtesy of the American Museum of Natural History it has been possible to make direct comparisons with the type specimens of *Xylophomya laramiensis*, on which the genus was based. The study of these specimens, which came from the Lance formation near Alkali Creek,¹ eastern Wyoming, and of large collections, apparently belonging to the same species, from the "Lower Laramie" opposite the mouth of Medicine Bow River, Carbon County, Wyo., shows that they have

all the generic characters of *Teredina* and that they differ from the New Mexico shell here described only in their larger size and in slight differences in the outline of the posterior end of the valve. Whitfield described the hinge of *Xylophomya* as having "four minute toothlike denticles on the right valve anterior to the beaks," and the figure as well as the fragment itself suggests taxodont teeth at first glance, but a closer examination shows that they can not be hinge teeth, for they are strictly marginal and connected with the outer surface, and the shell was doubtless edentulous like other members of its family.

Locality and position: At Bauer's locality 22, near the base of the Fruitland formation, 12½ miles south of San Juan River and 1 mile east of Chaco River, N. Mex. (locality 9283), associated with *Corbula chacoensis*, with several species of *Unio*, and with *Tulotoma thompsoni* and other fresh-water gastropods.

***Neritina baueri* Stanton, n. sp.**

Plate LXXXIII, figures 1-4.

Shell large, subglobose, consisting of about three very rapidly increasing volutions; spire so much depressed that it scarcely projects above the general curved surface of the shell; aperture nearly semicircular, with sharp outer lip and broadly flattened, simple inner lip; surface polished and without sculpture except numerous very fine growth lines but on well-preserved specimens retaining the color pattern, which consists of numerous irregular dark-brown spots and bands, some of which tend to have a spiral arrangement, while others run in zig-zag fashion nearly parallel with the growth lines. The color pattern varies in different individuals.

The largest specimen collected, which is figured as the type, measures 38 millimeters in height and 37 millimeters in greatest breadth. The smaller figured specimen is believed to be a young individual of the same species.

This species is much larger than any other American Cretaceous *Neritina* that has been described, and it is also distinct in form and proportions.

Localities and position: The type was obtained at Bauer's locality 21, about 140 feet above the base of the Fruitland formation, 12 miles south of San Juan River and 2 miles east

¹ Mr. Barnum Brown, who collected these fossils, states in a personal letter that the locality is on the "east side of Alkali Creek, 3 miles from the mouth and not more than 50 feet above the Fox Hills or marine Cretaceous."

of Chaco River (locality 9281), where six other specimens were collected. The other figured specimen came from about the same horizon in Amarillo Canyon, 10 miles south of Jewett, N. Mex. (locality 9270), and others were collected in the same neighborhood (locality 9271). One lot of nine small specimens referred to this species was found near the base of the Fruitland formation, 12½ miles south of San Juan River, and 1 mile east of the Chaco (locality 9283), and one imperfect cast 200 feet above the base of the Fruitland formation, 17 miles south of the San Juan (locality 9285).

Neritina (Velatella) sp.

A single small, imperfect specimen belonging to Meek's subgenus *Velatella* was collected in the Fruitland formation, 120 feet above the base, at Bauer's locality 36, 18 miles south of San Juan River and 3 miles east of Chaco River, N. Mex. (locality 9286). In size and form it does not differ greatly from *Neritina (Velatella) baptista* White, which was originally described from specimens obtained in the lower part of the coal-bearing formation at Black Buttes station, Wyo., and which has also been found in the Laramie of northeastern Colorado.

Campeloma amarillensis Stanton, n. sp.

Plate LXXXIII, figures 5 and 6.

Shell small, rather slender, consisting of about 6 moderately convex whorls that are slightly compressed above; suture distinctly impressed; surface nearly smooth but showing when magnified fine, slightly sinuous growth lines and, especially on the upper part of the last whorl, fine raised revolving lines; aperture ovate, with length a little less than half the height of shell.

Height of larger figured type, 22 millimeters; greatest breadth, 13 millimeters; height of aperture, 10 millimeters; breadth of aperture, 7 millimeters. Apical angle about 40°.

In size, general form, and other external features this species is intermediate between *Campeloma vetula* Meek and Hayden, from the Judith River formation, and *C. producta* White, from the Fort Union.

Locality and position: The types came from Bauer's locality 14, in Amarillo Canyon, 10 miles south of Jewett, N. Mex. (locality 9270), in the Fruitland formation, 115 to 140 feet above its base. The species was collected at several other localities, ranging from 12 to 25

miles south of San Juan River and from 50 to 300 feet above the base of the Fruitland formation.

Tulotoma thompsoni White.

Plate LXXXIII, figures 9-11.

Tulotoma thompsoni White, in Powell, Geology of the eastern portion of the Uinta Mountains, p. 134, U. S. Geol. and Geog. Survey Terr., 2d div., 1876; U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, p. 100, pl. 28, figs. 2a-h, 1880; U. S. Geol. Survey Third Ann. Rept., p. 467, pl. 24, figs. 17-22, 1883.

This well-characterized and easily recognized species was first found at Black Buttes station, Wyo., in the lower part of the Black Buttes coal group, which, in my opinion, should be correlated with the "Lower Laramie" of Carbon County, Wyo., and with the Lance formation. The species has a wide distribution in the Lance formation in Wyoming and Montana and is abundant in the Laramie on Crow Creek, Colo., where a number of the specimens figured by White were obtained. It has also been found abundantly and typically developed in the Mesaverde formation of northwestern Colorado, especially in the upper part of the formation near Axial, Colo.

Locality and position: The specimens figured came from Bauer's locality 14, in Amarillo Canyon, 10 miles north of Jewett, N. Mex. (locality 9270), in the Fruitland formation 115 to 140 feet above its base. The species ranges through the entire thickness of the Fruitland and has been collected at many localities.

Melania insculpta Meek?

Melania insculpta Meek, U. S. Geol. Survey Terr. Sixth Ann. Rept., for 1872, p. 515, 1873. White, U. S. Geol. and Geog. Survey Terr. Twelfth Ann. Rept., pt. 1, p. 94, pl. 20, fig. 4a, 1880; U. S. Geol. Survey Third Ann. Rept., p. 54, pl. 26, figs. 4, 5, 1883.

Two collections obtained near the base of the Fruitland formation at Bauer's localities 22 and 25, 12½ and 13 miles south of San Juan River, N. Mex. (localities 9283 and 9284), and one collection obtained near the middle of the same formation at Bauer's locality 51, 15 miles farther south (locality 9290), contain imperfect specimens of a *Melania* which in form and sculpture seems to agree very well with *M. insculpta* Meek. The specimen from which this species was first described was found in rocks now referred to the Mesaverde formation

near Rock Springs, Wyo., and it also occurs in the Laramie of northeastern Colorado.

Goniobasis? subtortuosa (Meek and Hayden) Meek.

Plate LXXXIII, figures 7 and 8.

Melania subtortuosa Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., vol. 9, p. 136, 1857.

Goniobasis? subtortuosa Meek, U. S. Geol. Survey Terr. Rept., vol. 9, p. 569, pl. 42, figs. 17a, b, text figs. 75, 76, 1876.

White, U. S. Geol. Survey Third Ann. Rept., p. 57, pl. 27, fig. 34, 1883.

Whiteaves, Contr. Canadian Paleontology, vol. 1, p. 74, pl. 10, fig. 7, 1885.

Meek's description based on specimens from the Judith River formation near the mouth of Judith River, Mont., is as follows:

Shell conoid-screw-shaped, thin; spire rather low; volutions about five, very convex, and strongly carinate around the middle, increasing rather rapidly in size from the apex; suture deep in consequence of the prominence of the angular whorls; surface with moderately distinct lines of growth; aperture rhombic-suboval, about as long as wide. Length 0.39 inch; breadth 0.21 inch; slopes of spire nearly straight, with a divergence of 47°. Some crushed specimens show that it attained nearly twice the linear dimensions of that from which the above measurements were taken.

Better material than Meek had, from both Montana and Alberta, shows that adult shells consist of six or seven whorls and that they vary considerably in proportions. A few specimens which retain part of the surface of the shell when magnified show very faint revolving lines on the last whorl, especially above the carina, and agree in this feature, as well as in form, with the well-preserved specimens from New Mexico that are referred to the species.

The larger specimen figured measures 20 millimeters in height and 12 millimeters in breadth.

Locality and position: At Bauer's localities 14, 15, and 17, in Amarillo Canyon, 10 miles south of Jewett, N. Mex. (localities 9269, 9270, 9271), 115 to 140 feet above the base of the Fruitland formation. It is noteworthy that the species has not been recorded from any locality between Montana and New Mexico.

Physa reesidei Stanton, n. sp.

Plate LXXXIII, figures 12 and 13.

Shell large, stout, with very small depressed spire; surface sculpture not preserved.

Height 44 millimeters; greatest breadth about 32 millimeters; height of aperture almost equal to length of shell, and breadth about half the breadth of the shell.

This species seems to be sufficiently distinct to justify its description, even from the imperfect material at hand—eight more or less distorted casts, of which the best-preserved one is selected as type. Its nearest relative among American fossil forms appears to be *Physa felix* White, from the Laramie of Crow Creek, Colo.

Locality and position: About 200 feet above the base of the Fruitland formation at Bauer's locality 27, 17 miles south of San Juan River and 4 miles east of Chaco River, N. Mex. (locality 9285)

Physa sp.

Another species of *Physa*, smaller and much more slender than *P. reesidei*, is represented by two fragmentary specimens from Bauer's locality 22, near the base of the Fruitland formation, 12½ miles south of San Juan River and 1 mile east of Chaco River, N. Mex. (locality 9283).

Planorbis (Bathyomphalus) chacoensis Stanton, n. sp.

Plate LXXXIII, figures 14-16.

Shell small, consisting of about five very gradually increasing whorls; spire flat; whorls slightly rounded above, carinate on the periphery, broadly rounded from the carina to the margin of the umbilicus, which is nearly as broad as the last whorl; surface marked by relatively coarse lines of growth.

Greatest diameter 7 millimeters; height 3 millimeters; breadth of last whorl 2 millimeters.

This little species is evidently congeneric with *Planorbis (Bathyomphalus) kanabensis* White, from the so-called Laramie of the Kanab Valley, Utah. It appears to differ from White's species in its somewhat more rapidly increasing whorls and its more distinctly carinate periphery.

Locality and position: At Bauer's locality 22, near the base of the Fruitland formation, 12½ miles south of San Juan River and 1 mile east of Chaco River, N. Mex. (locality 9283).



PLATES LXXIX-LXXXIII.

PLATE LXXIX.

***Ostrea glabra* Meek and Hayden var. (p. 311).**

FIGURES 1, 2. Upper valves.

3. Lower valve.

U. S. N. M., catalogue No. 32026.

***Anomia gryphæiformis* Stanton (p. 311).**

FIGURES 4, 5. Side and profile views of typical form.

6. Side view of broader, less convex specimen.

U. S. N. M., catalogue No. 32027.

***Anomia gryphorhynchus* Meek (p. 311).**

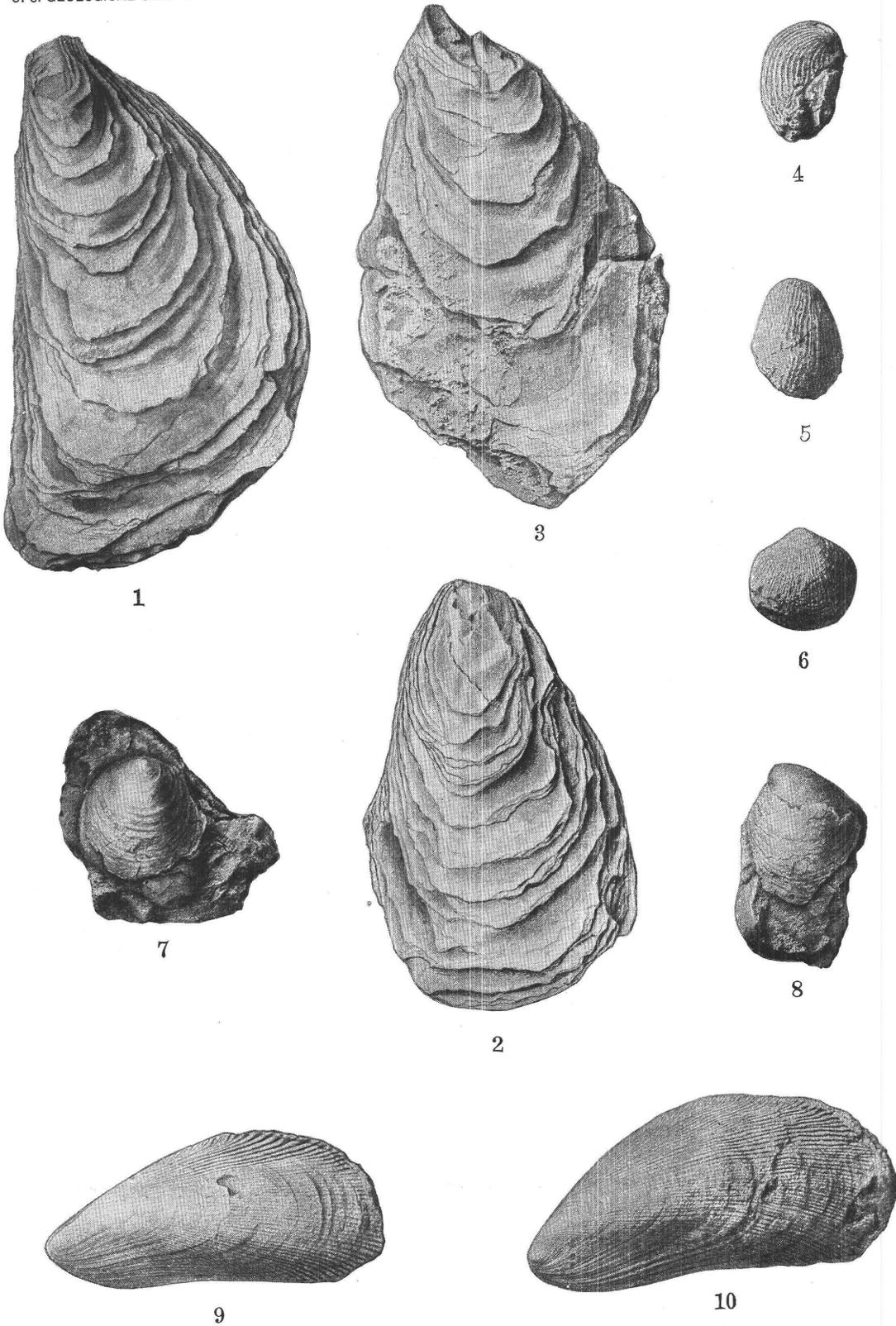
FIGURES 7, 8. Side views of two specimens varying in outline and convexity.

U. S. N. M., catalogue No. 32028.

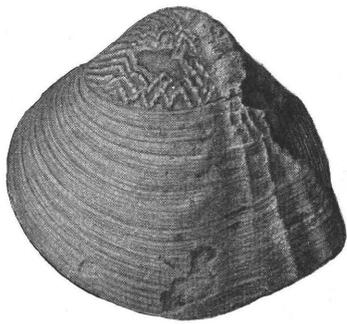
***Modiola laticostata* (White) (p. 311).**

FIGURES 9, 10. Left valves of two specimens varying in form and sculpture.

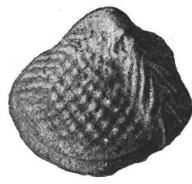
U. S. N. M., catalogue No. 32029.



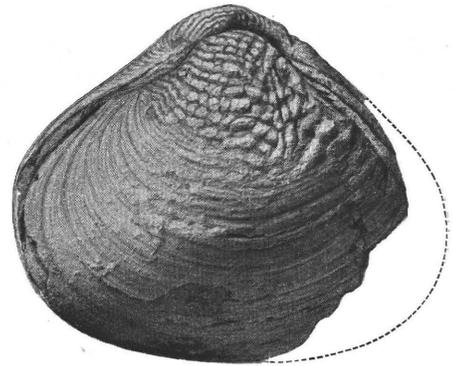
NONMARINE CRETACEOUS INVERTEBRATES OF THE SAN JUAN BASIN.



1



2



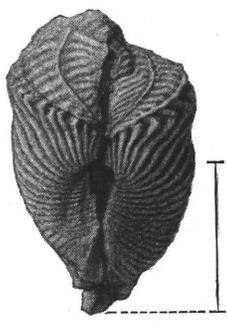
3



5



4



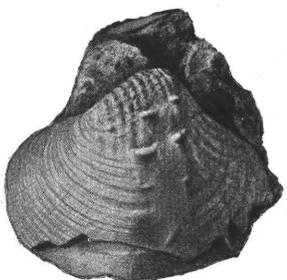
6



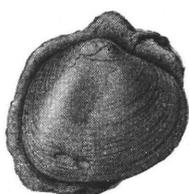
7



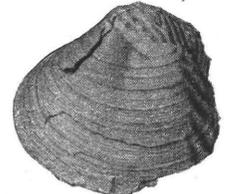
8



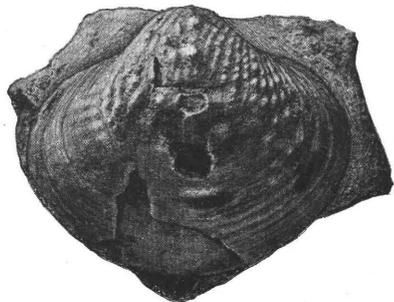
10



12



9



11



13

NONMARINE CRETACEOUS INVERTEBRATES OF THE SAN JUAN BASIN.

PLATE LXXX.

Unio holmesianus White (p. 312).

- FIGURES 1, 2. Type specimens from Black Buttes, Wyo., figured by White.
U. S. N. M., catalogue No. 9041.
- 3, 4. Specimens from T. 35 N., R. 7 W., Ignacio quadrangle, Colo.
U. S. N. M., catalogue No. 32030.
5. Fragmentary specimen, showing beak sculpture, from Amarillo Canyon, N. Mex.
U. S. N. M., catalogue No. 32031.
- 6, 7. Immature specimens, showing details of beak sculpture, from T. 35 N., R. 8 W., Ignacio quadrangle,
Colo. Figure 6 is enlarged 2 diameters.
U. S. N. M., catalogue No. 32032.

Unio amarillensis Stanton (p. 313).

- FIGURES 8, 9. Side and profile views of type.
U. S. N. M., catalogue No. 32033.

Unio gardneri Stanton (p. 314).

- FIGURE 10. Left valve.
11. Right valve. Both from Ignacio quadrangle, Colo.
U. S. N. M., catalogue No. 32034.

Unio pyramidatoides Whitfield? (p. 313).

- FIGURE 12. Small right valve.
13. Larger right valve with surface partly exfoliated.
U. S. N. M., catalogue No. 32035.

PLATE LXXXI.

Unio reesei Stanton (p. 314).

- FIGURE 1. Type specimen.
U. S. N. M., catalogue No. 32036.

Unio brachyopisthus White (p. 314).

- FIGURE 2. Left valve of an elongate specimen from Amarillo Canyon, N. Mex.
U. S. N. M., catalogue No. 32037.
3. Right valve of typical form from Yellow Jacket Creek, Colo.
U. S. N. M., catalogue No. 32038.

Unio neomexicanus Stanton (p. 315).

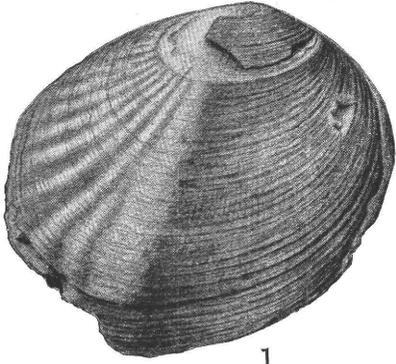
- FIGURE 4. Left valve, slightly distorted by crushing.
5. Smaller left valve.
U. S. N. M., catalogue No. 32039.

Unio baueri Stanton (p. 315).

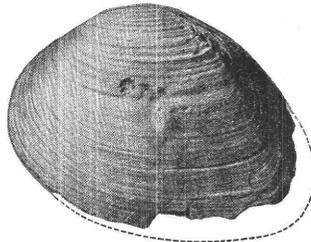
- FIGURE 6. Type specimen, left valve.
U. S. N. M., catalogue No. 32040.

Unio brimhallensis Stanton (p. 315).

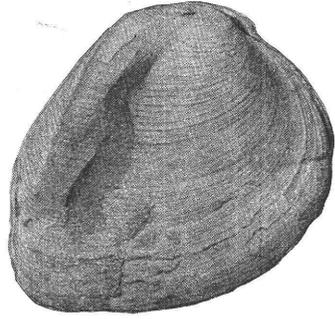
- FIGURE 7. An imperfect right valve. Outline restored from specimen represented by Pl. LXXXII, fig. 1.
U. S. N. M., catalogue No. 32041.



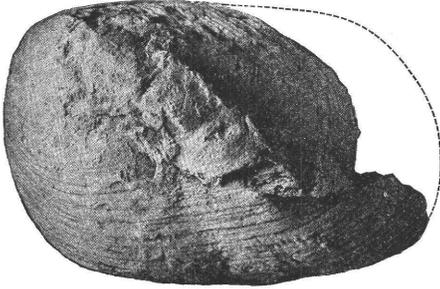
1



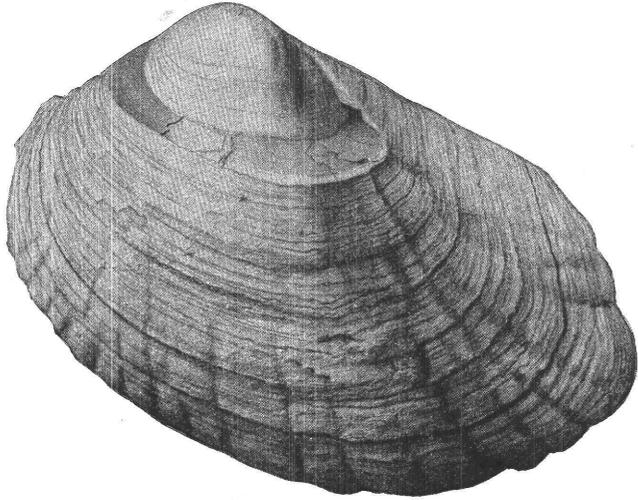
2



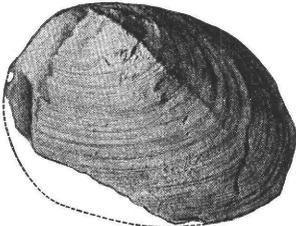
3



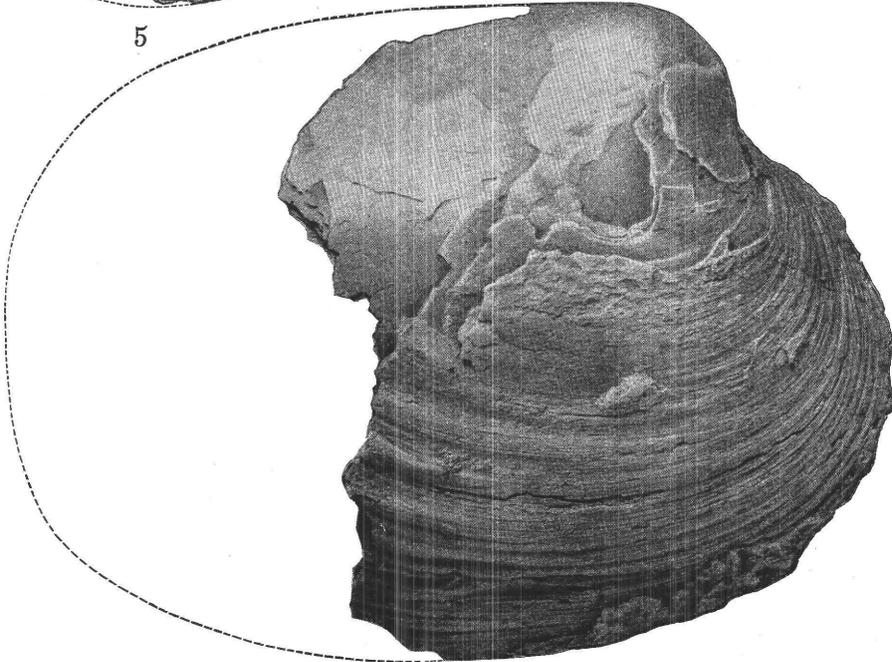
4



6

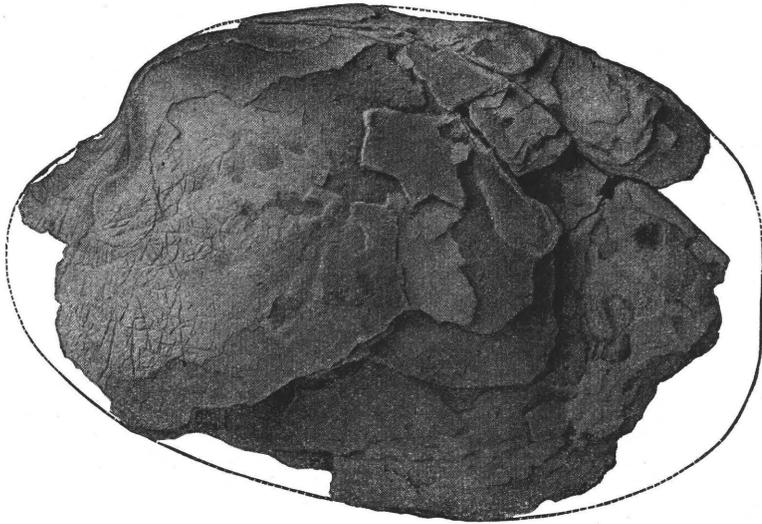


5

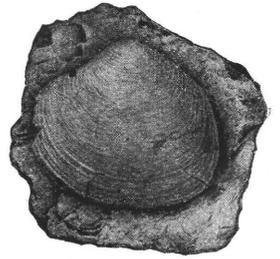


7

NONMARINE CRETACEOUS INVERTEBRATES OF THE SAN JUAN BASIN.



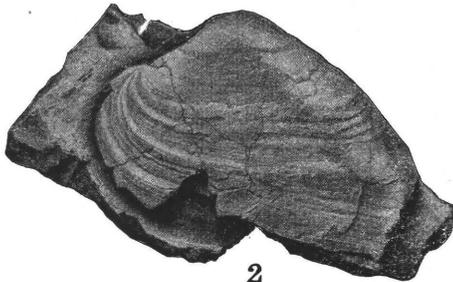
1



4



5



2



3



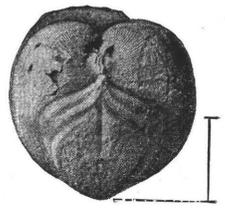
6



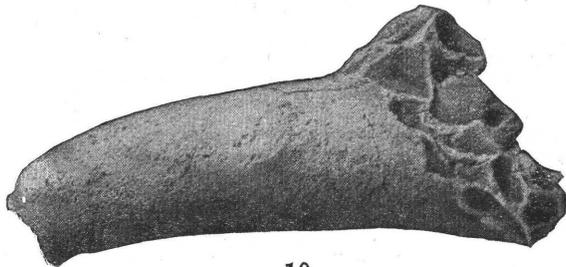
7



8



9



10



11

NONMARINE CRETACEOUS INVERTEBRATES OF THE SAN JUAN BASIN.

PLATE LXXXII.

Unio brimhallensis Stanton (p. 315).

FIGURE 1. An exfoliated left valve.

U. S. N. M., catalogue No. 32041.

Unio sp. cf. U. primævus White (p. 315).

FIGURE 2. Imperfect left valve, distorted by crushing.

U. S. N. M., catalogue No. 32042.

3. Fragment showing umbonal portion of right valve.

U. S. N. M., catalogue No. 32043.

Corbicula cytheriformis Meek and Hayden (p. 316).

FIGURE 4. Small left valve.

U. S. N. M., catalogue No. 32044.

Corbula chacoensis Stanton (p. 316).

FIGURES 5, 6. Left side and profile views of type.

U. S. N. M., catalogue No. 32045.

Teredina neomexicana Stanton (p. 317).

FIGURE 7. Left side of specimen retaining part of tube.

8, 9. Right side and front views of another specimen, $\times 2$.

10, 11. Casts of tubes believed to belong to this species. U. S. N. M., catalogue No. 32046.

PLATE LXXXIII.

Neritina baueri Stanton (p. 317).

- FIGURES 1, 2. Front and back views of type.
U. S. N. M., catalogue No. 32047.
3, 4. Front and back views of smaller specimen.
U. S. N. M., catalogue No. 32048.

Campeloma amarillensis Stanton (p. 318).

- FIGURE 5. Front view of large type.
6. Back view of smaller specimen.
U. S. N. M., catalogue No. 32049.

Goniobasis? subtortuosa (Meek and Hayden) (p. 319).

- FIGURE 7. Front view of large specimen.
8. Back view of smaller specimen.
U. S. N. M., catalogue No. 32050.

Tulotoma thompsoni White (p. 318).

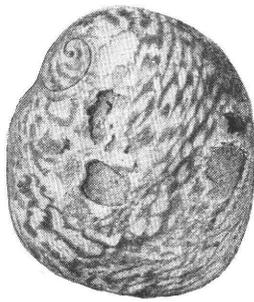
- FIGURES 9, 10. Back views of two specimens.
11. Front view of another specimen.
U. S. N. M., catalogue No. 32051.

Physa reesidei Stanton (p. 319).

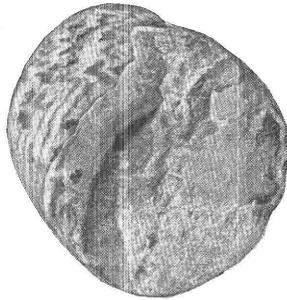
- FIGURES 12, 13. Back and front views of slightly distorted cast.
U. S. N. M., catalogue No. 32052.

Planorbis (Bathyomphalus) chacoensis Stanton (p. 319).

- FIGURES 14-16. Top, bottom, and front views of the type, $\times 2$.
U. S. N. M., catalogue No. 32053.



1



2



3



4



5



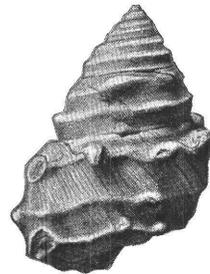
6



7



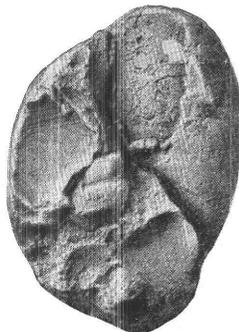
8



9



12



13



10



14



15



16



11