Fresh-Water Mollusks of Cretaceous Age From Montana and Wyoming

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By TENG-CHIEN YEN

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By TENG-CHIEN YEN

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ABSTRACT

The paper presents a fresh-water molluscan assemblage found in the Kootenai formation southeast of Harlowton, Montana, which indicates that the enclosing bed is of fluviatile origin. Molluscan faunas from contemporary beds, such as the Cloverly formation of central Wyoming and the Peterson limestone in the Gannett group of western Wyoming, are compared with it. An account of 29 species of pelecypods and gastropods is given, of which 4 genera and 8 species of gastropods are herein described as new.

INTRODUCTION

It is nearly half a century since the invertebrate fauna of the Kootenai formation near Harlowton, Montana, was first described by T. W. Stanton. Dr. Stanton's paper (1903) was based on a collection made by members of the Geology Department of Princeton University, and in it he described the following species of fresh-water mollusks:

Unio farri Stanton
Unio douglassi Stanton
Campeloma harlowtonensis Stanton
Viviparus montanensis Stanton
Goniobasis? ortmani Stanton
Goniobasis? silberlingi Stanton

On the evidence of these few species, Dr. Stanton concluded at this initial stage of geological exploration of the area, that the fossil-bearing bed is "certainly not older than Lower Cretaceous." The conclusion was significant as the recognition of a new assemblage, still acceptable as the standard Lower Cretaceous fresh water molluscan fauna in North America.

The fossiliferous bed is exposed in the SW¼ sec. 27, T. 7 N., R. 16 E., about 12 miles southeast of Harlowton, about 6 miles southwest of Winnicook, and about 1½ miles northwest of the old Widdecomb Ranch. The bed is well exposed over a few hundred square feet at the top of a low foothill of the West Dome of the Shawmut anticline, on the west side of a trail leading to the abandoned ranch.

After publication of Dr. Stanton's report, several additional collections were made at this locality. They, plus certain species from the Cloverly formation and the Peterson limestone of Wyoming, are the basis of the present paper.

COMPOSITION OF THE FAUNA, AND ITS ORIGIN

The fossiliferous bed, which consists of coarse-grained, shaly sandstone and nodular limestone of rusty color, yielded the following species of mollusks in addition to some ostracodes and teeth of fish and reptiles:

Pelecypoda
- Family Unionidae
  - *Protelliptio douglassi* Stanton
  - *Unio farri* Stanton
  - *U. natosini* McLearn
- Family Sphaeridae
  - *Eupera onestae* (McLearn)

Gastropoda
- Family Neritidae
  - *Mesoneritina nebrascensis* (Meek and Hayden)
- Family Amnicolidae
  - *Reesidella montanaensis* (Stanton), n. gen.
  - *Stantonogyra silberlingi* (Stanton)
  - *Mesochilina cretacea*, n. gen and sp.
- Family Viviparidae
  - *Campeloma harlowtonensis* Stanton
- Family Pleuroceratidae
  - *Circamelania ortmanni* (Stanton), n. gen.
- Family Physidae
  - *Physa montanensis*, n. sp.
  - *P.* sp. undet. A
- Family Planorbidae
  - *Gyraulus* cf. *G. veternus* (Meek and Hayden)
  - *Carinulorbis* sp. undet.

The molluscan fauna is rich in variety as well as in individuals. The prosobranchian gastropods include six species represented by many specimens, but the pulmonates yield only four species, each represented by only a few individuals.

The fauna seems to indicate that the enclosing bed was of fluviatile origin and that molluscan species

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from the upper course of a river were drifted by floods and gathered in a "pocket," where they were preserved. A strikingly similar Recent molluscan assemblage was collected from silt at a high-flood level at the Great Falls of the Potomac River, near Washington, D. C. The similarity is emphasized when the faunas are listed in parallel columns:

Kootenai bed near Harlowton	Great Falls of the Potomac River [2]
Protelliptio douglassi (common)	
Unio farri (rare)	*Elliptio complanatus* (common)
Unio natosini (rare)	
Eupera onestae (common)	*Sphaerium stamineum* (abundant)
Mesoneritina nebrascensis (rare)	----------
Reesidella montanaensis (abundant)	*Amnicola limosa* (common)
Stantonogyra silberlingi (rare)	*Amnicola decisa* (rare)
Mesochilina cretacea (rare)	*Gillia altilis* (common)
Campeloma harlowtonensis (rare)	*Campeloma decisum* (rare)
	Lioplax subcarinatus (common)
Circamelania ortmanni (abundant)	*Goniobasis virginica* (abundant)
	Anculosa carinata (common)
Physa montanensis (rare)	
Physa sp. undet. A (rare)	*Physa heterostropha* (rare)
Gyraulus cf. *G. vernus* (rare)	
Carinulorbis sp. undet. (rare)	----------

However remote it may be, the possibility that the Kootenai formation is lacustrine should be considered. A few molluscan species similar to those in the assemblage found at the Great Falls are also obtainable in lakes, especially in large ones connected with streams. In such lakes the assemblage of species is generally different, however, for there are generally more species of pulmonates and more shallow-water forms, and the fluviatile species, if any, may be represented by few individuals. A convincing example is an assemblage drifted to the shore of Bear Lake, Idaho and Utah, which includes the following molluscan species:

Sphaeriidae
- *Sphaerium pilsbryanum* Sterki (common)
- *Pisidium compressum* Prime (abundant)

Valvatidae
- *Valvata utahensis* Call (common)
- *Valvata humeralis californica* Pilsbry (common)

Amnicolidae
- *Amnicola longinqua* Gould (abundant)
- *Fluminicola fusca* (Haldeman) (common)

Physidae
- *Physa ampullacea* Gould (rare)
- *Physa* sp. undet. (common)

Lymnaeidae
- *Lymnaea utahensis* Call (abundant)
- *Lymnaea palustris buttoni* Baker (common)

Planorbidae
- *Gyraulus vermicularis* (Gould) (rare)
- *Helisoma subcrenatum* (Cooper) (rare)
- *Carinifex newberryi* (Lea) (abundant)

The similarity in composition of the Kootenai fauna to that of the deposit near the Great Falls of the Potomac River, in addition to suggesting a fluviatile origin for the Kootenai formation, may possibly also imply a general similarity of the water body, in which the Kootenai formation was deposited, in movements, depth, and volume of the water, permanency and size of the river, and constituents of soil and climate of the area. However, the abundance of rissoid snails, together with planorbid species, in the Kootenai formation may indicate that a more luxuriant aquatic vegetation along the extinct river favored such gastropods.

The faunal lists indicate only relative abundance and the species listed are not to be taken as completely representative of the existing fauna. Likewise, it is known that, although planorbid species have been found in some parts of the Potomac River they are not represented in the collection made at the Great Falls. This incompleteness suggests that the assemblage has come together from parts of the river where planorbids are rare or wanting and the other species are abundant.

STRATIGRAPHIC POSITION AND CORRELATIONS

It is generally accepted now that the Kootenai formation in Montana is of Early Cretaceous age. On the evidence of the molluscan species, part of these beds may be correlated with the Cloverly formation in Wyoming and part with the Peterson limestone of the Gannett group in Wyoming and Idaho. The precise position of these beds in the Lower Cretaceous is not definitely known, for it is generally recognized merely that they occur below the Upper Cretaceous and above the Upper Jurassic. Therefore, a detailed comparison of their molluscan faunas is of interest. (See table, p. 3.)

As differing contemporary faunal facies are generally incompletely represented by fossil assemblages at most times in geologic history, it is difficult to correlate contemporary beds with maximum accuracy on the basis of the fossil assemblages that may have been derived from several facies. It has been mentioned that the Kootenai

[2] The collection was made by Dr. John B. Reeside, Jr., of United States Geological Survey in October 1946 from pockets of sand on bare metamorphic rocks near Great Falls of Potomac River. The dead shells were probably brought in from the upper course of the River at high flood and preserved with silt and sand in crevices and pockets. In addition to the fresh-water mollusks, the collection contains eight species of terrestrial snails.

formation near Harlowton contains a drifted assemblage of fluviatile origin. The molluscan species of the Cloverly formation near Sage Dome, Wyoming (Yen, 1946) may also imply a fluviatile origin for the enclosing rocks. Those of the Cloverly formation near Bacon Ridge in the Jackson Hole area, Wyoming, seem, however, to belong to a lenitic assemblage, in water 4 to 5 feet or less in depth. Such an assemblage is commonly found on the shore of a lake or in a partly enclosed bay where the water is relatively quiet and aquatic vegetation is abundant. The Peterson limestone considered here is probably of lacustrine origin, possibly representing a quiet littoral zone some distance from the shore, where the water is deeper and there is less vegetation.

The differences in the molluscan assemblages of the four localities shown in the table below are obviously due to the differences in habitat conditions represented. In most cases a drifted assemblage contains a greater number of varieties, because it is gathered from various parts of a water body. Accordingly, 6 out of 14 species, or nearly 43 percent from the Kootenai formation mentioned above, were not found in the other three localities. On the other hand the differences in the list of forms contained in the Cloverly formation at the two localities seems to be partly due to difference in the habitat conditions represented. The congeneric forms of the two are closely related and difficulty in establishing specific identification is in part due to imperfect preservation. Allowance must be made for that factor. However, it seems significant that the Peterson limestone contains 3 out of 11 species, or about 27 percent, which have not been found in the other three beds. *Reesidella? lanistoides* has been found only in the Peterson limestone, and *Mesocochliopa cretacea* and *Zaptychius* cf. *Z. cylindricus* are closely related to species of the Morrison formation (Late Jurassic). Such differences may well indicate a difference in age.

The faunal similarities revealed by the table below suggest that part of the Peterson limestone may be older and part contemporaneous with the Cloverly formation, and that part of the Cloverly formation may be contemporaneous and part slightly older than the Kootenai formation in Montana.

Mollusca in Lower Cretaceous deposits at four localities
[x indicates identical forms; r indicates related forms]

	Kootenai formation near Harlowton	Cloverly formation in Sage Dome	Cloverly formation near Jackson Hole	Peterson limestone near Cokeville
Protelliptio douglassi	x	x	r	r
Sulcatapex cretaceus		x		
Unio farri	x	x		r
natosini	x			
Eupera onestae	x	x	r	
Mesoneritina nebrascensis	x	x		r
Campeloma harlowtonensis	x		r	r
Lioplacodes cretaceus		x		
convexiculus		x		
Rubeyella carinata				x
Protamnicola naticoides		x		
Charydrobia cretacea		x		
Mesocochliopa cretacea			x	x
Stantonogyra silberlingi	x	x	r	
Reesidella montanaensis	x		x	r
Reesidella? lanistoides				x
Circamelania ortmanni	x			
Zaptychius tetonensis			x	
cylindricus		r	x	r
Mesochilina cretacea	x			
Physa cf. P. walcotti		x	x	
montanensis	x			
sp. undet. A	x			
sp. undet. B				x
Aplexa sp. undet			x	
Gyraulus cf. *G. veternus*	x	r	x	r
Carinulorbis sp. undet	x			
Lymnaea sagensis		x		
cretacea			x	

SYSTEMATIC DESCRIPTIONS

Class PELECYPODA

Family UNIONIDAE

Protelliptio douglassi (Stanton)

Plate 1, figure 1

Unio douglassi Stanton Am. Philos. Soc., Proc., vol. 42, p. 195, pl. 4, fig. 3, 4, 1903.

This species and its varieties are commonly found in the Lower Cretaceous of Montana, Wyoming, and Nevada. Commonly it is found in association with *Unio farri* Stanton, *Eupera onestae* (McLearn) and a number of gastropods, as shown on the accompanying table.

It is characterized by its ovately oblong outline of shell, moderate convexity of both valves, and markedly distinct concentric ribs on the umbonal region. The number and degree of development of these concentric ribs seem to be varied, but the biological or stratigraphic significance of such variation is unknown.

Figured specimen: U. S. Nat. Mus. 106606.

Sulcatapex cretaceus Yen

Sulcatapex cretaceus Yen, Acad. Nat. Sci. Philadelphia Notulae naturae, no. 166, p. 6, figs. 2, 2a–c, 1946.

This species is known only from the Cloverly formation at the south end of the Sage Creek dome, Fremont County, Wyoming. Specimens representing another species of the genus have been found in Lower Cretaceous beds exposed north of Pryor, Montana.

Unio farri Stanton

Unio farri Stanton, Am. Philos. Soc. Proc., vol. 42, p. 194, pl. 4, fig. 1, 2, 1903.

This species has generally been found with *Protelliptio douglassi* (Stanton), but it is easily distinguished by its subovate outline, smaller size, and lack of concentric ribs on its umbonal area.

Unio natosini McLearn

Plate 1, figure 2

Unio natosini McLearn, Nat. Mus. Canada Bull. 58, p. 73, pl. 13, fig. 7–9, 1929.

The illustrated specimen was found in the Kootenai formation, about 12 miles southeast of Harlowton. The species has also been found north of Pryor, Montana, but it seems to be less abundant than *P. douglassi.*

The species was described on immature and imperfectly preserved specimens. The illustrated specimen is about 71 mm. long and 40 mm. high. One of the examples in the type lot was given by McLearn as "length 50 mm., height 35 mm."

Figured specimen: U.S.N.M. 106772.

Family SPHAERIIDAE

Eupera onestae (McLearn)

Corbula? onestae McLearn, Nat. Mus. Canada Bull. 58, p. 75, pl. 14, fig. 1–4, 1929.

Eupera onestae, Yen, Acad. Nat. Sci. Philadelphia Notulae Naturae, no. 166, p. 7, fig. 4a–f, 1946.

This species is abundant in most of the Lower Cretaceous beds in Montana and Wyoming. It is generally found in association with *Protelliptio douglassi, Unio farri,* and *Campeloma harlowtonensis,* possibly preferring to live on muddy bottom.

Class GASTROPODA

Family NERITIDAE

Mesoneritina nebrascensis (Meek and Hayden)

Plate 1, figure 3

Mesoneritina nebrascensis Yen, Acad. Nat. Sci. Philadelphia Notulae Naturae, no. 166, p. 9, fig. 5, 1946.

The specimen figured here is somewhat compressed by distortion and it appears to be more elongated in outline than is normal but it agrees well with the species, originally described from the "head of Wind River," Wyo.

The species has been recorded from Lower Cretaceous beds at several localities. Several almost perfectly preserved specimens were collected southeast of Dillon, Montana.

Figured specimen: U.S.N.M. 106607.

Family VIVIPARIDAE

Campeloma harlowtonensis Stanton

Plate 1, figure 4

Campeloma harlowtonensis Stanton, Am. Philos. Soc. Proc. 42, p. 196, pl. 4, fig. 11, 12, 1903.

This is a well-characterized species of *Campeloma.* The specimen figured here is in a collection made by Dr. Stanton from the type locality. The apex and outer lip are restored in the illustration.

This species, or a closely related form, has been recorded at various horizons of the Lower Cretaceous. It differs from *Campeloma macrospira* Meek, from the Bear River formation of Upper Cretaceous age, by its larger size in about same number of whorls, broader outline of shell, and less convex whorls.

Figured specimen: U.S.N.M. 30158.

Lioplacodes cretaceus (Stanton)

Lioplacodes cretaceus (Stanton). Yen, Acad. Nat. Sci. Philadelphia Notulae Naturae, no. 166, p. 11, fig. 10, 1946.

This species is more abundant in the "Gastropod limestone" of southwestern Montana, occupying a higher stratigraphic position than in the Kootenai formation exposed near Harlowton.

Lioplacodes convexiculus Yen

Lioplacodes convexiculus Yen, Acad. Nat. Sci. Philadelphia Notulae Naturae, no. 166, p. 11, fig. 9, 9b, 1946.

This species occurs more commonly in the "Gastropod limestone." It was also found at a locality southeast of Dillon, Montana that has yielded a molluscan fauna very similar to that of the Kootenai formation near Harlowton.

Rubeyella Yen, n. gen.

Shell imperforate or narrowly perforate, melanoid in outline, having a turritid spire and somewhat dilated body whorl. Whorls rapidly increasing in size, strongly convex and carinated along the periphery. Aperture angulately ovate in outline, peristomal margin thin, more or less continuous, and parietal wall well defined.

Genotype: *Rubeyella carinata* Yen

The genus superficially resembles *Cassiopella* White, but it differs distinctly by the absence of a well exposed and deep umbilicus and by its less turritid outline. It resembles *Lioplacodes* Meek and Hayden more closely, but is readily distinguished from that genus in its strong primary and secondary carinae and its adnate aperture.

Rubeyella carinata Yen, n. sp.

Plate 1, figure 5

Shell imperforate, broadly melanoid in outline, having a highly turritid spire and obliquely dilated body whorl. Whorls increasing in size, coiling below the periphery and strongly convex; surface with a strong peripheral carina traceable to early whorls and occasionally with secondary carinae on the later and body whorls. Aperture adnate, angulately subovate in outline; peristomal margin thin and continuous, angulated on outer lip; parietal wall thin and well defined; columellar margin short and more or less appressed on basal part of body whorl.

Measurements of holotype: 20.0 mm. in altitude of shell, 10.0 mm. in width; 9.0 in height of aperture, 6.4 in width; 6⅛ whorls.

The holotype and a number of free specimens were obtained at a locality about 13 miles south of Dillon, in the west branch of Small Horn Canyon, Montana, together with a number of other species that are in common with the Kootenai formation near Harlowton, Montana. The species also occurs in the Peterson limestone, in which, however, the shells are preserved as replacements of crystalline calcite in a hard, impure limestone matrix and are not extractable.

Holotype: U.S.N.M. 106608; paratypes: U.S.N.M. 106609.

Family AMNICOLIDAE

Protamnicola naticoides Yen

Protamnicola naticoides Yen, Acad. Nat. Sci. Philadelphia Notulae Naturae, no. 166, p. 9, fig. 6, 1946.

This species is characterized by its almost globose outline, well-thickened inner lip, and gibbous body whorl. The height of spire is somewhat varied, but the spire is never much elevated.

Charydrobia cretacea Yen

Charydrobia cretacea Yen, Acad. Nat. Sci. Philadelphia Notulae Naturae, no. 166, p. 10, fig. 8, 1946.

This species is characterized by its ovately oblong outline of shell, tapering toward the apex, gently or scarcely convex whorls, and obtusely angulated periphery of the body whorl.

Wenz considered *Charydrobia* Stache a synonym of *Pseudamnicola* Paulucci but it sems desirable to retain this genus to include the more or less elongated species of rissoid gastropods that existed during Cretaceous time.

Mesocochliopa cretacea Yen, n. sp.

Plate 1, figures 6a–c

Shell subglobose in outline, having an elevated spire and dilated body whorl. Whorls about 5, increasing moderately rapidly in size; surface shouldered and very convex. Suture well impressed. Aperture descending, ovate in outline; outer lip and parietal margin thin; columellar lip bearing a distinct plica, the plica lying horizontally near the upper extremity of the columella. Umbilicus well exposed, deep, about ⅓ of the diameter of the shell.

Measurements of holotype: 2.3 mm. in altitude of shell; 2.1 mm. in width; 1.2 mm. in height of aperture, 0.9 mm. in width; diameter of umbilicus 0.76; about 5 whorls.

This species has been found both in the Cloverly formation and in the Peterson limestone. The type lot was collected from NW¼SW¼ sec. 13, T. 40 N., R. 111 W., Teton County, Wyoming.

The species is well differentiated from *Mesocochliopa assiminoides* Yen and Reeside (1946) by the more globose outline of the shell, shouldered whorls, and wider umbilicus.

The genus *Mesocochliopa* was described on the basis of three specimens collected from the Morrison formation exposed near Lower Green River Lake, Wyoming. The aperture of the genotype is not well preserved and the internal tooth is hardly traceable. As the Lower Cretaceous species is characterized by a distinct tooth

at the columellar margin, the generic description should be revised to include the internal plicae or lamellae as a morphological character of the genus.

Holotype: U.S.N.M. 106610; paratypes: U.S.N.M. 106611.

Stantonogyra silberlingi (Stanton)

Stantonogyra silberlingi Yen, Acad. Nat. Sci. Philadelphia Notulae Naturae, no. 166, p. 10, fig. 7, 1946.

This species is rare in the Kootenai formation near Harlowton, Montana (type locality), but it is rather common in the Cloverly formation near Sage Creek dome, Wyoming. This is the only 1 of the 6 species described by Dr. Stanton from the type locality that are not represented in more recent collections from the same bed.

Reesidella Yen, new genus

Shell imperforate, subovate to globose in outline, rather stout, large among commonly known rissoid snails. It has a more or less elevated spire and ventricose body whorl. Whorls rapidly increasing in size, distinctly shouldered, and very convex on surface. Aperture pyriform in outline, peristome continuous and well thickened, outer lip expanding and slightly reflected, parietal wall appressed to the preceding whorl. Columellar margin short and slightly oblique. Operculum pyriform in outline, thick and of calcareous substance; whorls concentric on the external side, and spiral in the young stages and concentric in the more mature stages on the inner side; nucleus subcentral and close to the inner margin.

The new genus has an operculum similar to that of *Bulimus* Scopoli (=*Bithynia* Leach), but it differs by its pyriform outline and fewer concentric whorls on the external side. The shell differs by its larger size, distinct shoulder of the whorls, and expanding outer lip margin. Superficially it resembles the rissoid genera *Somatopyrus* Gill and *Fluminicola* Stimpson, but differs from both in opercular and in shell features. The shell outline closely resembles that of *Parabithynia* Pilsbry (for example *P. humerosa* v. Martens), operculum differs markedly.

This genus resembles in some degree *Turbinicola* Ammandale and Prashad, of the Ampullariidae, but it differs by its smaller imperforate shell, and by the broader outline of the operculum with fewer concentric whorls on the external side.

The known morphological features of shell and operculum, the new genus seems to be more closely related to genera of the Amnicolidae rather than for the Viviparidae and Ampullariidae.

Amnicola gilloides Yen and Reeside, *Ampullaria? powelli* Walcott, and similar species should be included in this genus, as they bear precisely the same type of operculum and in some shell features resemble *R. montanaensis*.

Reesidella montanaensis (Stanton)

Plate 1, figures 7a–f

Viviparus montanaensis Stanton, Am. Philos. Soc. Proc., vol. 42, p. 195, pl. 4, fig. 5, 1903.

This species is abundant in the Kootenai formation 12 miles southeast of Harlowton, and occurs in the Cloverly formation and the Peterson limestone in Montana and Wyoming.

Some of the well-preserved specimens distinctly show two colored bands on the body whorl, and a few specimens have their opercula preserved in natural position.

Figured specimens: U.S.N.M. 106612, 106613.

Reesidella? lanistoides Yen, n. sp.

Plate 1, figure 8

Shell sinistral, median in size, with elevated spire and laterally dilated body whorl. Whorls 4 to 5, moderately rapidly increasing in size, having the surface roundly convex and slightly shouldered. Aperture descending, ovate in outline; peristome more or less continuous.

Measurements of the holotype: 12.0 mm. in altitude of shell, 9.0 mm. in height; 7.0 mm. in height of aperture, 5.0 mm. in width.

The type lot contains 6 specimens, collected in the Peterson limestone at the center of NE¼ sec. 8, T. 29 N., R. 118 W., Lincoln County, Wyoming. The species has also been found in the lower part of the Peterson limestone on both sides of Lander-Cutoff road in SW¼ sec. 15, T. 29 N., R. 118 W., Lincoln County, Wyoming.

The poorly preserved specimens in the type lot reveal only a general outline of the shell and the shape of aperture in cross-section. However, these features seem to be characteristic enough to indicate a distinct species. It is provisionally assigned to *Reesidella* because the outline of the shell is similar in reverse to that of *R. montanaensis*. The calcite replacement of the shell in hard limestone matrix makes it impossible to separate them. No free specimen has been obtained, and definite settlement of the generic status must be deferred until better preserved specimens are available.

Holotype: U.S.N.M. 106614; paratypes: U.S.N.M. 106615.

Family PLEUROCERATIDAE

Circamelania Yen, new genus

Shell narrowly perforate or imperforate, moderate in size; a few gently or strongly convex whorls, with sculptured or smooth surface and well-impressed suture. Aperture subovate in outline; peristome continuous, more or less thickened, and slightly notched on basal margin.

Genotype: *Goniobasis? ortmanni* Stanton.

Circamelania differs from *Goniobasis* by its more roundly convex whorls, deeply impressed suture, and especially by the well-thickened peristomal margin. The apertural features and smaller number of whorls also differentiate this Lower Cretaceous genus from other *Pleurocera*-like genera, to which *Circamelania* may be an ancestral group.

Circamelania ortmanni (Stanton)

Plate 1, figures 9a–c

Goniobasis? ortmanni Stanton, Am. Phil. Soc. Proc., vol. 42, p. 197, pl. 4, fig. 7–10, 1903.

This species is so far known only from the Kootenai formation near Harlowton, Mont., but it is very abundant there and numerous free specimens may be obtained. As Dr. Stanton has already remarked, the species includes both smooth and sculptured forms, as does the living species, *Goniobasis virginica* Gmelin.

Figured specimens: U.S.N.M. 106616.

Family ELLOBIIDAE

Zaptychius tetonensis Yen, n. sp.

Plate 1, figures 10a, b

Shell imperforate, narrowly oblong in outline, having a high spire and a rather compressed body whorl. Whorls scarcely convex and slightly shouldered below the upper suture, increasing rapidly in size. The surface bears sharp-margined, lamella-like ribs with fine but distinct rib lines on their interspaces. Aperture narrowly elongate in outline, descending, slightly produced at the base, peristome continuous, outer lip margin thin and reflected, inner lip thin and bearing two well-developed, oblique plicae near the upper extremity of the columellar margin.

A score of specimens contained in the type lot was collected from a bed in the Cloverly formation exposed in the NW¼SW¼ sec. 13, T. 40 N., R. 111 W., Teton County, Wyo. Most specimens are broken but each has the last 3 to 4 whorls preserved and they have sufficient characteristic features to distinguish the species. It resembles closely *Zaptychius carbonaria* Walcott, from the Lower Cretaceous near Eureka, Nev., but it differs by having conspicuous lamella-like ribs on the less convex whorls, and it is much smaller. It differs from *Tortacella haldemani* White, from the early Upper Cretaceous near Cokeville, Wyo., by its larger size, expanding peristomal margin and the presence of well developed lamella-like ribs on the whorls.

After examining the available specimens, it seems certain that *Tortacella* White, 1895, is a synonym of *Zaptychius* Walcott, 1883. The genus may be closely related to *Pleurolimnaea* Meek, 1866, which was described from early Tertiary beds in Montana.

Holotype: U.S.N.M. 106617; paratypes: U.S.N.M. 106618.

Zaptychius cylindricus Yen, n. sp.

Plate 1, figure 11

Shell slender and cylindrical, having a high spire and a compressed body whorl. Whorls are slightly convex and increasing rapidly in size; the surface bears fine but distinct rib lines extending from suture to suture. Aperture narrowly oblong, wider towards the base; peristome continuous, simple, and thin, slightly produced at the basal margin, and more or less twisted at the columella.

The holotype measures 4.0 mm. in altitude of shell, 1.0 mm. in width; 1.5 mm. in height of aperture, 0.8 mm. in width; 5 whorls.

Numerous specimens in the type lot were found in the same bed as *Zaptychius tetonensis* n. sp., but *Z. cylindricus* n. sp. is much smaller, and lacks the lamella-like ribs and columellar plicae.

Holotype: U.S.N.M. 106619; paratypes: U.S.N.M. 106620.

Mesochilina Yen, new genus

Shell small, imperforate, more or less ovate in outline, having a moderately-elevated spire and somewhat dilated body whorl. Whorls increase in size, are slightly convex, and bear costulate lines of growth and incised spiral sculpture. Aperture ovately oblong; peristome more or less continuous, slightly produced at the base; parietal wall well defined, columella short and bears an oblique plica-like fold.

Genotype: *Mesochilina cretacea*, n. sp.

The new genus resembles *Chilina* Gray, of which about 30 species have been described from the Recent fauna in Argentina, Chile, and Brazil. It differs from this living genus by its much smaller size, its axial fold or plica, and its distinct sculpture of axial ribs and spiral lines.

Mesochilina cretacea Yen, n. sp.

Plate 1, figure 12

Shell subovate in outline, having a conically elevated spire and narrowly dilated body whorl, the former about same in height as the latter. Whorls increasing moderately rapidly in size, gently convex and bearing close, costulate lines of growth, and sparse but incised lines of spiral. Aperture narrowly ovate in outline, peristome continuous and bearing an oblique columellar fold or plica.

Holotype measures 3.0 mm. in altitude of shell, 1.6 mm. in width; 1.4 mm. in height of aperture, 1.1 mm. in width; about 4 whorls.

The type lot was collected in the Kootenai formation 12 miles southeast of Harlowton, Mont.

Holotype: U.S.N.M. 106621; paratype: U.S.N.M. 106622.

Family PHYSIDAE

Physa cf. P. walcotti Yen and Reeside

Physa prisca Walcott, Science, vol. 2, p. 808, 1883 (non Noulet 1854).

Physa walcotti Yen and Reeside, Jour. Paleontology, vol. 20, p. 57, fig. 10, 1946; Yen, Acad. Nat. Sci. Philadelphia Notulae Naturae, no. 166, p. 13, fig. 13, 1946.

Several imperfectly preserved specimens from the Cloverly formation in NW¼SW¼ sec. 13, T. 40 N., R. 111 W., Teton County, Wyo., resemble closely the form recorded from the Cloverly at the Sage Creek dome, Wyoming. Specimens from both localities resemble *P. walcotti* from the Lower Cretaceous of the Eureka, Nev., area, but are smaller and have a lower spire. They may represent a young stage of the species.

Physa montanensis Yen, n. sp.

Plate 1, figure 13

Shell large, ovately globose in outline, with an elevated spire and inflated body whorl; the spire is slightly smaller than the body whorl. Whorls roundly convex, slightly shouldered, and rapidly increasing in size. Aperture subovate in outline and slightly twisted at columella.

The holotype measures 22.5 mm. in altitude of shell, 14.0 mm. in width; 15.2 in height of aperture, 7.2 in width. Last 4 whorls preserved by apical part broken.

This species is characterized by its ovately globose outline, rather prominent spire, large size of shell, and rather narrow aperture. It resembles some Tertiary species of the genus, such as *Physa bridgerensis* Meek, but it is smaller, narrower in lateral outline, has a prominent spire and a less inflated body whorl.

The holotype and paratype were collected in the Kootenai formation from the same bed near Harlowton, Mont., but they were obtained in different collections.

Holotype: U.S.N.M. 106773; paratype: U.S.N.M. 106623.

Physa sp. undet. A

Plate 1, figure 14

Two imperfectly preserved examples were collected from the Kootenai formation near Harlowton, Mont., that appear to be of small size with an exerted spire. They are decidedly different from *Physa montanensis* in their much smaller size and higher spire. The figured specimen measures 6. 8 mm. in altitude of shell, 4.0 mm. in width, and has about 4½ whorls.

Figured specimen: U.S.N.M. 106624.

Physa sp. undet. B

A single specimen was found in the Peterson limestone at the center of NE¼ sec. 8, T. 29 N., R. 118 W., Lincoln County, Wyo. It differs from the preceding form by having a much lower spire and a rather dilated body whorl. The specimen is too poor to describe.

Aplexa sp. undet.

Several specimens were collected from the Cloverly formation in the NW¼SW¼ sec. 13, T. 40 N., R. 111 W., Teton County, Wyo., but none of them is well preserved. In slender outline of shell, high spire, and nearly flat surface of the whorls, this species seems to belong to the genus *Aplexa*, but the specimens are too poor to permit a full description or specific identification.

Family PLANORBIDAE

Gyraulus cf. G. veternus (Meek and Hayden)

Plate 1, figure 15a–c

A score of poorly preserved undeterminable specimens were collected from the Kootenai formation 12 miles southeast of Harlowton, Mont. Related forms have been found in the Cloverly formation in Wyoming and the Peterson limestone near Cokeville, Wyo. It differs from *Gyraulus veternus* (which was described from the Morrison formation) by its smaller size of shell.

Figured specimen: U.S.N.M. 106625.

Carinulorbis sp. undet.

Plate 1, figure 16a–c

One specimen belonging to this genus found in the Kootenai formation 12 miles southeast of Harlowton, Mont. It resembles in outline of shell *Carinulorbis planospiralis* (Yen), from the Fort Union beds (Paleocene) in Montana and Wyoming, but it differs by its much smaller size and slightly sunken spire. Better specimens are needed to establish its specific status.

Figured specimen: U.S.N.M. 106626.

Family LYMNAEIDAE

Lymnaea sagensis Yen

Lymnaea sagensis Yen, Acad. Nat. Sci. Philadelphia Notulae Naturae, no. 166, p. 12, fig. 12, 1946.

This species has been so far recorded only from the type locality, namely in the Cloverly formation near the Sage Creek dome, Wyoming.

Lymnaea cretacea Yen, n. sp.

Plate 1, figure 17

Shell, small, narrowly umbilicated, ovately oblong in outline, having an elevated spire and descending body whorl. The height of spire is about same as the height of the last whorl. Whorls gently convex, rapidly increasing in size and obtusely shouldered. The surface bears distinct but fine, close growth lines. Aperture ovate in outline, slightly oblique and reflected.

The holotype measures 3.3 mm. in altitude of shell, 1.6 mm. in width; 1.7 mm. in height of aperture, 1.0 in width; about 4½ whorls.

The species is characterized by its ovately oblong outline of shell, narrowly inflated and descending body whorl, and sculpture of growth lines. The type lot was

collected from the Cloverly formation in the NW¼SW¼ sec. 13, T. 40 N., R. 111 W., Teton County, Wyo.

Holotype: U.S.N.M. 106627; paratypes: U.S.N.M. 106628.

BIBLIOGRAPHY

MACNEIL, F. STEARNS, 1939, Freshwater invertebrates and land plants of Cretaceous age from Eureka, Nev.: Jour. Paleontology, vol. 13, pp. 355–360, 1 pl.

MANSFIELD, G. R., 1927, Geography, geology, and mineral resources of part of southeastern Idaho: U. S. Geol. Survey Prof. Paper 152.

MCLEARN, F. H., 1929, Cretaceous invertebrates, in Mesozoic paleontology of Blairmore region, Alberta: Nat. Mus. Canada Bull. 58, pp. 73–79, 7 pls.

PILSBRY, H. A., 1928, *Parabithynia* for *Paranerita* Ammandale 1920: Nautilus, vol. 41, p. 108.

STANTON, T. W., 1899, Mesozoic fossils of the Yellowstone National Park: U. S. Geol. Survey Mon. 32, pt. 2, pp. 600–650.

———, 1903, A new freshwater molluscan faunule from the Cretaceous of Montana: Am. Philos. Soc. Proc., vol. 42, pp. 188–199, 1 pl.

THIELE, Johannes, 1929–31, Handbuch der systematischen Weichtierkunde, Teil I–II.

WALCOTT, C. D., 1884, Paleontology of the Eureka district: U. S. Geol. Survey Mon. 8.

WHITE, C. A., 1877, Paleontological Papers, No. 2, Descriptions of new species of Unios and a new genus of freshwater gastropoda from the Tertiary strata of Wyoming and Utah: U. S. Geol. Geog. Survey Terr. Bull. 3, pp. 603–606.

———, 1895, The Bear River formation and its characteristic fauna: U. S. Geol. Survey Bull. 128.

YEN, T. C., 1946, On Lower Cretaceous freshwater mollusks of Sage Creek, Wyo.: Acad. Nat. Sci. Philadelphia Notulae Naturae no. 166.

———, 1948, Paleocene freshwater mollusks from southern Montana: U. S. Geol. Survey Prof. Paper 214–C.

———, 1949, Review of the Lower Cretaceous freshwater molluscan faunas of North America: Jour. Paleontology, vol. 23, pp. 465–470.

———, 1949, A new name for *Carinorbis* Yen: Jour. Paleontology, vol. 23, p. 573.

YEN, T. C., and REESIDE, J. B., Jr., 1946, Freshwater mollusks from the Morrison formation (Jurassic): Jour. Paleontology, vol. 20, pp. 52–58, 1 pl.

PART 2. AN UPPER CRETACEOUS NONMARINE MOLLUSCAN FAUNA FROM THE LEEDS CREEK AREA, LINCOLN COUNTY, WYOMING

ABSTRACT

This paper describes a nonmarine fauna from the lower part of a 6,000-foot unit formerly considered part of the Bear River formation. Sixteen species of gastropods are recognized. The new genus *Melampoides* and new species in *Parateinostoma, Parhydrobia, Goniobasis,* and *Anisopsis* are proposed. The fauna is interpreted to be a shallow- and still-water assemblage that characterizes the fresh-water extreme of a series of sediments deposited in waters ranging from fresh through brackish to marine.

INTRODUCTION

A nonmarine molluscan fauna was collected from a limestone bed exposed about two miles south of Antelope Creek, three miles south of Leeds Creek, and three-fourths of a mile east of U. S. Highway 30N, in sec. 17, T. 22 N., R. 119 W., Lincoln County, Wyoming. The fossil-bearing stratum is in the lower part of a 6,000-foot unit at present unnamed, but formerly considered part of the Bear River formation.

In studying the habitat conditions and age of the fossil zone, the closely related beds in the general area were examined in addition to those in the immediate vicinity of the present site. Eight exposures of fossil-bearing beds are discussed: six (in the area 2 miles south of Antelope Creek), I designate L1, L2, L3, L4, L5, and L6; one in the SE¼SE¼ sec. 5, T. 22 N., R. 119 W., near the Antelope Creek Coal mine, L7; one in the SE¼SW¼ sec. 25, T. 28 N., R. 119 W., L8 (probably the one referred to by White (1895) as "20 miles north of Cokeville"). The present paper is based primarily on specimens from L5. With the exception of those from bed L8, fossils included in the present paper are recorded for the first time.

The present paper results from one of the collections made on a field trip in 1949. My heartfelt thanks are extended to Mr. W. W. Rubey of U. S. Geological Survey for his personal guidance in the field. His unreserved cooperation and his many years of field experience made this season indeed a success. I am equally grateful to Mr. John B. Reeside, Jr., also of U. S. Geological Survey, for the benefit of his personal discussion from time to time, his helpful advice, and keen interest in the work. I also appreciate highly their kindness in reading the manuscript of this paper, making constructive criticisms and providing much useful information.

REVIEW OF PREVIOUS RECORDS

The best Upper Cretaceous nonmarine faunas in North America are those of the Bear River formation near the base of the series, those of the Fruitland, Judith River, and Belly River formations above the middle, and those of the Laramie and Lance formations at the top. Each is correlated with a marine sequence and each is characterized by a distinctive assemblage of molluscan species. Nonmarine forms have been reported from other horizons but are not well known. The Bear River species were described and recorded by Meek (1860; 1877) and White (1895); the Judith River species by Stanton and Hatcher (1905) and those of the Belly River chiefly by Whiteaves (1885); the Fruitland species by Stanton (1916); and the Lance species (= the Laramie, in the strict sense) chiefly by White (1877) and Whitfield (1903, 1907).

Comparable European nonmarine molluscan faunas from Upper Cretaceous strata were described for the Lignite beds in southern France by Matheron (1842), from the coal-bearing beds near Ajka in western Hungary by von Tausch (1886) and Oppenheim (1892), and from the St. Briz beds in southern Steiermark by von Tausch (1888) and Hoernes (1888).

There are few nonmarine molluscan species from North American beds contemporary with the deposit here described which is evidently younger than the Bear River and very much older than the Fruitland and the Judith River.

COMPOSITION OF THE FAUNAS

Bed L5.—This bed is 1 to 2 feet in thickness and consists of a limestone containing much silt. Most of the fossils are silicified but a few have been replaced by calcite. The gastropods occupy a dominant position in the fauna and the following species were found:

Family Valvatidae
- *Valvata praecursoris* (White)

Family Neritidae
- *Mesoneritina naticiformis* (White)
- *Mesoneritina stantoni* (White)

Family Viviparidae
- *Lioplacodes stachei* (White)

Family Amnicolidae
Parateinostoma altispirale, n. sp.
Parateinostoma convexum, n. sp.
Parateinostoma contractum, n. sp.
Parhydrobia cylindrica, n. sp.
Family Pleuroceritidae
Goniobasis leedsensis, n. sp.
Family Ellobiidae
Zaptychius cf. *Z. haldemani* (White)
Rhytophorus cf. *R. meeki* (White)
Melampoides clarki (White), n. gen.
Family Planorbidae
Anisopsis minuta, n. sp.
Family Physidae
Physa usitata (White)
Physa sp. undet.
Physa, sp. undet.

A few ostracodes and an abundance of stems and oogonia of *Chara*-like algae are associated with the gastropods.

The gastropod fauna is a rich and homogeneous one. Species of *Valvata*, *Lioplacodes*, *Parateinostoma*, *Goniobasis*, and *Physa* yield a large number of individuals, including many young, but specimens of *Anisopsis* are rare. The assemblage clearly indicates that the fossil-bearing bed represents the original habitat in which the fauna lived.

Species of *Valvata* are known to live generally at the bottom of rivers or lakes, especially where submerged plants grow and reed swamp borders the banks. They inhabit both muddy and stony bottoms, but they usually are most prolific when the bottom is covered with stones and gravel, coated with algae. *Lioplacodes*, presumably a viviparous genus, may have lived like *Viviparus*, and if so, may have lived on both stony and muddy bottoms. *Parateinostoma*, also an extinct genus, may have lived much as the *Amnicola*-like snails live, in sheltered places in aquatic vegetation. The *Physa*-like species of today prefer to live in dense growths of submerged plants along the shore. None of the members of the present assemblage appear to be rheophilous, although some of them may be able to endure exposure to some current. The assemblage is a lenitic, or still-water, society.

Chara-like algae generally grow today in protected shoals, ponds, and in the borders of lakes at depths below the heavy reach of strong wave action. They prefer waters that flow from calcareous soils and often attach to a stony bottom. An abundance of such algae offers a favorable environment to such gastropods as *Valvata*, *Parateinostoma*, *Zaptychius*, and *Physa*.

The present assemblage of organic remains indicates that the fossil-bearing bed L5 represents a shore deposit where the water was relatively shallow and still, with abundant aquatic vegetation, of high concentration in lime, in part muddy and in part somewhat sandy at the bottom.

Bed L4.—This bed lies approximately 100 feet above bed L5. The fossil content of bed L4 is exceedingly rich, almost rock-forming, but the fossils are very much distorted. Despite the poor state of preservation, the molluscan forms contained seem to indicate clearly that the bed was deposited in brackish water, perhaps approaching marine water in composition, and thus reveal a considerable change in habitat.

Bed L3.—A bed about 60 feet stratigraphically above bed L4 is of fresh-water origin and consists of impure limestone that contains silt and chert. It has a rich content of fossils, but they are only superficially silicified, and imbedded in the cherty matrix. The following gastropods were seen on the weathered surface:

Valvata cf. *V. praecursoris* (White)
Lioplacodes cf. *L. stachei* (White)
Parateinostoma sp. undet.
Hydrobia sp. undet.
Zaptychius sp. undet.
Anisopsis sp. undet.
Physa sp. undet.

Several species of *Sphaerium*- and *Pisidium*-like pelecypods, ostracodes, and oogonia of *Chara*-like algae are also found with the gastropods. Although fewer species are found in bed L3, the fauna is essentially like that of bed L5.

Bed L2.—This bed lies about 60 feet above bed L3, consists of silty limestone of fine texture. Poorly preserved calcified specimens on the weathered surface indicate a fauna essentially like that of bed L3:

Lioplacodes sp. undet.
Hydrobia sp. undet.
Zaptychius sp. undet.
Anisopsis sp. undet.
Physa sp. undet.

Bed L1.—A bed of silty limestone that lies about 10 feet above bed L2 is the uppermost unit considered here. It contains the following assemblage of molluscan genera in addition to minute, generically undeterminable gastropods, some ostracodes, and a few oogonia of *Chara*-like algae:

Unio sp. undet.
Unio sp. undet.
Lioplacodes sp. undet.
Micropyrgus? sp. undet.
Goniobasis? sp. undet.

Despite the poor preservation of the mollusks and their mode of occurrence the collection indicates clearly that the fauna is different from that of the beds below bed L1.

Bed L6.—Bed L6 is about 280 feet below bed L5 stratigraphically. It consists of dark argillaceous and calcareous shales, and contains a rich molluscan fauna that indicates a brackish-water origin for the deposit, perhaps tending toward fresh water. Several of the species in bed L6 are found also in bed L8.

In summary, the faunas of beds L6 to L1 indicate fluctuating habitat conditions at the times of deposition. Bed L6, at the botton, is of brackish-water origin, tending toward fresh water, and the large variety of forms indicates a large water body. Bed L5 is of fresh water origin—possibly the sea retreated from the area and the water was freshened by discharge from inland; the area was large and the average depth perhaps not much more than 10 feet.

The fossil content of bed L4 indicates a considerable change, from fresh-water to brackish-water habitat. Perhaps the advancing sea covered a large deltalike area, where such molluscan species as *Ostrea, Corbula, Glycymeris, Clarocerithium,* and *Cerithium*-like genera were accumulated, possibly by tidal action. The invasion was apparently short-lived, as there was relatively prompt return to fresh-water deposition in later beds.

When the sea retreated, the water was again freshened, and beds L2 and L3 contain faunas that resemble but are less varied than that of bed L5.

Bed L1 yields a somewhat different fauna, but still one of fresh-water origin. The differences may indicate that the deposit represents a sublittoral zone possibly over 20 feet in depth, where vegetation was scanty except for some algae. Today, species of *Unio* are generally important members of the fauna in such an environment as they prefer a muddy —and vegetation-free bottom.

Bed L7.—This bed of fine-grained, silty limestone lies approximately 2 miles north and 160 feet higher stratigraphically than bed L5. The molluscan fauna includes the following species:

Unio sp. undet.
Unio sp. undet.
Valvata cf. *V. praecursoris* (White)
Lioplacodes cf. *L. stachei* (White)
Lioplacodes sp. undet.
Parateinostoma sp. undet.
Hydrobia sp. undet.
"Pachymelania" cf. *"P." macilenta* (White)
Zaptychius cf. *Z. haldemani* (White)
Physa sp. undet.

This deposit seems to be well correlated with bed L1 or L2, and both beds seem to be close in time. The slight difference in assemblage of molluscan species may indicate a difference in habitat conditions. The occurrence of two species of *Unio,* which is absent in bed L5, may imply a comparative dearth of vegetation, as the unionids generally prefer muddy bottoms more or less free of vegetation. The reduction in species of pulmonates may also indicate lesser growth of emergent plants. On the other hand, an increase of prosobranchian elements in proportion generally implies deeper water more favorable to these gastropods.

Bed L8.—This bed is exposed 35 miles north of bed L5 and, from uncertain correlations, about 1,000 feet lower stratigraphically. It is very richly fossiliferous, and consists of dark argillaceous and calcareous shales. The fauna includes the following molluscan species, mostly as silicified fossils:

Unio sp. undet.
Valvata praecursoris (White)
Mesoneritina naticiformis (White)
Viviparus sp. undet.
Campeloma sp. undet.
Lioplacodes cf. *L. stachei* (White)
Lioplacodes sp. undet.
Helicina sp. undet.
Parateinostoma latente (White)
"Pachymelania"? *macilenta* (White)
Mesocochliopa sp. undet.
"Tornatellina"? cf. *"T." isoclina* (White)
Pyrgulifera sp. undet. (young forms)
Zaptychius haldemani (White)
Anisopsis sp. undet.
Physa usitata (White)
Physa sp. undet.
Physa sp. undet. (low spired)

This fauna is essentially similar in ecological assemblage to that of bed L5, and this similarity implies that the living faunas were similar. *Valvata, Lioplacodes, Zaptychins,* and *Physa* are the dominant genera in the assemblage and yield many specimens including young shells. In addition to the molluscan species, some ostracodes and oogonia of *Chara*-like algae are also not uncommon in the bed.

Despite the similarity in ecological assemblage, the fauna of bed L8 differs considerably in composition of species from that of bed L5. Only six out of a total of 26 species are found in both beds, perhaps because of a difference in age that is dealt with below.

STRATIGRAPHIC POSITION AND AGE OF THE FOSSILIFEROUS BEDS

Bed L5 is in the lower part of a 6,000-foot sequence of Cretaceous rocks, the exact age of which is unknown. It is about 2,000 feet above the top of a zone containing a Bear River fauna and typified by the beds exposed 20 miles north of Cokeville, which includes bed L8. In

the strata above bed L5 lie four fossiliferous beds of brackish or fresh-water origin and below it lie several similar beds, which with the intervening deposits constitute a thickness of several hundred feet.

The nonmarine molluscan faunas contained in this series of limestones indicate that bed L5 is younger than bed L8 which in turn seems to be younger than the typical Bear River bed.

First, only six (less than one-fourth) of the molluscan species are present in both beds. If the two faunas lived in very similar environments, in areas only 35 miles apart, and at about the same time, they certainly should have more species of mollusks in common.

Second, species of *Pyrgulifera* are absent from the series of limestones in the Leeds Creek area, but they are found in the beds north of Cokeville and in the beds exposed in the NE¼ Sec. 9, T. 22 N., R. 119 W., about 1.6 miles north-northeast of L5 and 2,400 feet below it. Species of *Pyrgulifera* have been recorded in Europe from beds considered to be younger than the Cenomanian age commonly assigned to the Bear River and Aspen formations, but they have not been found in beds younger than the Aspen in North America.

Third, species of *Parateinostoma*, which have not been reported in earlier beds in North America but constitute one of the dominant groups in bed L5, have been described from coal-bearing beds near Ajka in western Hungary that are considered to be much younger than Cenomanian.

SYSTEMATIC DESCRIPTIONS

Family VALVATIDAE

Valvata praecursoris (White)

Plate 2, figures 1a–g

Planorbis praecursoris White, U. S. Geol. Survey Bull. 128, p. 46, pl. 6, figs. 4, 5, 6, 7, 1895.

This form was described as a species of *Planorbis* and in the subgenus *Gyraulus*. Indeed its planorboid outline resembles that of a *Planorbis*. However, the tubular form of the whorls, impressed suture, circular aperture with continuous peristome, and wide and deep umbilicus well characterize it as a species of *Valvata*.

It is abundant in the present collection, and specimens in the collection form a developmental series. Younger ones appear to be more flattened on the apical side and the increasing convexity of the later whorls produces a "very slightly concave" appearance of the apical whorls.

The specimens contained in the type lot were obtained from a locality "20 miles north of Cokeville." Three of them seem to be young specimens, and the fourth is a species of *Planorbis*. White's original description was apparently based on the specimens illustrated as his figures 4, 5, and 7, by which the present specimens are identified.

Figured specimen: U.S.N.M. 106774; additional specimens: U.S.N.M. 106775.

Family NERITIDAE

Mesoneritina naticiformis (White)

Plate 2, figure 2

Neritina naticiformis White, U. S. Geol. and Geog. Survey Terr. Bull., vol. 4, p. 7, 5, 1878; U. S. Geol. Survey Bull. 128, p. 49, pl. 6, figs. 10, 11, 12, 1895.

Only immature specimens represent this species in the present collection, but they are typical in their naticoid outline, strongly thickened but somewhat excavated columellar margin and roundly convex whorls.

Figured specimen: U.S.N.M. 106776; additional specimens: U.S.N.M. 106777.

Mesoneritina stantoni (White)

Plate 2, figure 3

Neritina stantoni White, U. S. Geol. Survey Bull. 128, p. 49, pl. 6, figs. 16, 17, 18, 1895.

Several young specimens represent the species in the present collection. It is well characterized by its single, conspicuous carina on the shoulder of the early whorls and on the body whorl.

Figured specimen: U.S.N.M. 106778; additional specimens U.S.N.M. 106779.

Family VIVIPARIDAE

Lioplacodes stachei (White)

Plate 2, figure 4a–g

Charydrobia stachei White, U. S. Geol. Survey Bull. 128, p. 58, pl. 10, fig. 7, 8, 9, 1895.

This species is abundant in the present collection. The width of the shell varies somewhat and specimens having a narrower outline may represent males. They closely resemble the typical specimens obtained at the locality about 20 miles north of Cokeville.

The younger specimens appear broader and somewhat globose. The early whorls increase gradually in size and the later ones increase more rapidly in height than in width, so that a more mature shell has a subfusiform outline.

Figured specimens: U.S.N.M. 106780; additional specimens: U.S.N.M. 106781.

Family AMNICOLIDAE

Parateinostoma altispirale Yen, n. sp.

Plate 2, figures 5a–d

Shell, minute, narrowly oblong in outline, imperforate or narrowly perforate, with a high spire tapering gradually towards the apex and an inflated body whorl, final

half of which bears a well-developed shoulder. Whorls gently convex, gradually increasing in size. Suture well impressed. Aperture subovate in outline; peristomal margin continuous, slightly thickened within; outer lip angulated, somewhat retreating above, expanding in lower part, basal margin produced and bearing a slightly developed notch; inner lip well defined, nearly straight at columella.

Measurements (in millimeters):

Altitude of shell	4.0
Width of shell	1.6
Height of aperture	1.2
Width of aperture	.6
Number of whorls	6½

The species differs from *Parateinostoma manum* (Tausch 1886, p. 11, pl. 1, figs. 44a–d), which was described from an Upper Cretaceous horizon (Danian, according to Wenz) near Ajka in western Hungary, by its broader outline of shell, more convex whorls, and inflated body whorl.

It resembles closely *Hydrobia occulta* White (1895, p. 57, pl. 10, fig. 12, 13), but differs by its longer shell, less convex whorls, and more expanded outer lip and basal margins.

It is highly probable that *Hydrobia occulta* White may prove to be a species of *Parateinostoma*.

Holotype: U.S.N.M. 106782; paratypes: U.S.N.M. 106783.

Parateinostoma convexum Yen, n. sp.

Plate 2, figure 6a–c

Shell, minute, ovately oblong in outline, narrowly perforate, with a high spire and a moderately inflated body whorl. The whorls are roundly convex, gradually increasing in size. Suture well impressed. Aperture subovate in outline; periostomal margin continuous and slightly thickened; outer lip more or less retreating at upper part and expanding below; inner lip well defined and slightly oblique.

Measurements (in millimeters):

Altitude of shell	3.0
Width of shell	1.5
Height of aperture	1.0
Width of aperture	.5
Number of whorls	5½

This species differs from the preceding one by its smaller size and broader outline, more convex whorls, and wider aperture. It is readily differentiated from younger shells of the preceding species by its expanding outer lip and thickened peristomal margin.

Holotype: U.S.N.M. 106784; paratypes: U.S.N.M. 106785.

Parateinostoma contractum Yen, n. sp.

Plate 2, figures 7a–c

Shell minute, subovate in outline, narrowly perforate, with a high spire and laterally dilated body whorl. Whorls roundly convex and gradually increasing in size. Suture well impressed. Aperture laterally descending, barely adnate, and subovate in outline. Peristomal margin continuous; outer-lip expanding, inner lip well defined and slightly oblique.

Measurements (in millimeters):

Altitude of shell	2.5
Width of shell	1.5
Width of shell	1.5
Height of aperture	1.0
Width of aperture	.5
Number of whorls	5

The species differs from *P. convexum* by its pupoid outline and smaller shell, more inflated body whorl and laterally descending aperture. It resembles *Bythinella latentis* White (1895, p. 58, pl. 10, fig. 10, 11), better referred to *Parateinostoma*, but differs by its expanding outer lip and more inflated body whorl.

This species is represented by more individuals in the present collection than either one of the preceding two congeneric species. These species seem to form a decidedly dominant group in this fossil assemblage and its stratigraphic value should be carefully considered.

Holotype: U.S.N.M. 106786; paratypes: U.S.N.M. 106787.

Pachydrobia cylindrica Yen, n. sp.

Plate 2, figures 8a–b

Shell minute, cylindrical, with a highly turrited spire and moderately dilated body whorl. Whorls increasing gradually in size, closely coiled, convex. Suture well impressed by convexity of the whorls. Aperture descending, subcircular in outline; peristomal margin thickened, inner lip well defined, columella margin short and free.

Measurements (in millimeters):

Altitude of shell	3.5+
Width of shell	1.1
Height of aperture	.5
Width of aperture	.5
Number of whorls	8+

The species is characterized by its minute, cylindrical shell, close coiling, and convex body whorl.

The generic assignment is provisional. *Pachydrobia* Cossmann was described from the Bartonian beds of France. It is a very interesting species, and no closely similar species been reported from an earlier bed on

either side of the Atlantic. Only two imperfectly preserved specimens have been found.

Holotype: U.S.N.M. 106788; paratypes: U.S.N.M. 106789.

Family Pleuroceratidae

Goniobasis leedsensis Yen, n. sp.

Plate 2, figures 9a–e

Shell narrowly oblong in outline, imperforate, with a highly turrited spire and dilated body whorl. Whorls gently convex, increasingly gradually in size and slightly constricted near the suture. Apex rising, the first four whorls apparently smooth and subsequent ones with axial ribs. These ribs are rather faint on the early stages but become stronger on the later whorls. A set of four to six strongly developed spirals appears on the base of the body whorl. Aperture pyriform in outline, descending in front; outerlip slightly retreating above and produced below; inner lip well defined and thickened so as to covering the umbilical area.

Measurements of two specimens (in millimeters):

Altitude of shell	10.0+	12.0+
Width of shell	4.0	4.5
Height of aperture	3.0	4.0
Width of aperture	2.2	2.5
Number of whorls	5+	5½+

This species is assigned for the present to this broadly conceived North American genus. It also resembles some forms of other *Melania*-like genera, such as *Melanoides* Olivier and *Hemisinus* Swainson, but does not agree well with any of them.

It is characterized by its narrowly oblong outline, gently convex whorls gradually increasing in size, well-developed riblets and well-thickened inner lip margin. It is distinctly different from any fossil species of *Goniobasis* recorded from the Cretaceous and Tertiary beds in the Western Interior of North America.

Holotype: U.S.N.M. 106790; paratypes: U.S.N.M. 106791.

Family ELLOBIIDAE

Zaptychius haldemani (White)

Plate 2, figures 10a–b

Acella haldemani White, U. S. Geol. and Geog. Survey Terr. Bull., vol. 4, p. 714, 1878.

Tortacella haldemani White, U. S. Geol. Survey Bull. 128, p. 44, pl. 5, figs. 8–12, 1895.

This species seems to be a common form in the collection, and the specimens agree well with the typical form, originally described from the Bear River formation. The genus lived from Upper Jurassic to Upper Cretaceous times. Species have been recorded from the Morrison formation, the Cloverly formation and the Peterson limestone, and from the present deposit.

Figured specimen: U.S.N.M. 106792; additional specimens: U.S.N.M. 106793.

Rhytophorus cf. R. meeki White

Plate 2, figure 11

Rhytophorus meekii White, in Powell, Rept. Geol. Uinta Mountains, p. 118, 1876; U. S. Geol. Survey Bull. 128, p. 43, pl. 5, fig. 6, 7, 1895.

Only one very imperfect specimen was found in the course of the present investigation. Its visible shell features agree with those of *Rhytophorus* but it may be specifically different from *R. meeki*, as the two folds in the columellar margin are distinctly stronger and the inner lip is much more thickened.

Figured specimen: U.S.N.M. 106794.

Melampoides Yen, n. gen.

Shell small and of thin substance, imperforate, subovate in outline. Apex prominent, erect; spire small in contrast with a large body whorl. Whorls few, early ones more or less closely coiled and gradually increasing in size, last one rapidly dilated and constituting over two-thirds of the entire shell. Aperture narrowly oblong, slightly notched at anterior end; outer lip simple and nearly straight, and inner lip more or less thickened and bearing columellar folds.

Genotype: *Melampus clarki* White.

The genus differs from *Melampus* Montfort by its much smaller size, thin shell substance, simple inside of the outer lip and the slight notch on the basal margin.

Melampoides clarki (White)

Plate 2, figure 12

Melampus clarki White, U. S. Geol. Survey Bull. 128, p. 42, fig. 2, 3, 1899.

Most of the specimens in the present collection are of immature shells, but they agree well with the described characteristics of this species. It is characterized by its small size, prominent apex, short spire of conical form, narrowly oblong aperture and plica-like folds on the columellar margin, two on the young and three on the adult shell.

Figured specimen: U.S.N.M. 106795; additional specimens: U.S.N.M. 106796.

Family PLANORBIDAE

Anisopsis minuta Yen, n. sp.

Plate 2, figure 13a–c

Shell, minute, planorbid in outline, somewhat concave on the apical view and nearly flat on the base. Whorls rapidly increasing in size, obtusely carinated on the shoulder and more distinctly angulated along the periphery of the body whorls. The rapid increase in

size and convexity of the body whorl produces a sunken aspect of the apical whorls. Aperture semilunate in outline, outer lip thin and biangulated.

Measurements (in millimeters):

Altitude of shell	1.5
Width of shell	.5
Height of aperture	--
Width of aperture	--
Number of whorls	3¼

The species resembles *Anisopsis calcula* (Sandberger) and *A. loryi* (Coquand) in outline of shell, but differs from both by having much smaller size and being nearly flat on the basal side of the shell.

Only three specimens were found, but the species is quite distinct in its minute size, lower apical whorls and bicarinated body whorl.

Holotype: U.S.N.M. 106797; paratypes: U.S.N.M. 106798.

Family PHYSIDAE

Physa usitata White

Plate 2, figure 14

Physa usitata White, U. S. Geol. Survey Bull. 128, p. 47, pl. 6, figs. 8, 9, 1895.

This species is represented only by immature shells in the present collection. These specimens are much smaller in size than the adult and have only about three whorls, which evidently represent the initial whorls of a mature shell.

The type specimen of *Physa usitata* measures 16.0 mm. in altitude of shell and 8.5 mm. in width and has about 7 whorls. The body whorl constitutes about two-thirds of the entire shell and has about six gradually increasing and closely coiling whorls on the spire (which is a little over 5 mm. in altitude).

Measurements:

Altitude of shell	5.5
Width of shell	4.0
Height of aperture	5.0
Width of aperture	2.2
Number of whorls	3

Figured specimen: U.S.N.M. 106799; additional specimens: U.S.N.M. 106800.

Physa sp. indet.

Plate 2, figure 15

One well-preserved specimen in the collection is minute ovate outline, and has about 3 whorls. It is probably an immature shell of an undescribed species, but the single specimen does not warrant description of a new species.

Figured specimen: U.S.N.M. 106801.

Physa, sp. undet.

Plate 2, figure 16

Three imperfectly preserved specimens in the collection are characterized by subglobose shell, very small spire and narrowly oblong aperture. The state of preservation does not permit a full description of a species, especially as none of the shells have the basal part of the aperture well preserved.

Figured specimen: U.S.N.M. 106802; additional specimens: U.S.N.M. 106803.

BIBLIOGRAPHY

HOERNES, R., 1888, Ein Beitrag zur Kenntnis der suedsteirischen Kohlen-Bildungen: Naturwiss. Ver. Steiermark Mitt., Jahrg. 1887, pp. 35–46.

MATHERON, PHILIPPE, 1842, Catalogue méthodique et descriptif des corps organisés fossiles du départment des Bouches-du-Rhone et lieux circonvoisins, Marseille.

MEEK, F. B., 1860, Descriptions of new fossil remains collected in Nebraska and Utah: Acad. Nat. Sci. Philadelphia Proc., vol. 12, pp. 308–315.

———, 1877, Paleontology: U. S. Geol. Explor. 40th Parallel, vol. 4, pt. 1, pp. 1–197, 17 pls.

OPPENHEIM, PAUL, 1892, Ueber einige Brackwasser- und Binnen-Mollusken aus der Kreide und dem Eocan Ungarns: Deutsche geol. Gesell. Zeitschr., vol. 44, pp. 697–818, pls. 31–36.

PRUVOST, PIERRE, 1942, Un bassin houiller paralique d'age cenomanien: Les lignites de Pont-Saint-Esprit: Soc. géol. France Bull., ser. 5, vol. 12, pp. 165–180, figs.

SANDBERGER, FRIDOLIN VON, 1870–1875, Die Land- und Suesswasser-Conchylien der Vorwelt, Wiesbaden.

STACHE, GUIDO, 1889, Die liburnische Stufe und deren Grenz-Horizonte: K. k. geol. Reichsanstalt Abh. vol. 13, pt. 1.

STANTON, T. W., 1892, The stratigraphic position of the Bear River formation: Am. Jour. Sci., 3d ser., vol. 43, pp. 98–115.

———, 1916, Non-marine Cretaceous invertebrates of the San Juan Basin: U. S. Geol. Survey Prof. Paper 98–R, pp. 309–326.

———, and HATCHER, J. B., 1905, Geology and paleontology of the Judith River beds: U. S. Geol. Survey Bull. 257.

TAUSCH, LEOPOLD VON, 1886, Ueber die Fauna nicht-marinen Ablagerungen der oberen Kreide des Csingerthales bei Ajka im Bakony: K. k. geol. Reischsanstalt Abh., vol. 12, pt. 1.

———, 1888, Ueber die Fossilien von St. Briz in Suedsteiermark: K. k. geol. Reichsanstalt Verh., Jahrg. 1888, pp. 192–195.

VEATCH, A. C., 1907, Geography and geology of a portion of southwestern Wyoming: U. S. Geol. Survey Prof. Paper 56.

WENZ, W., 1938–1944, Gastropoda: Handbuch der Palaeozoologie, vol. 6, pts. 1–7, Berlin.

———, 1941, *Angulorbis:* Arch. Molluskenkunde, vol. 73, p. 221.

WHITE, C. A., 1878, Descriptions of new species of invertebrate fossils from the Laramie group: U. S. Geol. and Geog. Survey Terr. Bull., vol. 4, Art. 28, pp. 707–719.

———, 1880, On the antiquity of certain subordinate types of freshwater and land mollusca: Am. Jour. Sci., 3d ser., vol. 20, pp. 44–49.

———, 1883, A review of non-marine fossil mollusca of North America: U. S. Geol. Survey Third Ann. Rept., pp. 403–550.

———, 1892, On the Bear River formation, a series of strata hitherto known as the Bear River Laramie: Am. Jour. Sci., 3d ser., vol. 43, pp. 91–97.

———, 1895, The Bear River formation and its characteristic fauna: U. S. Geol. Survey Bull. 128.

WHITEAVES, J. F., 1885, Report on the invertebrata of the Laramie and Cretaceous rocks of the vicinity of the Bow and Belly Rivers and adjacent localities in the North-West Territory: Canada Geol. and Nat. Hist. Survey, Contrib. Can. Palaeontology, vol. 1, no. 1.

WHITFIELD, R. P., 1903, Notice of six new species of Unios from the Laramie group: Am. Mus. Nat. History Bull., vol. 19, no. 15, pp. 483–487.

———, 1907, Remarks on and descriptions of new fossil Unionidae from the Laramie clays of Montana: Am. Mus. Nat. History Bull., vol. 28, no. 26, pp. 623–628.

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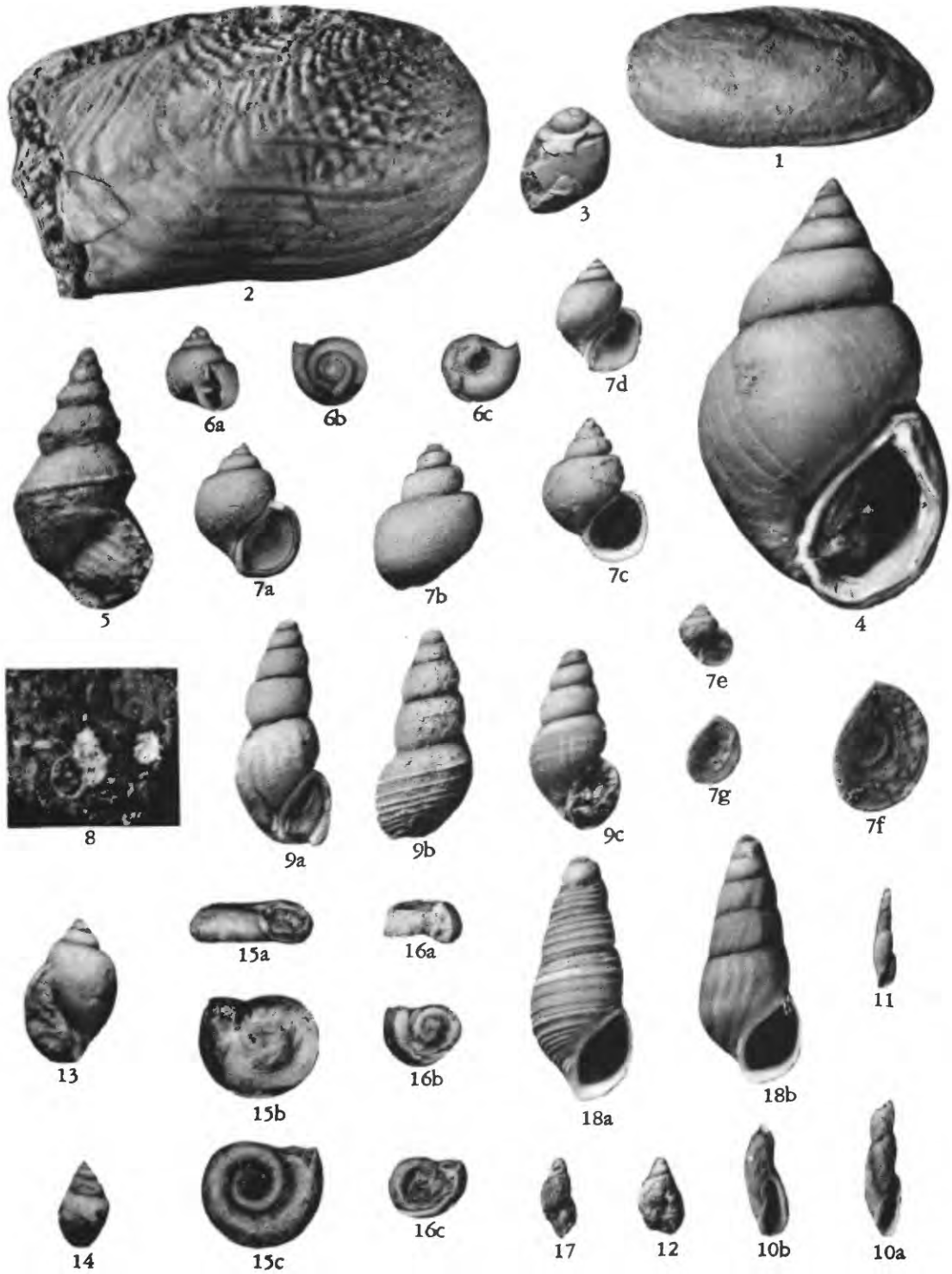

FOSSIL AND RECENT FRESH-WATER MOLLUSKS.

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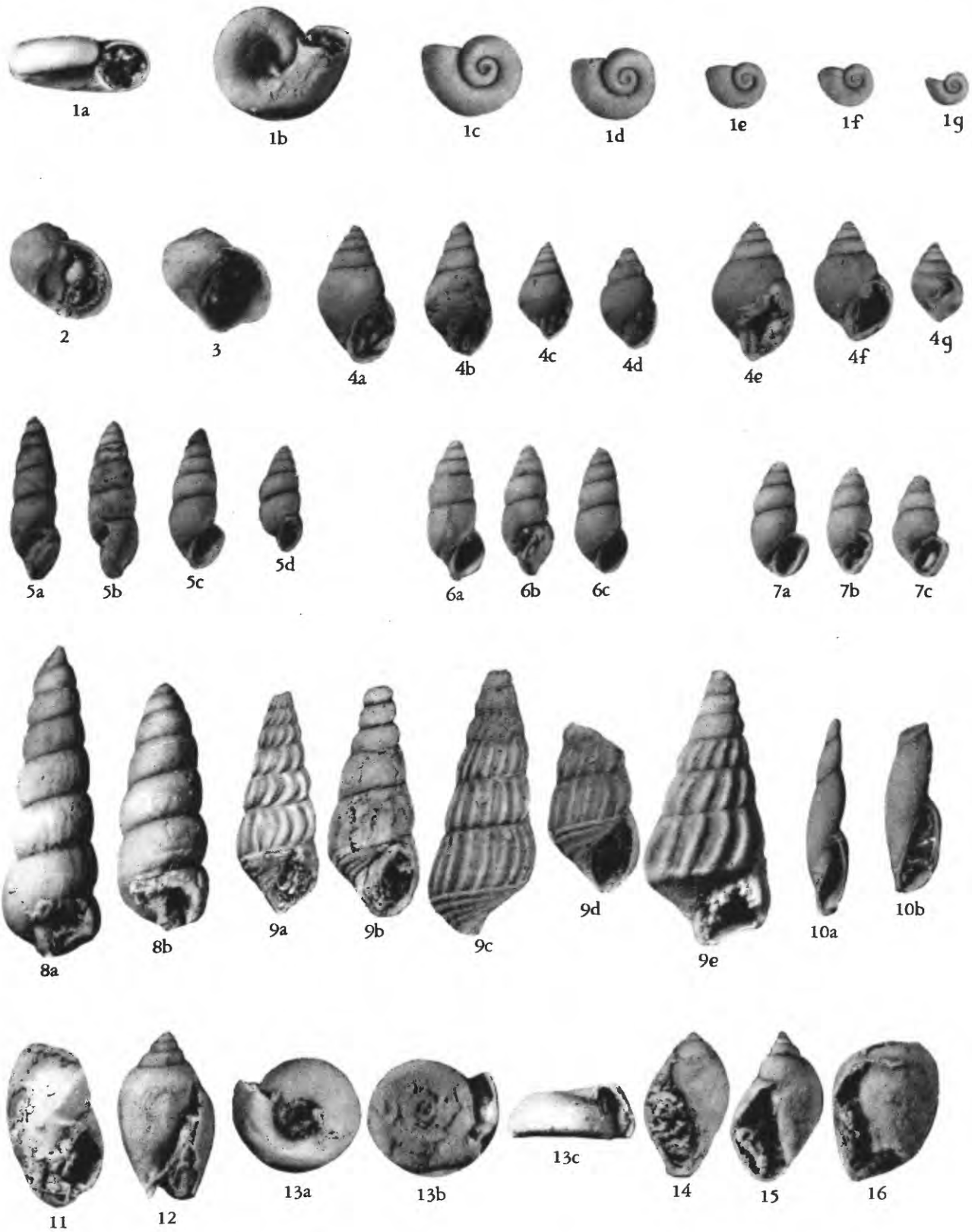

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