MALACOLOGIA , 1966, 4(1): 1-172

SUMMARY OF NORTH AMERICAN BLANCAN NONMARINE MOLLUSKS[1]

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ABSTRACT

All known North American nonmarine mollusks of Blancan (late Pliocene and early Pleistocene) age have been here fitted into the available framework of associated fossils, physical stratigraphy and radiogenic potassium-argon dates. Many of the independently dated molluscan assemblages are so similar to other faunas that most of the fossils summarized can be assigned confidently to the Blancan age. These assignments permitted compilation of lists of last appearances of genera and families that are unknown during or after Blancan times. About 50-55 Blancan assemblages are known, and together with about 10-15 older or younger faunas included for convenience of discussion they are summarized under 57 local geographic headings (map, Fig. 1).

For each local assemblage the following data have been given so far as possible: location, previous references to mollusks, stratigraphic unit and most recent geologic maps, number of species of mollusks, mention of other fossils from the same locality or formation, age, institution where fossils are preserved, and most recent topographic maps. The detail of treatment varies widely, according to available information, progress of knowledge since previous literature and the usefulness of new information. Lists of species are included usually only if the fauna is revised or first recorded in this paper, but the references to previous work are intended to be complete.

The Blancan faunas from the Great Plains region (Nebraska, Kansas, Oklahoma, Texas), and from Arizona, are generally similar and include mainly widespread living species. Blancan and post-Blancan molluscan change has been due mainly to the progressive extinction of relatively few species, and to changes in distribution of extant species caused by changes in local habitat and regional climate.

Blancan faunas from the western U. S. A. (California, Oregon, Idaho, Nevada, Utah, Wyoming) are substantially different from one another and from the living fauna. They include many extinct species and genera, and some families regionally extinct in North America that survive elsewhere, as well as some completely extinct families. Blancan molluscan change in the western U. S. A. was due to some local evolution, as well as termination of lineages. Post-Blancan change has been due mainly to drastic extinctions associated with draining or filling of lake basins, volcanism, changes in drainage patterns, widespread topographic changes and climatic change. In contrast to Blancan times, now scarcely any mollusks are restricted to a single lake basin; formerly local endemism was characteristic of most of the western faunas.

The living freshwater molluscan fauna east and west of the continental divide shows contrasts like that of the Blancan faunas. To the east are more widespread species, with no local endemic forms, but to the west local endemic species are

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[1]Publication authorized by the Director, U. S. Geological Survey.

widespread. The eastern limit of Recent local endemism in Utah and western Wyoming (map, Fig. 2) corresponds approximately to the eastern limit in the region of Blancan deposits (Fig. 1). This correlation, together with data from Blancan faunas, supports 2 propositions that apply to freshwater mollusks generally in North America and perhaps everywhere: (a) species of widespread habitats have relatively wide geographic and geologic distribution; (b) tectonic activity promotes taxonomic differentiation.

In western North America the differences between the Blancan faunas of local basins are so great that no clear pattern is evident in the present state of knowledge. The nearest approach to a regional pattern is the occurrence of common or closely related species in southern Idaho and in the San Joaquin Valley of California. This affinity is shown by Blancan and pre-Blancan species, and even by a few living forms. Presumably there was a former river connection between the 2 areas; if so, it was of early to middle Pliocene age, as that is the age of the oldest pertinent fossils and Blancan faunas are substantially different.

The geographic pattern of distribution to which the plurality of living west American freshwater mollusks are related is a crudely fishhook-shaped belt in and close to the northern and western edges of the Great Basin (Fig. 7). More Blancan fossils have affinities within this "fishhook" than within the Idaho-Californian pattern. Thus it seems that Blancan or immediately pre-Blancan events rearranged drainage and molluscan distribution to form this fishhook-like pattern, and that the modern fauna retains a marked stamp from those changes.

Supporting data include a list of all of the nominal species described from localities discussed in the text: included are all extinct species described from specimens of Blancan age, and a few older and younger ones. Data provided for each of 140 names include reference to original description, revised geographic and geologic location of type locality, location of type and synonymy. These species are listed in an outline of classification involving a number of changes in rank, generic assignment, and synonymy that are not explicitly discussed but have been listed in a section "Taxonomic changes". Only a few new taxa have been proposed, all in the gastropods. They include the Pliopholygidae, a new family (Viviparacea); *Calibasis, Oreobasis* and *Idabasis,* 3 new subgenera of *Juga* (Pleuroceridae); and *Savaginius,* a new genus (Hydrobiidae).

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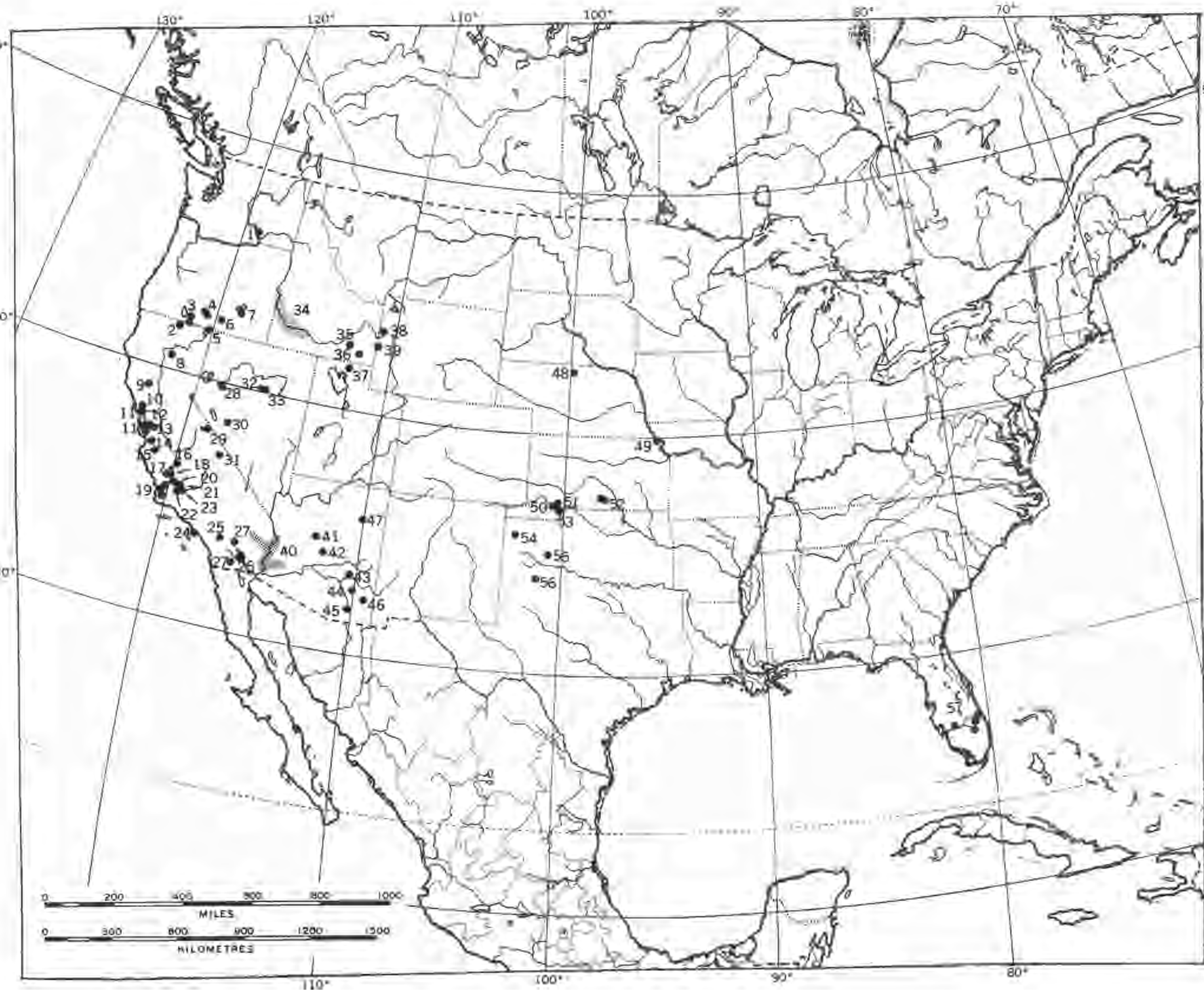

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INTRODUCTION

This summary of North American nonmarine mollusks of Blancan age (late Pliocene and early Pleistocene in current usage) is primarily a key to previous work. Critical review of the fossils would require several years even if no more material were collected, and no meaningful review of the faunas will be possible until such a review is substantially complete. I have tried to provide access to all published first-hand descriptions or records of Blancan nonmarine mollusks in North America, and recorded all the localities represented in collections of the U. S. Geological Survey. For convenience of discussion a few late Hemphillian assemblages have been included.

The map (Fig. 1) showing all these previously published or unpublished localities is a fair summary of present knowledge in spite of probable omissions. Stratigraphic names used in this report are compiled essentially from published literature and are not necessarily those used in U. S. Geological Survey puplications.

Summaries of the stratigraphic and geographic distribution of other groups of nonmarine organisms vary in completeness and recency, according to the intensity of study. Stirton (1936a) summarized the Pliocene mammalian faunas of North America from the stratigraphic point of view. A map by Savage (1958, fig. 2) shows the general distribution of localities where Pliocene mammals are known in North America. Hibbard et al. (1965) have summarized the stratigraphic and geographic occurrence of Pleistocene mammals in North America. There is no concise summary of the distribution of mammalian genera or species by locality.

Modern summaries of the known occurrence of other vertebrates have been provided by Brodkorb (1963, 1964a, and in progress) for birds; Gehlbach (1965) for reptiles and amphibians; and Uyeno and Miller (1964) and Miller (1965) for fishes. Most other groups have received even less study than mollusks; little literature and no summaries are available for such organisms as ostracodes, crayfishes or diatoms. Both pollen and leaves provide a record of higher plants that has been studied by R. W. Chaney, D. I. Axelrod and others, but no summaries like those of the vertebrates are available. The nearest approach to such a summary is Lamotte's (1952) "Catalogue of the Cenozoic plants of North America through 1950".

Abbreviations

The following abbreviations have been used to designate private or institutional collections:

AGS	A. G. Smith, Berkeley, California
ANSP	Academy of Natural Sciences, Philadelphia, Pennsylvania
CIT	California Institute of Technology
CAS	California Academy of Sciences, San Francisco
MC Z	Museum of Comparative Zoology, Cambridge, Massachusetts
SSB	S. S. Berry, Redlands, California
SU	Stanford University, Stanford, California
UCMNH	University of Colorado Museum of Natural History, Boulder
UCMP	University of California Museum of Paleontology, Berkeley
UMMZ	University of Michigan Museum of Zoology, Ann Arbor
USGS	U. S. Geological Survey
USNM	U. S. National Museum, Washington, D. C.
WOG	W. O. Gregg, Los Angeles, California.

THE BLANCAN AGE

In the study of stratigraphy and paleontology of nonmarine Cenozoic deposits, mammals have become the most useful group of fossils for subdivision and widespread correlation. Their value is due partly to relatively detailed taxonomic knowledge, partly to relatively rapid faunal change and spread. The successive faunal phases in the history of

North American mammals are the basis of a series of "mammalian ages" that have been given names and definitions by Wood et al. (1941) and Savage (1951). Potassium-argon radiogenic dates (Evernden et al., 1964) have shown that these mammalian ages are time-sequential, and have provided approximate dates in years for their limits. The Blancan age, distinguished by restricted ranges and first and last appearances of mammalian genera (summarized most recently by Savage, 1962; Evernden et al., 1964; Hibbard et al., 1965) probably ranges from about 2 million years ago to about 5 million years ago. In current American usage the Blancan is late Pliocene and early Pleistocene.

Future stratigraphic work will gradually provide a basis for correlating faunal sequences of fossil mammals and mollusks. Even now it can be said that there are no continent-wide faunal changes in mollusks as there are in mammals. The Blancan freshwater mollusks of Florida, Kansas and California are all more like the living faunas in these areas than like each other, whereas the reverse is true of mammals. The criteria for recognizing Blancan faunas of freshwater mollusks differ between faunal provinces, and may apply only to single sedimentary basins or physiographic regions.

Direct association of mammals and mollusks provided the basic dates for defining Blancan mollusks in this summary. These associations formed the framework into which local stratigraphies and less well dated molluscan faunas were fitted, resulting in lists of diagnostic last appearances. Lists of first appearances could be compiled also, but except in local areas would have little value in the present state of knowledge.

In the following lists an asterisk marks groups that became extinct in western North America but survive elsewhere. Species are listed only if widespread.

Hemphillian last appearances

The following groups did not survive after the Hemphillian (middle Pliocene of current American usage) so far as known:

*Viviparidae, Bellamyinae
*Bulimulidae
**Corbicula*
Scalez
Lacunorbis
Nematurella
Lymnaea albiconica (Taylor) and nearest relatives
Bulimnea petaluma (Hanna)
**Radix*
Pap yrotheca
**Coretus*
Vorticifex tryoni (Meek)
Helisoma binneyi (Meek) and nearest relatives

Blancan last appearances

Payettiidae
Pliopholygidae
Orygoceratidae
*Thiaridae
*Delavayidae
*Pleuroceridae, Semisulcospirinae
*Micromelaniidae
*Amphibolidae
**Pisidium supinum* Schmidt
"Aphanotylus"
*"*Melania*"
Calipyrgula
Savaginius
**Zelekina*
Brannerillus
Gyraulus (Idahoella)
Menetus (Planorbifex)
Paraplanorbis
Hannibalina

PLIOCENE-PLEISTOCENE LIMIT

Establishing a Pliocene-Pleistocene boundary over the continent of North America as well as locally depends on the criteria used. In principle the earliest recognized episode of marked climatic cooling in middle latitudes is accepted as marking the beginning of the Pleistocene (Hibbard et al. 1965, Taylor, 1965). The accumulation of potassium-argon rathogenic dates and of a sequence of geomagnetic reversals (Cox et al.,

1965) in the next decade will enable more precise correlation with western Europe than is possible now.

In the Great Plains region of central North America the known Blancan molluscan faunas can be related to an internally consistent sequence of ecological inference, vertebrate faunas and physical stratigraphy (Taylor, 1960b, 1965). Some are late Pliocene, some early Pleistocene. West of the Rocky Mountains the local endemic nature of the molluscan faunas, the lack of evidence of widespread climatic changes like those in the Great Plains, and the relatively fewer associated mammals preclude an equally reliable correlation within the region. The widespread occurrence of igneous rocks offers the hope that geochemical and geophysical studies will yield data leading to a refined chronology, already foreshadowed by Evernden et al. (1964).

The Blancan faunas of western North America include several extinct groups in common with southeastern Europe. This relationship with Eurasia is paralleled in the Recent fauna by species in the families Unionidae, Hydrobiidae and perhaps others. Although there are many genera common to eastern and western North America, in general the western Blancan freshwater molluscan faunas are more similar to the Pliocene to Recent faunas of Eurasia than to eastern American faunas. The following extinct groups are restricted to Pliocene deposits of southeastern Europe and of northwestern America:

Orygoceratidae (1 genus, *Orygoceras)*
Pap yrotheca
Gyraulus (Idahoella)

Other occurrences in common, and perhaps some vicariant pairs of genera, will probably be recognized as the faunas are reviewed critically. The stratigraphic intervals where these extinct groups occur in America can be correlated with accepted Pliocene rocks in southeastern Europe, but the weight of this evidence will be difficult to assay without an understanding of the changes in environment associated with the molluscan extinctions.

EARLY PLEISTOCENE IN THE GREAT PLAINS

The Pliocene-Pleistocene boundary in the Great Plains region has been drawn between the faunas like those in the Rexroad Formation (Rexroad, Bender, and Red Corral local faunas; Fig. 1, localities 51, 54; late Pliocene) and the younger Blancan faunas (Sand Draw, Spring Creek, Deer Park, Sanders, Dixon and Blanco local faunas; Fig. 1, localities 48, 51, 52, 56; early Pleistocene). New discoveries and new interpretations show that the molluscan faunal change between these assemblages is more gradual than supposed previously (Taylor, 1960b); and that the climatic changes correlated with the supposed Nebraskan glaciation are less marked than those associated with later glaciations. Correlation from the Plains to areas where radiogenic dates can be related to faunas is not precise, but the data available indicate that the later Blancan faunas in the Plains are about 2-3 million years old. These faunas are all older than the earliest faunas with boreal elements, i.e., older than any fossil record of a climate like that associated with the continental ice sheets. The evidence is suggestive rather than compelling, but I think that all of these "Nebraskan" and "Aftonian" faunas are probably pre-Nebraskan-older than deposits of the first major continental glacier in Kansas and Nebraska. I suggest that the physical and paleontological evidence in southwestern Kansas that has been interpreted as being correlative with the Nebraskan glaciation represents an alpine glaciation, or a pre-Nebraskan, limited continental glaciation.

The recently discovered mollusks from the Rexroad Formation extend several ranges downward into the Pliocene, whether one considers them part of the Bender local fauna (B. B. Miller, 1964) or Rexroad local fauna (this paper). The break in molluscan ranges between the Bender and Sand Draw local faunas (Taylor, 1960b: 12) is blurred, and with it any molluscan evidence for a marked climatic change at the beginning of the Pleistocene. The first evidence in the central Great Plains of markedly northern elements (vertebrate or invertebrate) is in the Cudahy fauna, associated with the Pearlette ash, of Kansan glacial age (Hibbard, 1960; Taylor, 1960b).

The Spring Creek local fauna (Fig. 1, locality 51; Berry and Miller, this volume) includes one of the most significant fossil occurrences in southwestern Kansas. The fauna is from the Ballard Formation, previously correlated as Nebraskan and Aftonian, and contains the extinct freshwater snail *Biomphalaria kansasensis* Berry. Out of the literally millions of Pliocene and Pleistocene shells collected in the intensively studied area of southwestern Kansas, the species is the only one found north of the present range of the genus. *Biomphalaria* is a tropical and subtropical group now found sparsely in the United States only along the southernmost Coastal Plain. *B. kansasensis* is not closely related to any living form, but has affinities with an early Pliocene species from nearby Oklahoma. Hence most likely *Biomphalaria* lived in the southern Great Plains region through the Pliocene and became extinct in that region in the early Pleistocene. Its occurrence in the Ballard Formation is difficult to reconcile with an age less than that of a major continental glaciation, and emphasizes the faunal change inaugurated with the Kansan Cudahy fauna.

Radiogenic dates can be applied to later Blancan (early Pleistocene) faunas in the Plains only by correlation. Mammals of the Hagerman local fauna from the Glenns Ferry Formation, Idaho (Fig. 1, locality 34) are assigned a latest Pliocene age, immediately older than early Pleistocene faunas in the Plains (Hibbard et al., 1965). The Hagerman date of 3.5 million years (Evernden et al., 1964) places a maximum limit on these Pleistocene faunas of about 3 million years.

A minimum age of later Blancan faunas in the Plains is established by 2 dates. After the Irvingtonian Grandview local fauna, in the Glenns Ferry Formation, Idaho (Fig. 1, locality 34) lived, deposition of the Glenns Ferry Formation continued briefly and then ceased, the formation was deeply eroded, and then several hundred feet of lava and fine-grained sediments accumulated prior to 1.4 million years ago (Evernden et al., 1964, sample 1188).

The second post-Blancan date comes from the Merced Formation, California (not shown on Fig. 1). A vitric tuff stratigraphically above *Mammuthus,* indicating post-Blancan age, has been dated as 1.5 million years old (N. T. Hall, 1965).

The youngest date applicable to a Blancan fauna is that of the Coso Mountain local fauna, 2.3 million years old (Evernden et al., 1964). From these data the Blancan/Irvingtonian faunal change seems to have taken place about 2 million years ago.

Although there is definite evidence that the climate during the Wisconsin glaciation was more rigorous than during any previous interval in central North America (Taylor, 1965), the Kansan, Illinoian and Wisconsin molluscan faunas are all broadly similar in having a number of now montane or more northern species. From comparison with these younger assemblages none of the Blancan faunas seems likely to have lived either during or after a glaciation when ice reached as far south as Nebraska, the type area of the Nebraskan till. The tentative correlation from the unglaciated to the glaciated region (Taylor, 1960b: 14) is probably oversimplified. More plausibly the faunal evidence of late Blancan climatic change, and the physical evidence of glacially striated pebbles in the Ballard Formation, indicate only an alpine glaciation, or a limited continental glaciation whose evidence has been obscured by later, more extensive ice sheets. This suggestion may complicate the interpretation of some local stratigraphic sections, but it renders geologic history more natural by being more transitional from pre-glacial to Ice Age times.

SEQUENCE WITHIN BLANCAN FAUNAS

Faunal sequence within the Blancan molluscan assemblages can be recognized only within local areas where the stratigraphy has been studied, and where superposition of faunas is demonstrable. Most of the known Blancan occurrences are in rocks of local geographic and stratigraphic extent, and in most areas perhaps only a short segment of Blancan times is recorded.

The wealth of stratigraphic data available in the southern San Joaquin Valley, California, permits the correlation of subsurface as well as outcrop samples. Distinctive assemblages of freshwater mollusks occur in the lower and upper parts of the San Joaquin Formation and in the Tulare Formation (Fig. 1, localities 16-23), representing latest Hemphillian time and an uncertain part of the Blancan. Virtually none of the species in the Tulare Formation occurs in the underlying San Joaquin.

In southwestern Kansas and northwestern Oklahoma a series of faunas (Fig. 1, localities 50-53) is dated as late Hemphillian and early to late Blancan within a framework of physical stratigraphy and associated mammals. The differences between the faunas can practically all be explained by differences in habitat. The sole possible instance of progressive change within this sequence is the differentiation of a species of land snail, *Gastrocopta franzenae,* into 2 descendent extant species (Taylor, 1960b).

Inasmuch as the differences between successive faunas in the Great Plains are relatively subtle, their stratigraphic study has been devoted principally to understanding the environmental changes responsible for the differences and similarities between the faunas. West of the Rocky Mountains the faunal differences are due to more conspicuous environmental differences from basin to basin, to tetonic activity and to rapid evolution. The faunal shifts of the Great Plains are a large-scale version of the local changes in facies that can be observed in the western sedimentary basins. Evidence of regional climatic change in Blancan and Pleistocene faunas, an essential tool for study of Great Plains mollusks, is unrecognizable in the present state of knowledge of western Blancan faunas.

DIFFERENTIATION IN BLANCAN FAUNAS

The geographic distribution of Blancan mollusks illustrates 2 propositions that apply to freshwater mollusks generally in North America, and perhaps everywhere. One is that species of widespread habitats have relatively wide geographic and geologic distribution. The second is that tectonic activity promotes taxonomic differentiation. These generalizations are drawn partly from the Blancan faunas, partly from older and younger assemblages including the recent fauna.

The larger Blancan faunas east and west of the Rocky Mountains show marked contrast in degree of endemism as well as in faunal composition. The western faunas have relatively few living species, a high percentage of local endemic species and genera, and few terrestrial snails. The eastern faunas (including those in Arizona) have few extinct species, and about equal numbers of aquatic and terrestral species. These differences are illustrated by comparison of the mollusks from the Tulare Formation, California (Fig. 1, locality 18) and Rexroad Formation, Kansas (Fig. 1, locality 51) in Table 1.

The species listed under "Tulare Formation" are those found in the basal part of the Tulare Formation exposed in the Kettleman Hills, revised from Woodring et al. (1941). The species listed under "Rexroad Formation" are those from the Rexroad and Bender local faunas from the upper part of the Rexroad Formation, from Hibbard and Taylor (1960), Miller (1964) and Taylor (1960b). The differences between the faunas are attributed entirely to local habitat, geographic provinciality, and subsequent history. Differences in age or intensity of collecting are negligible.

TABLE 1. Comparison of mollusks from Tulare Formation, California and Rexroad Formation, Kansas

Species	Tulare Formation	Rexroad Formation
Freshwater clams		
Unionidae		
Anodonta (s. s.) kettlemanensis Arnold	X	
Gonidea coalingensis Arnold	X	
Ligumia subrostrata (Say)		
Sphaeriidae		
Sphaerium kettlemanense Arnold	X	
Sphaerium partumeium (Say)		cf
Sphaerium striatinum (Lamarck)	X	
Sphaerium sulcatum (Lamarck)		X
Pisidium (Rivulina) casertanum (Poli)		X
Pisidium (Rivulina) supinum Schmidt		
Pisidium (Neopisidium) insigne Gabb		
Pisidium (Neopisidium) punctatum Sterki		
Pisidium (Neopisidium) n. sp.		
Freshwater snails		
Valvatidae		
Valvata humeralis Say		
Valvata virens platyceps Pilsbry		
Pleuroceridae		
Juga arnoldiana (Pilsbry)		
Juga kettlemanensis woodringi (Pilsbry)		
Hydrobiidae		
***Calipyrgula carinifera* Pilsbry		
***Calipyrgula ellipsostoma* Pilsbry		
***Calipyrgula stewartiana* Pilsbry		
Fontelicella "longinqua Gould"		
**Hydrobia? andersoni* (Arnold)		
**Hydrobia? birkhauseri* Pilsbry		
**Marstonia crybetes* (Leonard)		X
**Pyrgulopsis vincta* Pilsbry		
**Savaginius spiralis* (Pilsbry)		
**Savaginius* cf *S. yatesianus* (Cooper)		

TABLE 1 (cont.)

Species	Tulare Formation	Rexroad Formation
**Zetekina woodringi* (Pilsbry)	X	
Lymnaeidae		
Bakerilymnaea bulimoides techella (Haldeman)		
Fossaria dalli (Baker)		
Fossaria obrussa (Say)		
Lymnaea (Hinkleyia) caperata Say		
Lymnaea (Stagnicola) exilis Lea		
Lymnaea (Stagnicola) reflexa Say		
Ancylidae		
Ferrissia meekiana (Stimpson)		
Ferrissia parallela (Haldeman)		
Ferrissia rivularis (Say)		
Planorbidae		
**Omalodiscus pattersoni* (Baker)		
Gyraulus parvus (Say)		
**Brannerillus involutus* Pilsbry		
**Brannerillus physispira* Hannibal		
Helisoma (s. s.) anceps (Menke)		
**Helisoma (s. s.)? kettlemanense* Pilsbry		
**Helisoma (Carinifex) marshalli* (Arnold)		
**Vorticifex* cf *V. effusus (Lea)*		
Menetus (s. s.) centervillensis (Tryon)		
Menetus (Planorbifex) vanvlecki* (Arnold)		
**Promenetus (s. s.) exacuous kansasensis* (Baker)		
Promenetus (Phreatomenetus) umbilicatellus (Cockerell)		
Physidae		
Physa (s. s.) *skinneri* Taylor		
**Physa (Costatella) wattsi* Arnold	X	
Physa (Physella) virgata Gould	X	
Land Snails		
Ellobiidae		
Carychium exiguum (Say)		
Cionellidae		
Cionella lubrica (Müller)		
Vertiginidae		
**Vertigo (s. s.) hibbardi* Baker		
Vertigo (Angustula) millium (Gould)		
Chondrinidae		
Gastrocopta (s. s.) cf *G. cristata* (Pilsbry and Vanatta)		

TABLE 1 (cont.)

Species	Tulare Formation	Rexroad Formation
**Gastrocopta (s. s.) franzenae* Taylor		
**Gastrocopta (s. s.) paracristata* Franzen and Leonard		
Gastrocopta (s. s.) pellucida hordeacella (Pilsbry)		
**Gastrocopta (s. s.) scaevoscala* Taylor		
Gastrocopta (Albinula) armifera (Say)		
Gastrocopta (Albinula) holzingeri Sterki		
**Gastrocopta (Immersidens) rexroadensis* Franzen and Leonard		
Gastrocopta (Vertigopsis) tappaniana (Adams)		
Pupillidae		
Pupoides (s. s.) albilabris (Adams)		
Pupoides (Ischnopupoides) inornatus Vanatta		
Strobilopsidae		
**Strobilops (s. s.) sparsicostata* Baker		
Valloniidae		
Vallonia gracilicosta Reinhardt		
Vallonia parvula Sterki		
Vallonia perspectiva Sterki		
Succineidae		
cf. *Succinea*		
Endodontidae		
Helicodiscus (s. s.) parallelus (Say)		
Helicodiscus (Hebetodiscus) singleyanus (Pilsbry)		
Zonitidae		
Hawaiia minuscula (Binney)		
Nesovitrea (Perpolita) electrina (Gould)		
Retinella (Glyphyalops) rhoadsi (Pilsbry)		
Retinella (Glyphyalus) wheatleyi (Bland)		
Zonitoides (s. s.) *arboreus* (Say)		
Limacidae		
**Deroceras aenigma* Leonard		
Polygyridae		
**Polygyra (Erymodon) rexroadensis* Taylor		

* extinct species
** extinct genus or subgenus

Widespread species and habitats

The low percentage of extinct aquatic species in the Rexroad Formation is correlated with the widespread occurrence of the types of habitat represented, and the wide geographic range of the aquatic species in general. The living species are all widespread in eastern North America, some of them over much of the continent. *Promenetus exacuous kansasensis* and *Omalodiscus pattersoni* are known widely in Blancan and post-Blancan rocks. *Mars tonia crybetes*, the single species known only from Blancan deposits in the Plains, is one of the few forms restricted to a perennial-water habitat. The others are mostly forms of seasonal ponds, shallow and fluctuating streams and marginal aquatic situations.

The high percentage of extinct species in the Tulare Formation is correlated with their lacustrine habitats and local geographic range. By its nature, a lacustrine habitat is likely to be restricted to a given basin. Of the extinct species in the Tulare Formation none is found in post-Blancan deposits, none outside central California, and very few in the underlying San Joaquin Formation. The living species in the Tulare Formation are all found outside of central California, some of them widely, and none is characteristically lacustrine.

Many of the western Blancan faunas include only extinct species of a lacustrine or large-river assemblage. The known samples of less restricted habitat support the belief that most extant species were already in existence in the late Pliocene, but many lived in shallow or seasonal streams and ponds that have left practically no fossil record. Post-Pliocene events have extinguished almost all the rich local endemic lacustrine faunas, leaving an impoverished fauna with fewer local forms.

There are no longer any lakes inNorth America with large endemic faunas like those of the Blancan basins of western America. The nearest approximations are Klamath Lake, Oregon, and Clear Lake, California. Closer parallels are found in the streams draining the southern Appalachians in southeastern North America. Here there is an exuberance of local species in groups restricted to perennial streams (mainly Unionidae, Pleuroceridae, Hydrobiidae, some Ancylidae, Planorbidae and Viviparidae). These richly differentiated groups surely have a long unrecorded history, and probably the living species were in existence by late Pliocene times, as on the Plains. Perhaps in this region of tectonic stability and ample rainfall in the southeastern United States there has been negligible extinction since the Pliocene.

Tectonism and evolution

Tectonic activity can affect the differentiation of mollusks in 2 ways: either directly, by separating areas of formerly continuous habitat or joining formerly isolated habitats; or indirectly by environmental changes. The generalization that tectonic activity during the Blancan favored the differentiation of new taxonomic groups is supported by several lines of evidence:

(1) Local endemism in aquatic mollusks is correlated with geologically young tectonism.

(2) The vicariant or locally disjunct species in Blancan faunas imply a former, more widespread continuity of distribution of their ancestors.

(3) Faunal change during the Blancan was slight in the southern Great Plains, but marked in the tectonically active San Joaquin Valley, California.

(4) Hemphillian faunas, so far as known, include more widespread species and are regionally more similar to each other than are the Blancan faunas.

(5) Theoretically geographic isolation and environmental changes favor evolution of new forms, either simply through geographic segregation of populations or by changing the selective pressure on given genotypes.

FIG. 2. [illegible]

The correlation of local endemism and tectonic activity can be observed among both Blancan and Recent mollusks. The living fauna of aquatic mollusks in the Great Plains is sparse and includes no endemic species; this region is the largest area of North America with no species peculiar to it. As one goes westward in the central and northern Rocky Mountains the fauna is poor up to the eastern limit of young topographic basins where locally endemic species occur (Fig. 2). Thus there are no aquatic mollusks peculiar to North Dakota, South Dakota, Nebraska or anywhere in the southern Great Plains until one reaches the Balcones Escarpment along the Edwards Plateau in Texas, and in the Rocky Mountains, all of Colorado and most of Wyoming and Montana lack local forms. The eastern limit of local endemic mollusks is also the eastern limit of Blancan or post-Blancan basin subsidence. Comparison of a map of recorded earthquake epicenters (King, 1965, Fig. 2) with a map of local endemic species (Fig. 2) shows a general correlation. Surely this reflects the influence of past tectonic activity (still continuing) on evolution of species.

Local endemism can be caused not only by the differentiation of new forms, but also by the narrowly restricted survival of an old form, i.e., relictual endemism. The more striking local forms in the Blancan faunas of Idaho, such as the Amphibolidae, Delavayidae, Orygoceratidae, Payettiidae and Pliopholygidae, are examples of such ancient stocks. In contrast, local species of widespread genera, such as *Helisoma, Vorticifex, Fontelicella* and other Hydrobiidae are interpreted as newly evolved during the Blancan. The distribution of all such local forms, whether living or extinct, provides another tool in studying late Cenozoic geologic history.

Summary

Geographic differences between Blancan faunas, the similarities and differences with older and younger faunas, and the correlation of local endemism with areas of recent tectonism provide a basis for some inferences about evolution in freshwater mollusks in general. Species of widespread habitats are widely distributed in time and space; they are not readily subject to geographic differentiation and evolve slowly. Tectonism promotes the differentiation of mollusks both by changing their environments, and by separating or joining given habitats. Species living in a variety of habitats, or in a widely available habitat such as shallow or seasonal ponds, are rarely geographically isolated, and generally slow in evolving. Thus in stable regions that are ecologically rather uniform the fauna is similar over large areas andthe species are both long-ranging geologically and wide-ranging geographically. The Great Plains are the clearest example of such an area in North America The Holarctic boreal nonmarine mollusks are examples of such widespread species too.

Tectonically active areas, with topographic and ecologic diversity at any given time and with changing drainage patterns and habitats are rich in local forms that are restricted both stratigraphically and geographically. The species of perennial water bodies (lakes, larger streams, springs) are especially subject to geographic isolation and are most diversified in such a region. The local basins in and around the northern Great Basin and in California are North American examples of this kind of region. The Pliocene to Recent basins of southeastern Europe are similar, but larger in size and in diversity of faunas.

BIOGEOGRAPHY OF BLANCAN FAUNAS

The living nonmarine mollusks of North America are markedly different on either side of the eastern edge of the Rocky Mountains. As Henderson (1931) concluded, these differences probably go back to early Tertiary or Cretaceous times.

Blancan faunas from within the eastern region are all much like the modern faunas of that region. Despite a number of extinct species, the late Pliocene and early Pleistocene faunas of the Plains are all much like the living fauna of the Plains (Taylor, 1960b). Similarly, the Blancan faunas from Florida (Fig. 1, locality 57) are more like the modern fauna of Florida than like the faunas of the Plains or western North America.

In the western region of Henderson (1931) such easy generalizations are impossible. Local endemism, post-Blancan extinctions and more rapid differentiation have produced many sharp contrasts between the Blancan faunas and the local living faunas. Evidently both faunal history and geologic history are so complicated that detailed local studies are necessary for an understanding of both.

An unexpected discovery has been the close similarity between the Blancan faunas of Arizona and of the southern High Plains. The mollusks of the Benson local fauna (Fig. 1, locality 45) could be duplicated in the Pleistocene of Kansas, Oklahoma or Texas. Although there are characteristic species in the living fauna of Arizona, none of these are present in the known fossil assemblages. On this evidence one may expect regional similarities in the Pleistocene faunas of much of the southwest.

Outside of Arizona, in the other western states, most of the faunas are lacustrine assemblages more or less distinct from each other. Some geographically close faunas are obviously similar. Examples are those in southeastern Idaho and northern Utah (Fig. 1, localities 35-37), and some in Oregon and northern California (localities 4-6). The nearest approach to a regional pattern is the occurrence of common species, or closely related species, in southern Idaho and in the San Joaquin Valley of California. This relationship is shown by fossil and Recent groups, presumably in correlation with a former hydrographic connection and different rates of subsequent change in different species. Representative groups of these common or related species have been selected to document this relationship, but obviously no thorough analysis is practicable in the present state of knowledge.

The list below summarizes the species whose distributions have been mapped, that show this geographic pattern. Other mollusks (distributions not mapped) showing this relationship are listed on p 72. A genus of minnows, *Mylopharodon*, and a sunfish, *Archo-Mites,* are known living only in central California but occur as fossils in southwestern Idaho (R. R. Miller, 1965).

The inferred river connection between areas now in Idaho and California [redacted] That is the age of the oldest fossils showing this geographic affinity, and in late Pliocene times the faunas of the 2 areas were substantially different.

A second reason for supposing that this Idaho-Californian faunal affinity dates to pre-Blancan times is its relationship to an apparently younger, Blancan pattern of distribution (Fig. 7). This pattern, crudely fishhook-shaped, is the dominant pattern in the living fauna of the west.

	California	SE Oregon, S. Idaho, W.Wyoming
Fig. 3	*Pisidium punctatum,* late Pliocene	*Pisidium punctatum,* late Pliocene - Recent
Fig. 4	*Gonidea coalingensis,* late Pliocene	*Gonidea malheurensis,* middle - late Pliocene
Fig. 5	*Scalez petrolia,* middle Pliocene	*Scalez* sp. , early - middle Pliocene
Fig. 6	*Valvata utahensis,* late Pleistocene	*Valvata utahensis,* middle Pleistocene - Recent

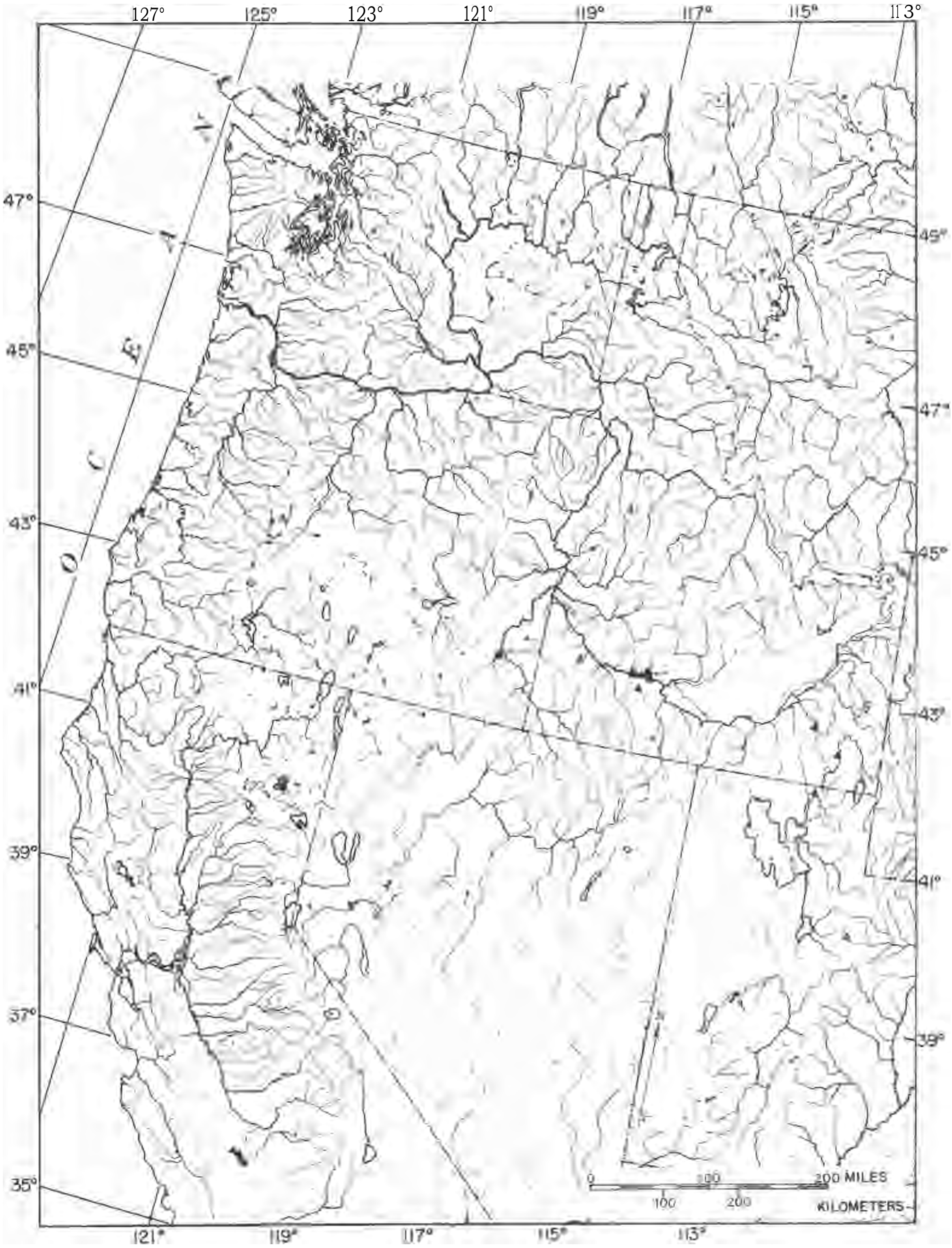


FIG. 3. Distribution of the freshwater clam *Pisidium (Neopisidium) punctatum* Sterki, 1895, family Sphaeriidae, in western North America. Solid dots, living occurrences (specimens in USNM). Triangles, Blancan fossil occurrences (specimens in USGS), in the basal part of the Tulare Formation, Kettleman Hills, California; Glenns Ferry Formation, southwestern Idaho; Salt Lake Group, Marsh Creek Valley, southeastern Idaho; and Cache Valley Formation, southeastern Idaho and northern Utah. The species occurs widely in eastern North America also.

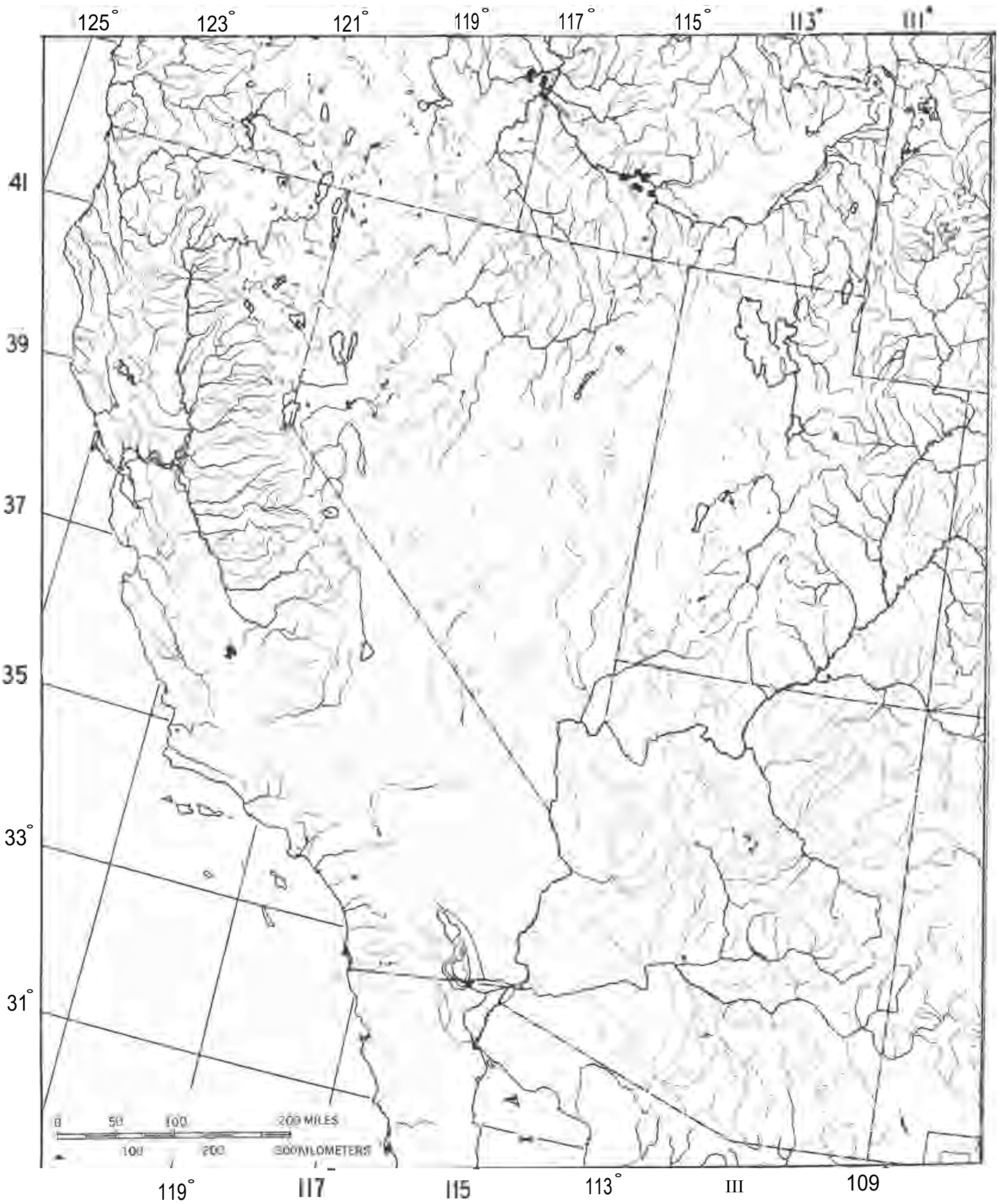


FIG. 4. Distribution of *Gonidea coalingensis* Arnold, 1910, and *G. malheurensis* (Henderson and Rodeck), 1934, family Unionidae, freshwater mussels known only from deposits of Pliocene large lakes and streams. Dots, *G. malheurensis*; triangles, *G. coalingensis*. From specimens in USGS collections.

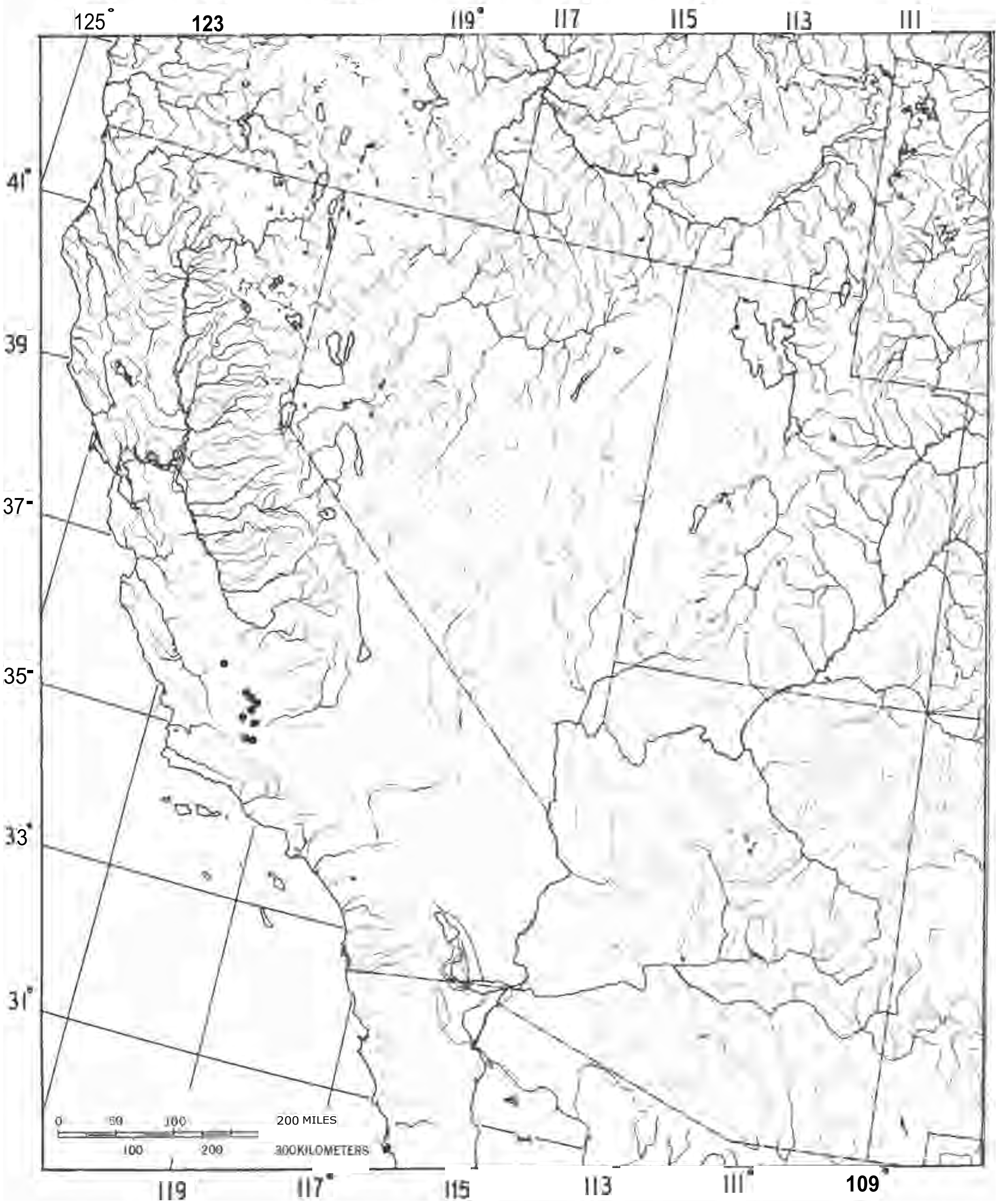


FIG. 5. Distribution of *Scalez* Hanna and Gaylord, 1924, family Viviparidae, an extinct genus of snails known from Pliocene lake deposits. Dots, *S. petrolia* Hanna and Gaylord, 1924; triangles, perhaps a separate species. From specimens in USGS collections, and from Woodring et al. (1932).

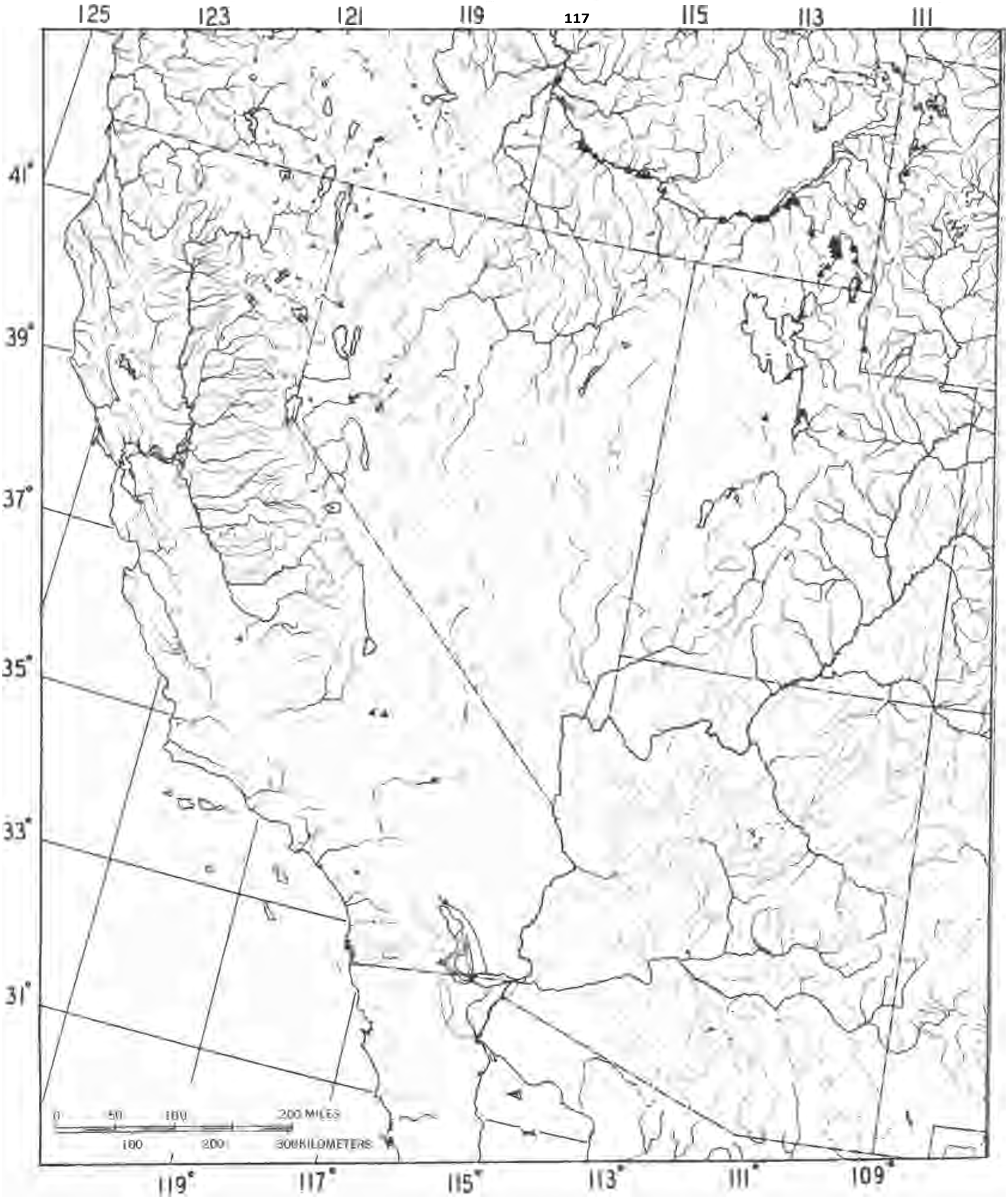


FIG. 6. Distribution of *Valvata utahensis* Call, 1884, family Valvatidae, a snail of lakes and large streams. From specimens in collections UMMZ , USGS and USNM. Included as a synonym is *Valvata utahensis horatii* Baily and Bally, 1951. Living, dots; Pleistocene, triangles. The record by Henderson (1929: 172) from Washington is based on a misidentification of *V. humeralis* (specimens UCMNH 15400); that by Roscoe (1964: 4) from Sevier Desert, Utah. is based on misidentification of *V. humeralis* (specimens USGS 2158, USNM 1117031.

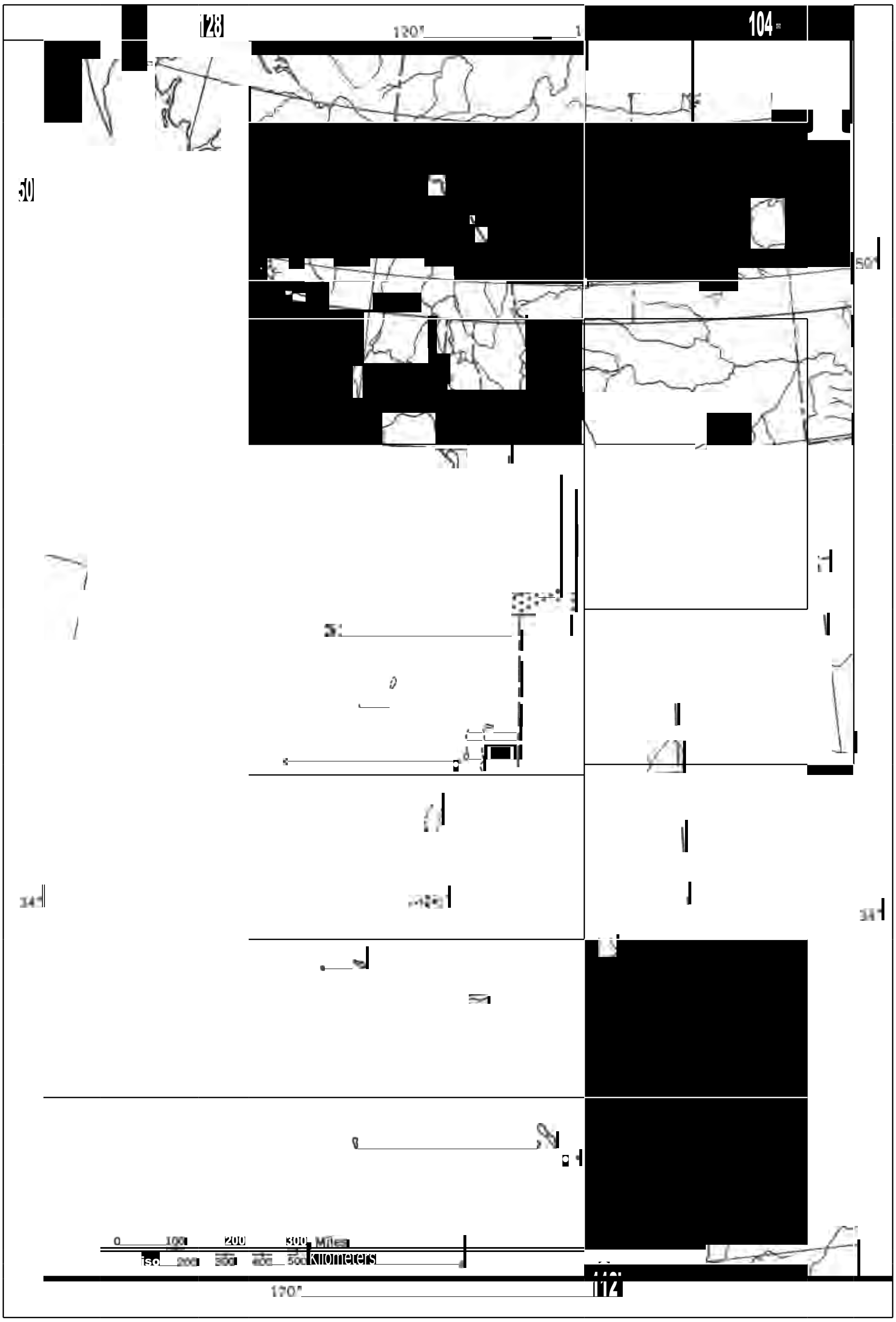


FIG. 7. Two geographic patterns of distribution of Pliocene to Recent freshwater mollusks. The "fishhook" pattern (heavy stipple) includes the ranges of many living and late Pliocene species. It seems to cut across a pattern (light stipple) that includes the ranges of some Pliocene species, but few living species. See text for fuller explanation.

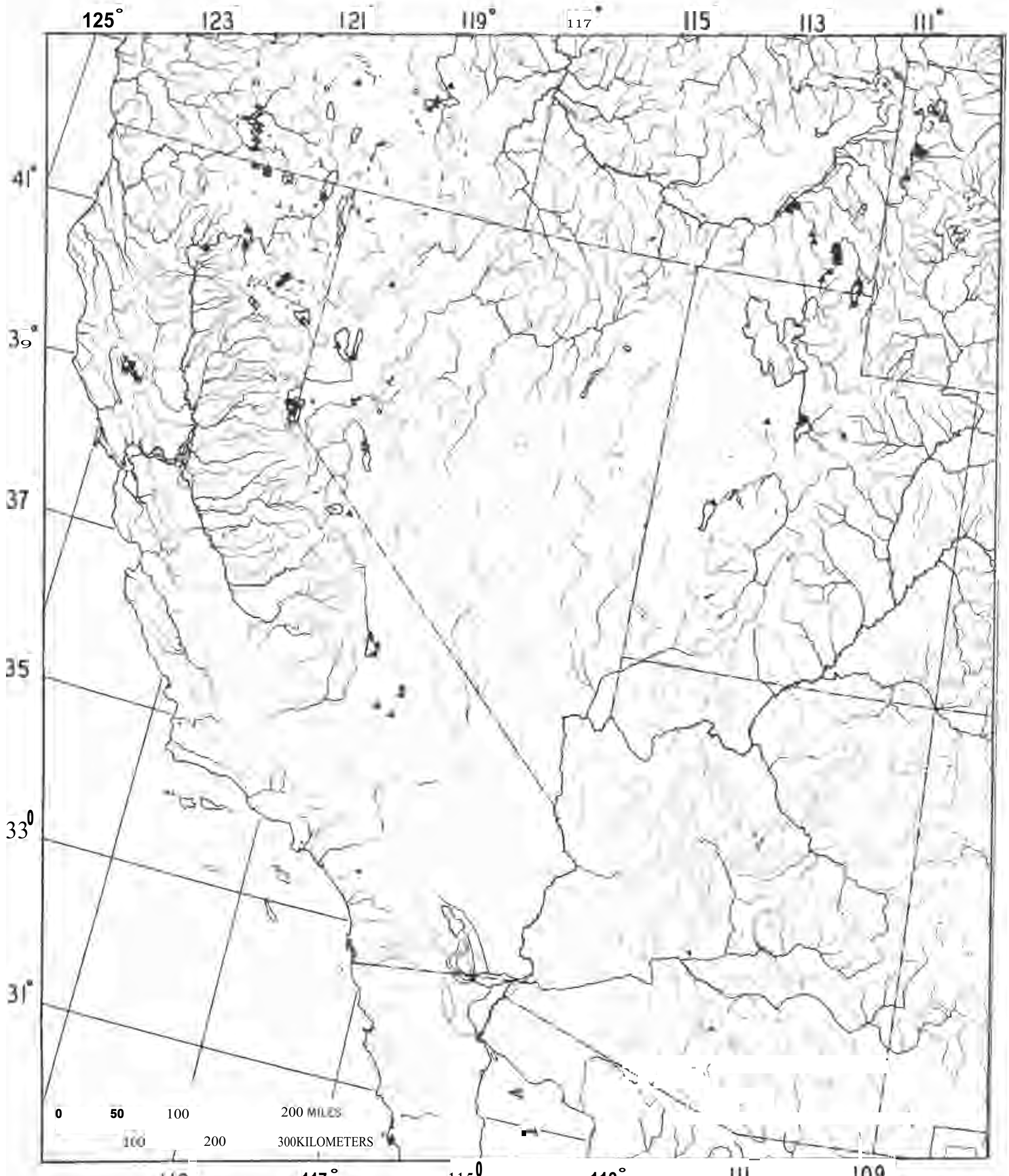


FIG. 8. Distribution of *Helisoma (Carinifex),* family Planorbidae, snails of lakes and large streams. From specimens in collections UCMNH, USGS, USNM and WOG. *Helisoma minus* (Cooper), 1870, squares, all Recent; *H. ponsonbyi* (E. A. Smith), 1876, diamonds, all Recent; *H. newberryi* (Lea), 1858, dots, living, triangles, fossil. Included as synonyms in *H. newberryi* are *Carinifex atopus* Chamberlin and Jones, 1929, *C. jacksonensis* Henderson, 1932; *C. newberryi malleata* Pilsbry, 1934a; *C. occidentalis* Hanna, 1924; and *C. newberryi subrotunda* Pilsbry, 1932.

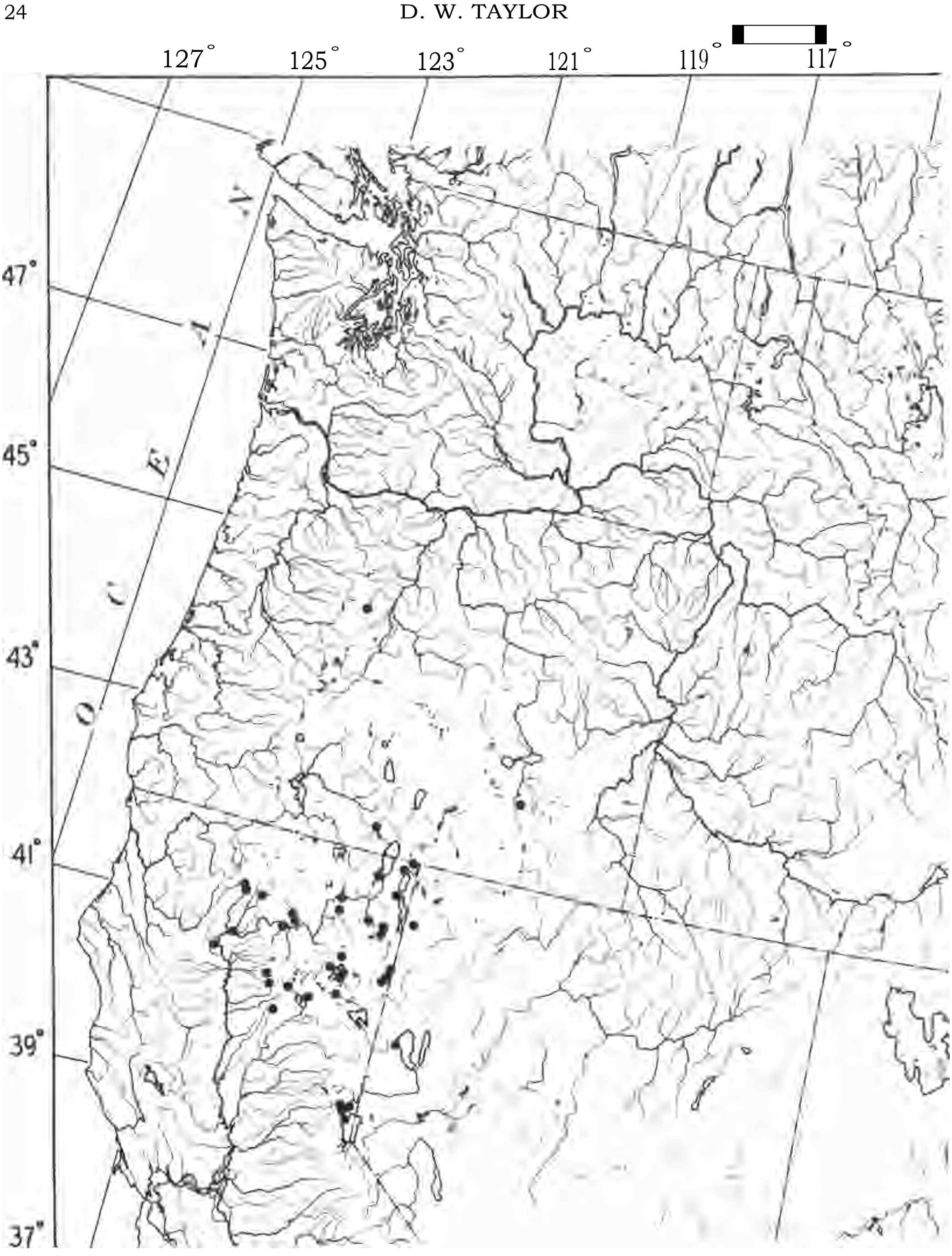


FIG. 9. Distribution of ***Lithoglyphus turbiniformis*** (Tryon), 1865, family Hydrobiidae, a snail of springs and mountain streams. From specimens in collections of AGS, CAS, MCZ, SSB, SU, UCMNH, UMMZ, USGS and USNM; and from published records by Cooper (1890), Pilsbry (1899), and Tryon (1865). Included as synonyms *are Amnicola dalli* Call (1884) and *Flumini cola modoci* Hannibal (1912b). All records are Recent; no fossils are known.

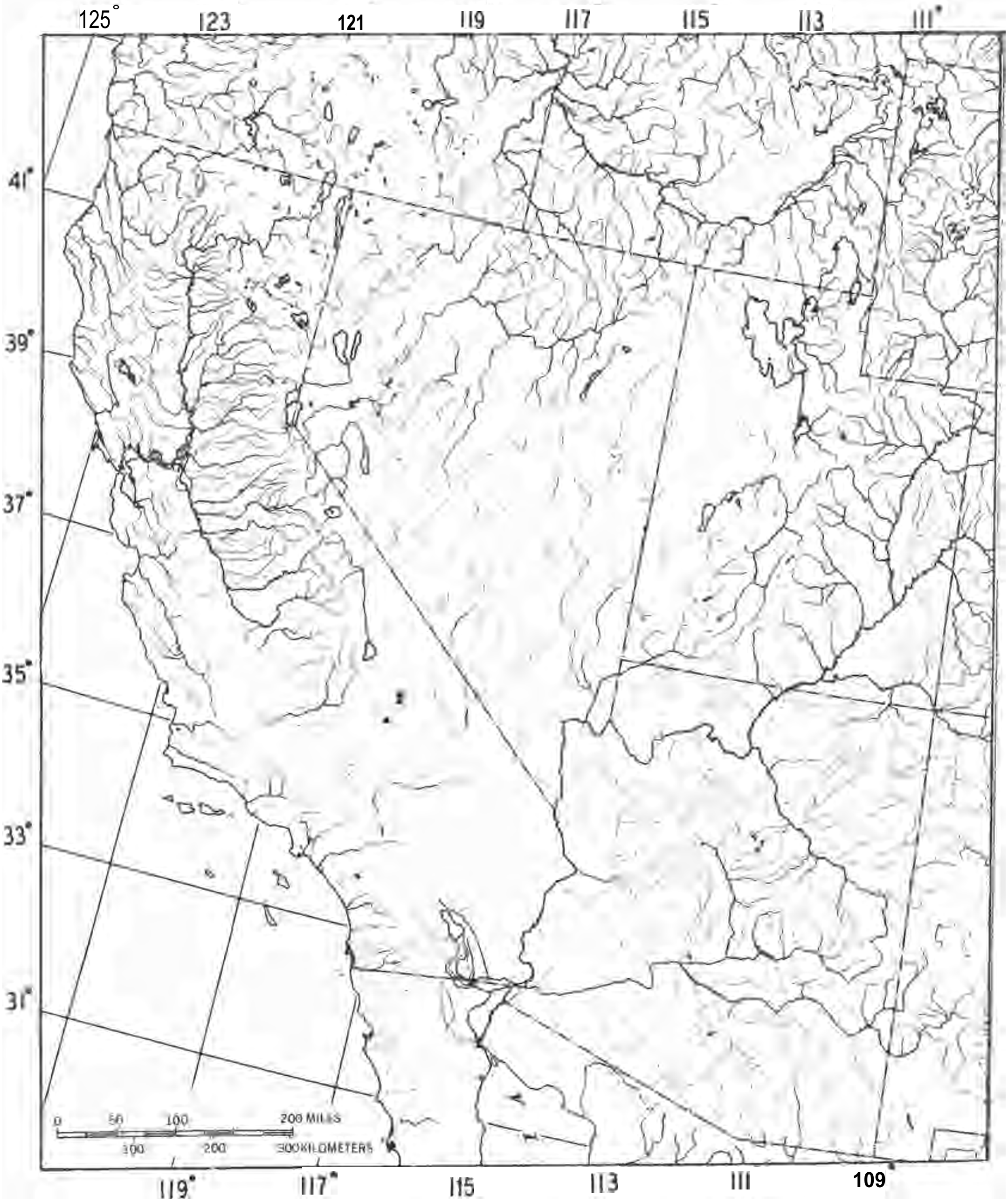


FIG. 10. Distribution of *Lymnaea (Stagnicola)kingii* Meek, 1877, family Lymnaeidae, a snail known living only in Utah Lake, Utah, and as a fossil only in lacustrine deposits. The only Blancan occurrences are in the Cache Valley Formation of northern Utah; other fossil records are all late Pleistocene. From specimens in collections USGS and USNM. Included as a synonym is *Radix ampla utahensis* Call (1884).

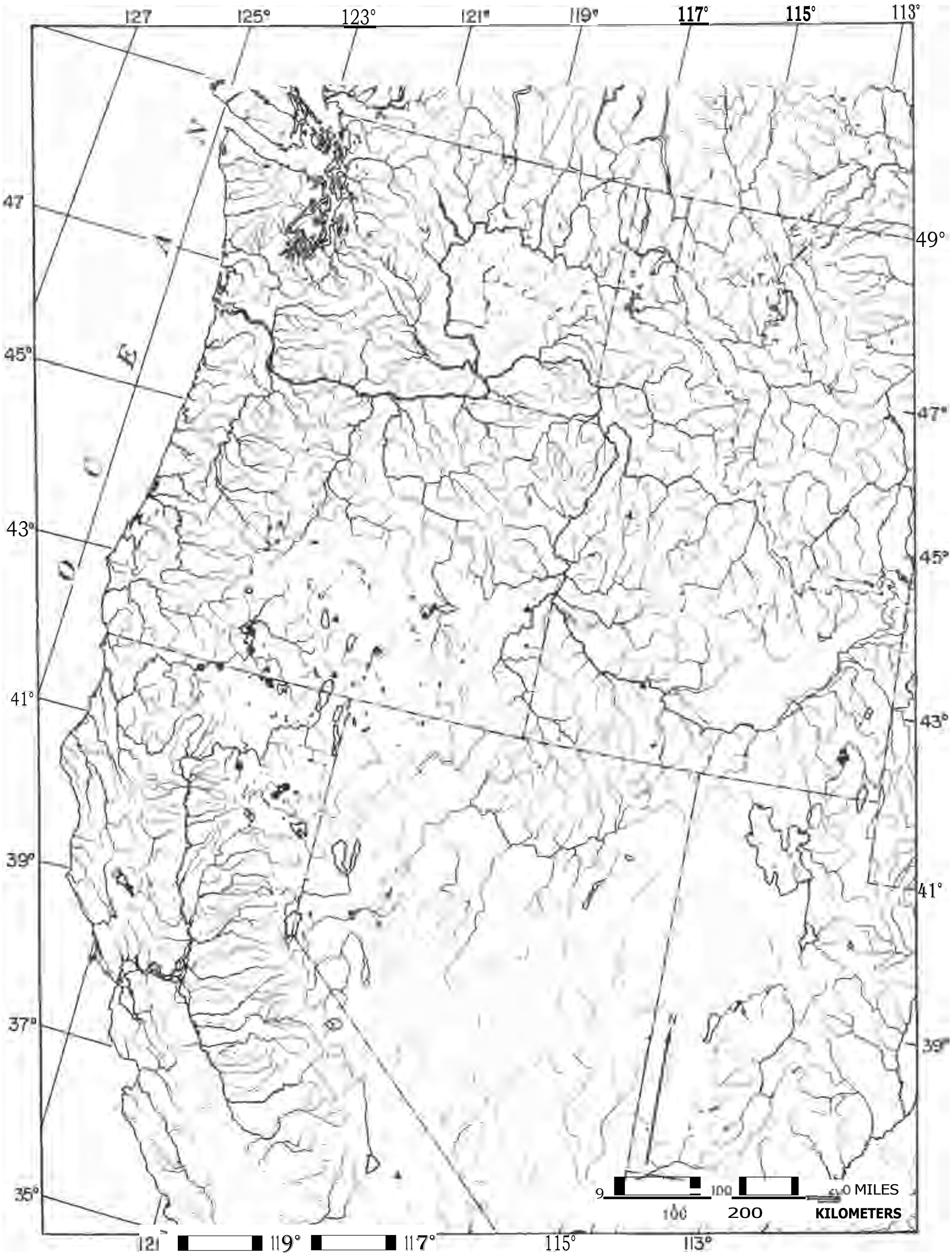


FIG. 11. Distribution of *Pisidium (Rivulina) ultramontanum* Prime, 1865, family Sphaeriidae, a small freshwater clam known only from lakes and large streams. Blancan occurrences are in the Yonna Formation of 'rule Lake Basin, Summer Lake, Warner Lakes and Goose Lake (all in Oregon). From specimens in collections AGS, CAS, SSB, UMMZ, USGS, USNM and WOG. Comparison with a previous distribution map (Taylor, 1960a) shows that the subsequently discovered localities fall along the "fishhook". Pliocene records in southern Idaho (Taylor, 1960a) are now considered to represent another, undescribed species.

More species are restricted to this belt, or have some of their geographic limits in it, than any other biogeographic pattern in western America. This "fishhook" is a composite of the distributions of individual species, some of which occupy much of the pattern *(Helisoma newberryi,* Fig. 8), a small part of it *(Lithoglyphus turbiniformis,* Fig. 9) or widely separated areas *(Lymnaea kingii,* Fig. 10). Many more Blancan fossils as well as living species can be related to this fishhook type of distribution than to the Idaho-Californian pattern. Thus it seems probable that the "fishhook" is younger, resulting from Blancan or immediately pre-Blancan tectonic activity that caused considerable changes in drainage patterns, faunal evolution, and geographic distribution.

In a previous discussion (Taylor, 1960a) of biogeography of this region I included Klamath Lake, Oregon, in what is now the "fishhook" pattern. More thorough taxonomic study of the mollusks, and additional information on their distribution, shows the molluscan fauna of this lake is not as similar to that of adjacent basins as I thought then. *Pisidium ultramontanum,* whose distribution includes both Klamath Lake and areas to the east and south (Fig. 11), is virtually unique among perennial-water species in this respect. It is probably significant that this clam has the longest geologic range of any living west American freshwater mollusk. It is known as far back as the early Pliocene, indicating an unusually slow rate of change that is responsible for its persistent, wider distribution as a single species. The distribution of *Helisoma (Carinifex)* (Fig. 8), with distinct species in Klamath Lake and neighboring regions, represents a more common result of molluscan evolution and geographic spread.

R. R. Miller (1965) discussed the relationship between fossil fishes from southwestern Idaho and former drainages to the west. His data too are consistent with the interpretation that the inferred river connections between parts of Idaho and California, and Idaho and the Klamath Lake basin, are older than the "fishhook" pattern.

SUMMARY OF LOCALITIES

The molluscan faunas are summarized in numerical order according to their number on the index map (Fig. 1). So far as possible the following data are given:

- Location
- Previous references to mollusks
- Stratigraphic unit and most recent geologic maps
- Number of species of mollusks, and mention of endemic genera or subgenera
- Other organisms described from the same locality or formation
- Age
- Institution where fossils are preserved
- Most recent topographic map

The name, letters and numbers in parentheses after the heading of each locality specify an area that is 15 minutes of latitude by 15 minutes of longitude. The name and the letters and numbers preceding the name designate the U. S. Geological Survey quadrangle at scale 1:250000, 1 degree of latitude by 2 degrees of longitude.[2] The final letter and number designate the 15-minute quadrangular area according to the system shown in Fig. 12.

In most of the United States the land has been surveyed according to a rectangular system, based on equal-sized "townships" 6 miles square, each including 36 "sections" 1 mile square. Townships are related to a series of "Principal Meridians" running north-south, and "Base Lines" running east-

[2]An index map showing the quadrangles is available free on application to the Geological Survey. The United States is mapped completely by this series of topographic maps, mostly published after 1957.

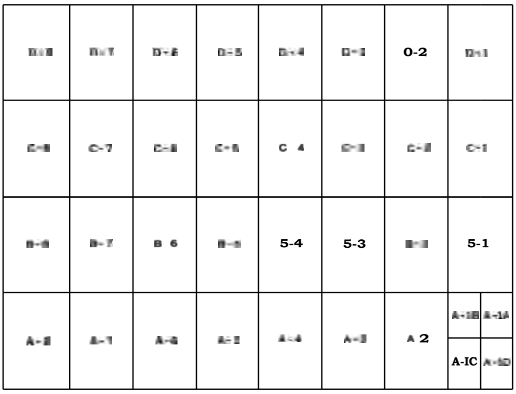


FIG. 12. System for designation of 15-minute quadrangles within the U. S. Geological Survey quadrangles at scale 1:250000, 2 degrees of longitude by 1 degree of latitude. Quadrangles 7.5 minutes on a side are designated as in the lower right corner.

west, established by the Federal Government. A column of townships east or west of a Principal Meridian forms a "Range", and a row of townships north or south of a Base Line forms a "Tier". The location of any mile-square area can be described according to this system, so that "sec. 5, T 18 N, R 10 E" means section 5 in the township 18 tiers north, and 10 ranges east, of the Base Line and Principal Meridian. Within any given county, and usually within a state, there is no duplication of tier and range designations, so that specification of a particular Base Line or Principal Meridian is unnecessary. Subdivisions of sections are described ordinarily by quarters, so that "NW 1/4 NE 1/4 sec. 16" means the northwestern quarter of the northeastern quarter of section 16.

When adequate topographic maps and locality data are available, a particular locality can be described conveniently and more precisely by its distance from the nearest 2 sides of the section, for example "900 ft north, 1600 ft east, sec. 12, T 8 N , R 12 E ". This indicates the locality has been located to the nearest hundred feet, and lies within section 12, 900 feet north of the south side, and 1600 feet east of the west side, in the township 8 tiers north and 12 ranges east.

In areas to which a land survey has not been extended, or where surveying is incomplete, a locality can be described approximately by the extension of the nearest survey lines on a specified map. "Sec. 4, T 6 N, R 4E, unsurveyed" means that the township has not been subdivided into sections on the available maps, but the locality is found in section 4 when the standard grid of 36 sections is applied. Original errors in surveying, the loss of markers and discrepancies between maps lead to irregularities in shape of both townships and sections, so that this extension of the lines is not a precise method for describing a locality.

Recent topographic maps have a supplementary system for plotting locations according to "progressive grid coordinates" that has been used when the standard land survey was inapplicable.

1. Ringold Formation, Washington
(NL 11-4 [Walla Walla] B-6)

The one known locality is on the east side of the Columbia River, in the White Bluffs 9 miles north of Richland. Mollusks have not been recorded previously; mammals and a turtle have been described from other localities by Brattstrom and Sturn (1959), Merriam and Buwalda (1917) and Strand and Hough (1952). The outcrop area of the formation was shown on a small-scale map by Newcomb (1958b, Fig. 1). The fossil mammals have been interpreted as Pleistocene, but the formation is so thick that its lower part might be Pliocene. The known mollusks may be Blancan or post-Blancan; specimens are in the USGS collections. Most recent topographic map: U. S. Geological Survey Richland quadrangle (1951) 1: 62500.

Fossil mollusks from Ringold Formation

U. S. Geological Survey Cenozoic locality 23214 (WMG-60-8F). Franklin County, Washington. Richland quad. (1951) 1:62500. 1400 ft E, 550 ft N, sec. 25, T 11 N, R 28 E. First caliche? layer above conglomerate member of Ringold Formation. About 600 ft elevation. M. J. Grolier, J. W. Bingham, 1960.

Only 3 species of freshwater snails are represented:

Planorbidae
Omalodiscus pattersoni (Baker)
Planorbella cf *P. subcrenata* (Carpenter)
Physidae
Physa

This assemblage probably represents a shallow-water environment, such as a flood-plain or the edges of a stream or lake, rather than an open lake. The water body might have been subject to seasonal fluctuation, but probably did not dry up entirely.

The only species of stratigraphic significance is the extinct *Omalodiscus pattersoni* (Baker). In eastern North America the species is known from deposits as young as Wisconsin in age, but is common only in those older than late Pleistocene (Taylor, 1958). The distribution in western North America (Fig. 13) is limited to upper Pliocene rocks except for the occurrence in the Ringold Formation. This meager evidence favors an age earlier than late Pleistocene, perhaps Blancan, for the part of the Ringold from which the mollusks come. Additional collections and more detailed stratigraphic studies will be necessary to establish the age-range represented by the formation, and the relationship of the fossil mammals to the mollusks.

2. Butte Valley, California
(NK 10-9 [Alturas] D-8)

The described fossil localities are all within a radius of 1 1/2 miles, on the northeastern side of Butte Valley, south and southeast of the town of Dorris. Mollusks were described and illustrated by Hanna and Gester (1963), and listed from another locality by Wood (1961: 40). The fossiliferous unit is shown as nonmarine upper Pliocene on the Geologic Map of California, Olaf P. Jenkins edition, Alturas sheet (1958), and as part of Quaternary alluvium by Wood (1961, pl. 1). The fauna includes 9 species and one endemic genus, *Hannibalina.* No organisms besides mollusks have been described from this formation. The late Pliocene age assigned by the Geologic Map of California is accepted here. The fossils described by Hanna and Gester (1963) are in CAS collections; those listed by Wood (1961) are USGS 20235. Most recent topographic map: U. S. Geological Survey Dorris quadrangle (1950) 1:62500.

3. Yonna Formation, Oregon
(NK 10-6 [Klamath Falls] A-6, 8, B-7)

Yonna Valley

Freshwater mollusks were listed by Newcomb (1958: 46). Stratigraphic sections and a generalized map of the distribution of the Yonna Formation were given by Newcomb. (1958a). The fauna includes 9 species, the relationships of which cannot be determined in detail because of poor quality of preservation. No other fossils are known from Yonna Valley, but elsewhere the formation has yielded a peccary, interpreted as of middle Pliocene age, stratigraphically below the mollusks (Newcomb, 1958a: 47), and late Pliocene diatoms (Moore, 1937; Wood, 1961). A Blancan age is assigned to the mollusks. Fossils are in USGS and CAS collections. Most recent topographic map: U. S. Geological Survey Swan Lake quadrangle (1957) 1:62500.

Mollusks from Yonna Formation in Yonna Valley

U. S. Geological Survey Cenozoic locality 20218. Klamath Co., Oregon. Swan Lake quadrangle (1957) 1: 62500. NW 1/4 NE 1/4 sec. 34, T 37 5, R 11 1/2 E. Brown semiconsolidated

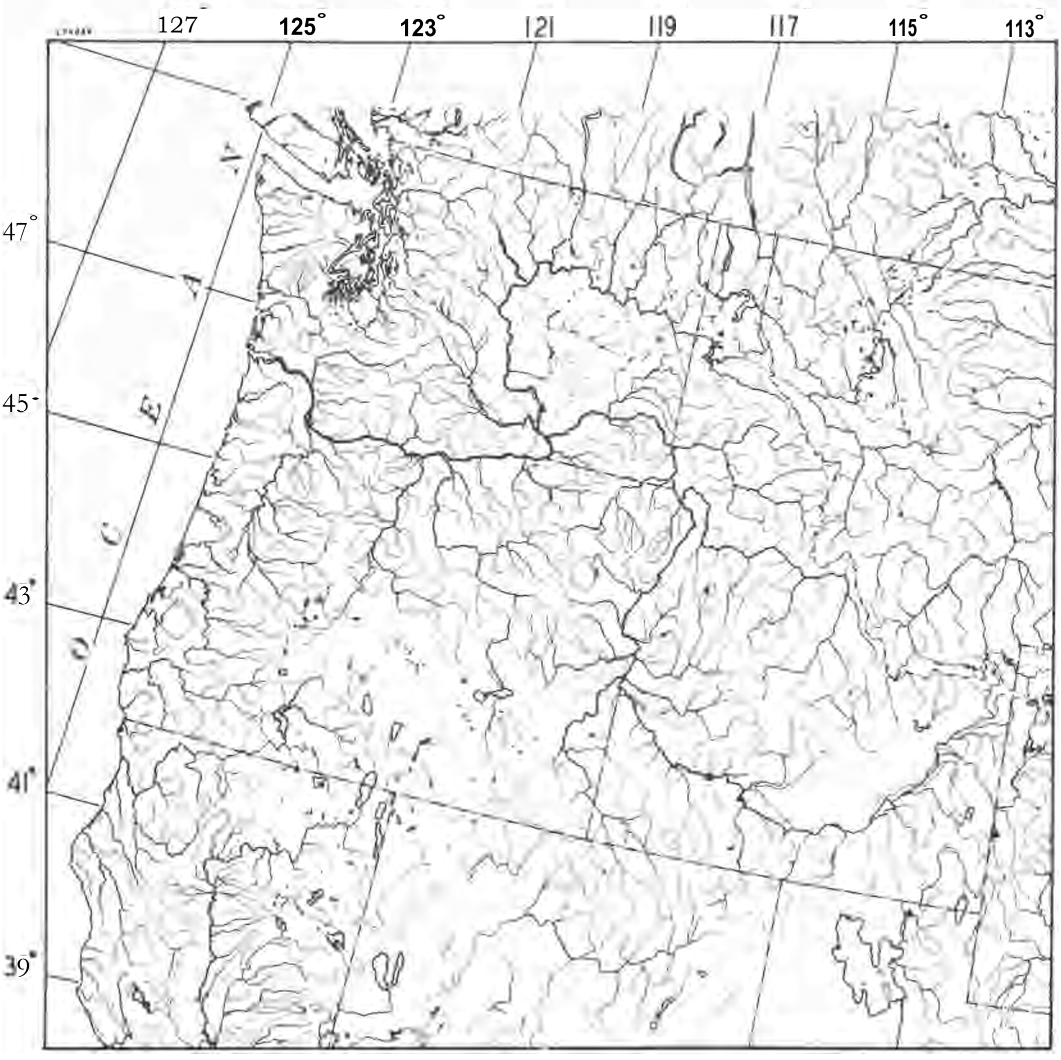


FIG. 13. Distribution of the freshwater snail *Omalodiscus pattersoni* (Baker), family Planorbidae, west of the continental divide in North America. Localities are from Taylor (1958), with addition of occurrence in the Ringold Formation recorded herein.

tuffaceous sandstone. J. D. Meyers. The fossils occur as molds with traces of shell remaining.

Sphaerium
Sphaerium: Newcomb, 1958a: 46
Payettiidae, indeterminate
Valvata
Valvata sp. undet.: Newcomb, 1958a: 46.
Juga?
Lithoglyphus
Amnicola: Newcomb, 1958a: 46
Lanx
Lanx cf *L. klamathensis* Hannibal:

Newcomb, 1958a: 46
Vorticifex
Parapholyx of *packardi* (Hanna): Newcomb, 1958a: 46
Lymnaea sp. undet.: Newcomb, 1958a: 46
Helisoma (Carinifex)
Carnifex: Newcomb, 1958a: 46
Vorticifex binneyi (Meek): Newcomb 1958a: 46
Physa
Physa sp. undet.: Newcomb, 1958a: 46

The preservation of the fossils is inadequate for specific identification, but general relationships are evident. The affinities of the fauna are entirely with other Blancan assemblages of the region. The *Helisoma (Carinifex)* is most like the species identified by Hanna and Gester (1963) from Butte Valley, California (Fig. 1, locality 2) as *Carinifex newberryi* (Lea). The *Vorticifex* is very large, attaining a width of 33 mm (slightly distorted internal molds), and in this respect is approached only by the large *Vorticifex* from the Summer Lake Basin (Fig. 1, locality 4). One internal mold of a pleurocerid shows traces of carination on the body whorl. It might represent *Juga,* living in the region, or else a species like *"Melania" taylori* from the Glenns Ferry Formation in southwestern Idaho (Fig. 1, locality 34).

Lower Klamath Lake basin

Hanna (1963: 17) recorded a large species of *Vorticifex* that is probably the same one found in the Yonna Formation of Yonna Valley, judging by size and proportions. The distribution of the formation in Lower Klamath Lake basin, Oregon, was shown generally by Newcomb (1958a: 43).

The southward extension of Yonna Formation in the Lower Klamath Lake basin, California, was described and mapped by Wood (1961: 35-38, pl. 1) as "diatomite (Pliocene)". Diatoms indicative of late Pliocene age occur both in this area of the Yonna Formation, California, and northward in Oregon. Wood identified the diatomite as "a continuation of the diatomite in the Klamath diatomite district" that Newcomb (1958a) described as Yonna Formation after Wood's manuscript was written.

The locality given by Hanna (1963: 17) as "Sec. 3, T 4 S, R 8 E" is probably an error for sec. 3, T 40S, R 8E. Fossils are in the CAS collections. Most recent topographic map: U. S. Geological Survey Klamath Falls quadrangle (1957) 1: 62500.

Tule Lake basin

Fossils in USGS collections from the Tule Lake basin have not been reported previously. Composition of the matrix is like that from Yonna Valley, and the map by Newcomb (1958a: 43) shows Yonna Formation in the immediate vicinity. Five species are represented, all aquatic. Moore (1937: 43-44) listed diatoms from the immediate vicinity. A Blancan age is assigned here. Fossils are in USGS collections. Most recent topographic map: U. S. Geological Survey Malin quadrangle (1957)1: 62500.

U. S. Geological Survey Cenozoic locality 7047. Klamath Co., Oregon. Malin quadrangle (1957) 1: 62500. Well near road from Tule Lake to Poe Valley, 4 1/2 miles north of state line. Fossils sent by Mr. Worden to Eugene Ricksecker. (About sec. 25, T 40 S, R 11 E).

Sphaerium n. sp., most similar to *S. idahoensis* Meek from the Glenns Ferry Formation, Idaho (Fig. 1, locality 34).
Pisidium ultramontanum Prime
Pisidium sp.
Lithoglyphus?
Vorticifex

4. Summer Lake, Oregon
(NK 10-6 [Klamath Falls] D-3,4)

Mollusks have been described or recorded from the Summer Lake basin by Waring (1908), Hannibal (1910, 1912b: 135, 136, 149, 158, 162, 163, 186, 197), Baker (1942) and Hanna (1963: 17-18). A fossiliferous unit, perhaps the one yielding some of the published material, was mentioned by Waring (1908: 24).

No geologic maps of stratigraphic data are available. Nearly 20 species are known, all aquatic. The genus *Paraplanorbis* is known only from the Warner Lake and Summer Lake basins. No other fossils have been described. A Blancan age is probable because nearly all species are extinct and not closely related to living species. Fossils are in SU and USGS collections. Most recent topographic map: U. S. Geological Survey Klamath Falls quadrangle (1958) 1: 250000.

Systematic Position of *Paraplanorbis*

The genus *Paraplanorbis* has been classified as a planorbid related to *Drepanotrema* (Pilsbry, 1934a; F. C. Baker, 1945; Zilch, 1959-1960). Harry and Hubendick (1964) have diagnosed the Drepanotrematinae, and included in the group only *Drepanotrema, Antillorbis* and probably *Acrorbis. Paraplanorbis* has thus been left temporarily without a home. I suggest it can be placed more reasonably in the Planorbulinae, beside *Menetus* and *Promenetus,* on the basis of material examined in USGS collections.

Especially characteristic features of *Paraplanorbis* are the closely coiled whorls, concave right side, narrow, deep pit on the left side and small size. The shell is coarsely sculptured with growth lines and thicker than that of *Drepanotrema.* None of the fossils seen are well enough preserved to show apical sculpture, which on the basis of the studies by Walter (1962) and unpublished observations by Walter and me would almost certainly enable one to determine whether the genus is closely related to *Drepanotrema.* The form, size and texture of the shell are all more like these features in *Menetus (s. s.), Menetus (Planorbifex)* and *Promenetus (Phreatomenetus)* than in presently recognized Drepanotrematinae.

5. Goose Lake, California-Oregon
(NK 10-9 [Alturas] D-2,
NK 10-6 [Klamath Falls] A-2)

Waring (1908: 30) briefly mentioned mollusks from the southeastern side of the lake. One vaguely located collection is known from "near Lakeview". Mollusks are the only fossils, and are recorded for the first time. About 8 species are represented, most of them endemic but with near relatives in the Summer Lake basin to the north (Fig. 1, locality 4). A Blancan age is assigned here. All material is in USGS collections. Most recent topographic maps: U. S. Geological Survey Klamath Falls quadrangle (1958) 1: 250000, Willow Ranch (1962) 1: 62500.

A single collection, USGS 10989, "lake beds near Lakeview", H. T. Stearns, 1926, provides the only evidence for Blancan mollusks in the basin. The general aspect of the assemblage is like that from the Summer Lake basin with which it is correlated. The species of *Valvata* and *Vorticifex* are most common and are related to those in the Summer Lake basin. Most of the species are undescribed, but formal naming would be unwise without precise locality information. Previously described species are *Pisidium compressum* Prime and *P. ultramontanum* Prime.

6. Warner Lakes, Oregon
(NK 11-4 [Adel] C-7, 8)

Hanna (1922) described mollusks from the vicinity of Warner Lake. No stratigraphic data are available, and not even precise locality data, for that collection or other material in USGS collections. The only fossils known are about 15 species of mollusks, all aquatic, most of them found also in the Summer Lake Basin (Fig. 1, locality 4). A Blancan age is probable because of the high percentage of extinct species. Fossils are in collections of the University of Oregon and USGS. Most recent topographic map: U. S. Geological Survey Adel quadrangle (1958) 1: 250000.

7. Danforth Formation, Oregon
(NK 11-1 [Burns] A-4)

The 2 known fossil localities are less than a quarter-mile apart, west of the Donner and Blitzen River on the south side of Harney Lake basin. Mollusks were listed previously by Piper et al. (1940: 48). The fossiliferous unit is shown as the basalitic breccia member of the Danforth Formation by Piper et al. (1940, pl. 2). The fauna includes about 10 species, perhaps as many as half still extant. No organisms besides mollusks have been described from this formation. The Danforth was tentatively assigned a Pliocene age by Piper et al. (1940); the mollusks are late middle Pliocene or late Pliocene. All fossils are in USGS collections. Most recent topographic map: U. S. Geological Survey Burns quadrangle (1959) 1: 250000.

Mollusks from the Danforth Formation

The following notes are intended mainly to correct previous records and to provide a basis for age assignment. A fuller description of the fauna would be premature without larger collections.

U. S. Geological Survey Cenozoic locality 12851 (F-18). Harney Co., Oregon. NW 1/4 NW 1/4 sec. 18, T 28 S, R 31 E. Unit 10 of Piper et al. (1940: 45). C. F. Park, Jr. The fossils are preserved as light-colored casts, more often as internal molds.

U. S. Geological Survey Cenozoic locality 22687 (R-25-61). Harney Co., Oregon. NW 1/4 NW 1/4 sec. 18, T 28 S, R 31 E. About 3/4 way up south face of isolated double-peaked butte, and about 30 feet below the olivine basalt that is unit 11 of Piper et al. (1940: 45). G. W. Walker et al., 1961. This collection was intended to be an additional sample from 12851, but the faunal differences are such that it came evidently from a slightly different spot. C. A. Repenning, one of the collectors, doubted there is more than 20 feet stratigraphic difference between the samples (letter dated January 23, 1962). The shells are mineralized, light gray, and some are worn as if transported before deposition.

Sphaeriidae

Pisidium spp. (locality 12851)

Pisidium sp.: Piper et al., 1940, U. S. Geol. Survey Water-Supply Pap., 841: 48.

Seven poorly preserved specimens represent more than one species, but cannot be identified.

Valvatidae

Valvata sp. n. (locality 12851).

One poorly preserved specimen represents a multicarinate species, neither *V. whitei* Hannibal nor *V. calli* Hannibal, described from Summer Lake basin, Oregon (Fig. 1, locality 4), nor any species known from Blancan or younger faunas of southern Idaho.

Hydrobiidae

Lithoglyphus hindsii (Baird) (localities 12851, 22687)

Fluminicola fusca Haldeman: Piper et al., 1940, U. S. Geol. Survey Water-Supply Pap., 841: 48, in part.

This occurrence is slightly outside the recent range of the species (see distribution map, Fig. 14), and the only known Blancan record. In southwestern Idaho many species of the genus are known in the Glenns Ferry Formation, but *L. hindsii* first appears in the geologic record in the Middle Pleistocene Bruneau Formation (Malde, 1965). If *L. hindsii* lived in southeastern Oregon while the Glenns Ferry Formation was being deposited, it probably lived in southern Idaho also, in environments not represented by known fossil localities.

Hydrobiidae? (locality 12851)

Fluminicola fusca Haldeman: Piper et al., 1940, U. S. Geol. Survey Water-Supply Pap., 841: 48, in part.

Poorly preserved specimens represent other species or genera of larger Hydrobiidae, or of Pliopholygidae.

Lymnaeidae

Lymnaea (Stagnicola) sp. n. (locality 12851)

Fossaria? sp.: Piper et al., 1940, U. S. Geol. Survey Water-Supply Pap., 841: 48.

Well-preserved material permits recognition of a small, slender species of *Stagnicola* with numerous coarse axial riblets. It is not close to any living

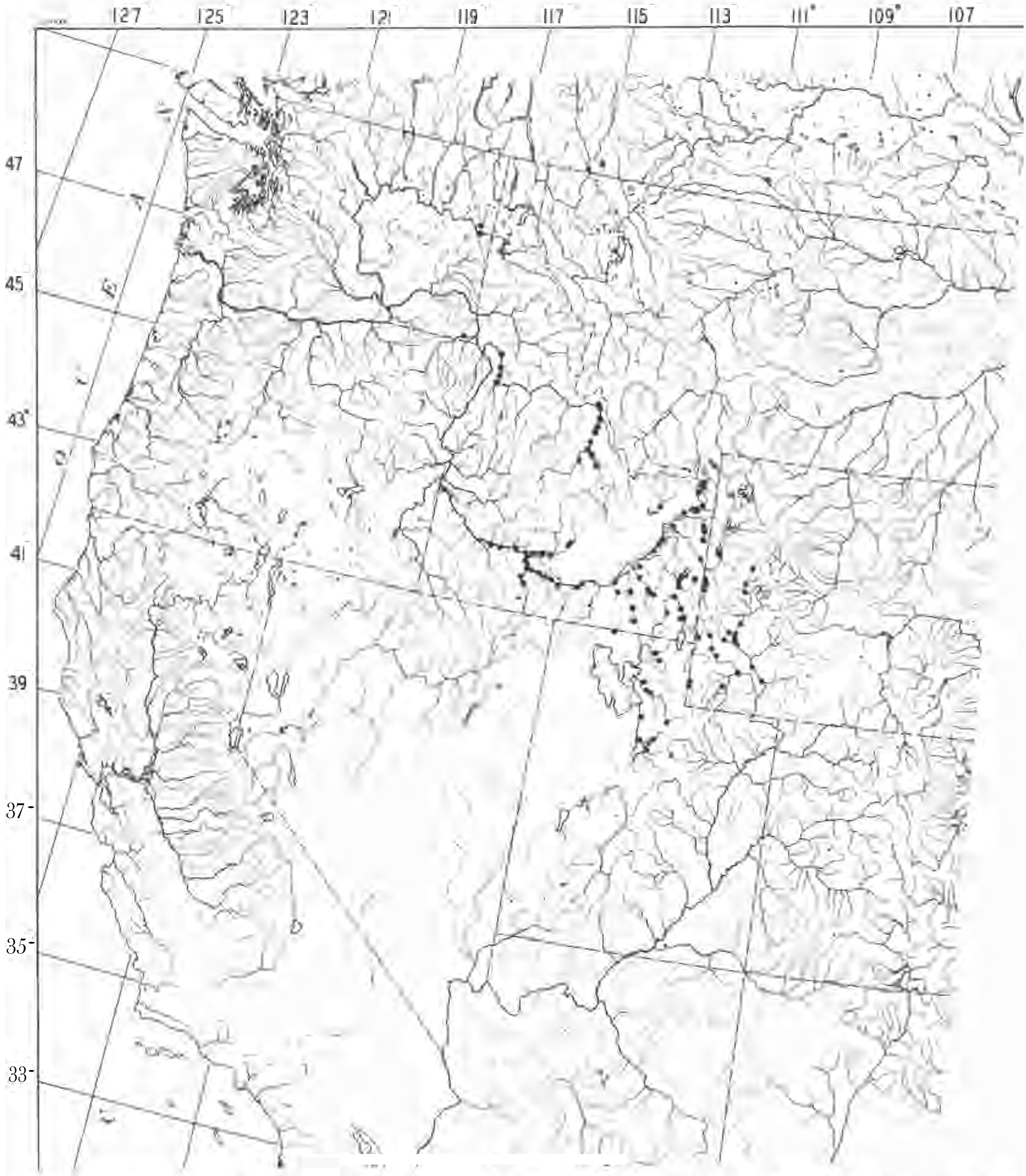


FIG. 14. Distribution of Lithoglyphus hindsii (Baird), 1863, family Hydrobiidae, a snail of creeks and rivers. From specimens in collections AGS, CAS, MCZ, SSB, SU, UCMNH, UMMZ, USGS, USNM and WOG; and from published records by Carpenter (1864). Included as synonyms are Fluminicola coloradoense Morrison (1940), *F.* fusca of practically all authors except Haldeman (1841), the original describer, and Anculotus nuttalii Reeve (1861). The numerous Pleistocene records are not shown; there are many in northwestern Utah in the deposits of Lake Bonneville. The record by Henderson (1936a: 139) from the Clearwater River, Spalding, Nez Perce Co., Idaho was based on *L.* nuttallianus *(Lea)* as determined by a series examined alive (DWT T63012601). The triangle west of the area of living occurrences (dots) marks the fossil occurrence in the Danforth Formation.

species. The nearest described forms are *L. albiconica* Taylor and *L.filocosta* Hanna, known from Pliocene rocks in California, Arizona, Wyoming and Idaho. An even closer similarity is shown by the species listed by Carr and Trimble (1963: G13) as *Stagnicola* n. sp. from the Starlight Formation of early to middle Pliocene age in southeastern Idaho.

Lymnaea (Stagnicola) hinkleyi Baker (locality 22687)

This is the oldest record of this extant species, common in the Snake River of southern Idaho and adjacent Oregon. Its ecological implications are significant, for it is strictly a large-stream species. In the Snake River drainage it is found only in the Snake River and its largest tributaries in east-central Idaho. Such superficially suitable rivers flowing into the Snake, as the Teton, Salt, Blackfoot, Portneuf, Bruneau, Malad and Owyhee, do not contain this species nor any other representative of the *Lymnaea emarginata* group of *Stagnicola.* Hence at the time this part of the Danforth Formation was being deposited a perennial river of considerable size probably was in communication with the Snake River of southern Idaho. This evidence alone is inadequate to suggest whether the stream was the Snake River, flowing westward from southern Idaho, or whether it was an eastward-flowing tributary of the Snake.

Lymnaea (Stagnicola) sp. (locality 12851)

Three specimens may be unusually broad and short-spired variants of *Lymnaea (Stagnicola)* n. sp., but probably are another species. Sculpture is poorly preserved, but seems to have been coarse.

Planorbidae

Helisoma (s. s.) anceps (Menke) (locality 22687)

This is the oldest record of this extant species from west of the Continental Divide. It is known by late Pleistocene fossils from several localities in southeastern Idaho, but the nearest living occurrences are in the Columbia River drainage of northern Idaho, northern Oregon, Washington and Montana.

If the populations of *Helisoma anceps* in the Snake River drainage were derived from the upper Missouri River drainage of western Montana, then these fossils from locality 22687 indicate that the transfer is at least as old as Blancan times.

Vorticifex cf *V. tryoni* (Meek) (locality 12851)

Pompholix ?sp.: Piper et al., 1940, U. S. Geol. Survey Water-Supply Pap., 841: 48.

Several specimens represent a species of *Vorticifex* that is distinct from any known from Oregon or Idaho. It is most similar to *V. tryoni* (Meek), from the Pliocene Truckee Formation of the Hot Springs Mountains, Nevada (Yen, 1950), but pending a revision of the numerous and variable species of this genus the proposal of a new name is unwise.

Promenetus umbilicatellus (Cockerell)? (locality 12851)

"*Gyraulus parvus* Say": Piper et al., 1940, U. S. Geol. Survey Water-Supply Pap., 841: 48.

This species is widespread today in much of North America (see distribution map in Hibbard and Taylor, 1960: 112) and known from rocks as old as middle Pliocene in southeastern Idaho (Carr and Trimble, 1963: G13). *Planorbis scabiosus* Hanna (1922) maybe this same species; if so it is the only one common to the Warner Lake area (Fig. 1, locality 6) and to the Danforth Formation.

The below summary of the stratigraphic and geographic distribution of the mollusks in the Danforth Formation, or of their near relatives, reveals the mixed affinities of the fauna. There are no species forming a clear link with the known Blancan faunas of the geographically nearest areas—southwestern Idaho or southern Oregon—but instead with the Recent fauna of the Snake River and the Pliocene of northwestern Nevada. The balance of these affinities makes reasonable a Blancan age assignment,

Danforth Formation species	Geographic affinities
Pisidium spp.	
Valvata sp. n.	Nearest relative late Pliocene, NW Nevada
Lithoglyphus hindsii (Baird)	Extant in Snake River, Idaho; unknown fossil or living in Harney Basin
Hydrobiidae?	
Lymnaea (Stagnicola) n. sp.	Nearest relative middle Pliocene, SE Idaho
Lymnaea (Stagnicola) hinkleyi Baker	Extant in Snake River, Idaho; unknown fossil or living in Harney Basin
Lymnaea (Stagnicola) sp.	
Helisoma (s. s.) anceps (Menke)	Extant in northern Columbia River drainage; late Pleistocene in SE Idaho; unknown otherwise in Harney Basin
Vorticifex cf *V. tryoni* (Meek)	Nearest relative early to middle Pliocene, NW Neveda
Promenetus umbilicatellus (Cockerell)	Widespread in North America

but if this is correct and if other Blancan faunas listed herein are correlative, then there was great diversity among the aquatic mollusks of adjacent basins within a geologically short interval. Such differences could be explained by the effects of geographic isolation coupled with evolution of locally endemic faunas, and with a narrow restriction of species to their habitats so that facies differences accentuated those due to provinciality.

Leaving aside paleontological sources of age assignment, there remains physical and stratigraphic evidence. In the Danforth Formation the mollusks occur in the basaltic breccia member, below the rhyolitic tuff breccia member (Piper et al., 1940: 47). Campbell et al. (1958) correlated the latter with the widespread rhyolite of the Rattlesnake Formation (Merriam et al., 1925), dated 6.4 million years old (Evernden et al., 1964, sample KA 1206). This date provides a minimum age for the mollusks, if both the local stratigraphy and relationship of the rhyolites are correctly understood. This age would seem to show that the extinct species in the Danforth, with relatives in the middle Pliocene, provide a more reliable clue to age than does a balance between the extinct and surviving species.

8. Tehama Formation, California
(NJ 10-2 [Ukiah] A-1)

The one known fossil mollusk locality is on the west side of the Sacramento Valley, 17 miles southwest of Colusa. Mollusks are reported here for the first time. The formation has been described and mapped by Anderson and Russell (1935), and is shown as nonmarine upper Pliocene on the Geologic Map of California, Olaf P. Jenkins editions, Ukiah sheet (1960) 1: 250000. Mammals from the Tehama Formation have been described by Russell and Vander Hoof (1931) and Vander Hoof (1933). A widely recognized pink dacitic tuff, the Nomlaki Tuff, occurs near the base of the Tehama Formation and has yielded a K/A radiogenic date of 3.3 million years (Evernden et al., 1964, sample KA 587). Fossils are in UCMP collections. Most recent topographic map: U. S. Geological Survey Colusa quadrangle (1953) 1: 62500.

Mollusks from Tehama Formation

UCMP locality B-930. Colusa County, California. Colusa quadrangle (1953) 1: 62500. North edge of NE 1/4 sec. 4, T 13 N, R 3 W. High steep bluff on north side of tributary to Sand Creek. Shells from pieces of float in wash bed, coming from bluff, near middle of Tehama Formation. H. I. Dobbins, 1954.

Unionidae
Anodonta wahlamatensis Lea
Sphaeriidae
Pisidium compressum Prime
Hydrobiidae
"Hydrobia"
Savaginius yatesianus (Cooper)

This small assemblage couldbe duplicated in the Santa Clara Formation (Fig. 1, locality 11) and is much like that reported from the San Benito Gravels (Fig. 1, locality 15). The geographic range of the extinct *Savaginius* species, and the contrast of the assemblages mentioned with those from the Petaluma Formation (Fig. 1, locality 10) or Purisima Group (Fig. 1, locality 14), lend credence to correlation of the mollusks from the Tehama, Santa Clara and San Benito localities.

9. Cache Formation, California
(Santa Rosa D-3, Ukiah A-2, A-3)

Mollusks from the Cache Formation have been listed or mentioned by Becker (1888: 220-221), Hannibal (1912b: 126, 127, 131, 136, 165, 186, 197) and Anderson (1936). Distribution of the Cache Formation is shown by Brice (1953), and the Geologic Map of California, Olaf P. Jenkins edition, Santa Rosa sheet (1963) and Ukiah sheet (1960). Nine species of mollusks were recorded by Hannibal, but no descriptions or illustrations have been published and previous literature is insufficient to identify any species by modern standards. Other fossils known from the formation include diatoms and a questionably identified mammoth (Anderson, 1936), and fragmentary remains of other mammals (Becker, 1888: 221). The age assignment of late Pliocene and early Pleistocene (Geologic Map of California) is accepted here. The mammoth, if correctly identified, indicates an age later than earliest Pleistocene for part of the formation. The fossils identified by Stearns and recorded by Becker (1888) have not been found in USNM or USGS collections. Most recent topographic maps: U. S. Geological Survey quadrangles, Clearlake Oaks (1960) 1: 62500, Lower Lake (1958) 1: 24000.

Mollusks from Cache Formation

USGS Cenozoic locality 222. Lake County, California. Grizzly Canyon, near Grigsby's (probably about sec. 2 or 3, T 14 N, R 6 W). Cache Formation. H. W. Turner.

This material, all that is in USGS collections from the Cache Formation, includes the following species:

Unionidae
Anodonta wahlamatensis Lea (Pl. 1, Fig. 5, 7)
Sphaeriidae
Pisidium compressum Prime
Valvatidae
Valvata humeralis Say
Hydrobiidae
Hydrobia? cf *H.? andersoni* Arnold
Planorbidae (fragment)
Physidae
Physa

10. Petaluma Formation, California
(NJ 10-5 [Santa Rosa] A-3, B-3)

Fossil mollusks occur in the valley of Petaluma Creek within a radius of about 5 miles of Petaluma. Dickerson (1922), Hanna (1923), Osmont (1905) and Weaver (1949a,b) recorded 12 species of freshwater and brackish-water mollusks. The Petaluma Formation was described and mapped by Dickerson (1922), Morse and Bailey (1935) and Weaver (1949a,b) and is shown on the Geologic Map of California (Olaf P. Jenkins edition) Santa Rosa sheet (1963) 1: 250000. Other nonmarine fossils known from the formation include a few mammals (Stirton, 1939, 1952) and plants (Axelrod, 1944a; Dorf, 1930: 16-17). The late Hemphillian age assigned by Stirton (1952) to the main body of the formation is accepted here. Fossil mollusks are in CAS and USGS collections. Most recent topographic maps: U.S. Geological Survey quadrangles (1954) 1: 24000: Cotati, Glen Ellen, Kenwood and Petaluma River.

Localities

More accurate topographic maps, and changes in place names used previously to describe the fossil localities, make desirable revised locality descriptions. All sites are in Sonoma County, California.

1. Cotati quadrangle (1954) 1: 24000. Sec. 33 or 34, T 6 N, R 7 W. Valley of Lichau Creek about 2 miles northeast of Penngrove. Osmont (1905: 62) recorded *Corbicula* near the headwaters of Petaluma Creek, 2 miles northeast of Penngrove. This may well be the same spot recorded by Dickerson (1922: 542) as on upper Lichau Creek.

2. CAS locality 417 (USGS 23269). Cotati quadrangle (1954) 1: 24000. Sec. 9, T 5 N, R 7 W, unsurveyed. Willow Brook (formerly Haggin Creek) about 200 ft below (southwest) of bridge on Adobe Road 1 mile southeast of Penngrove.

3. Glenn Ellen quadrangle (1954) 1: 24000. T 5 N, R 7 W, unsurveyed. Lynch Creek, no specific locality (Weaver, 1949a: 89; 1949b: 45).

4. CAS locality 415. Glen Ellen quadrangle (1954) 1: 24000. Sec. 14, T 5 N, R 7 W, unsurveyed. Unnamed canyon 2.1 miles N 26° E of Payran (formerly Elmore) School, and 0.4 mile southeast of road to Mountain School. This may be the locality mentioned by Weaver (1949a: 89) as in MountainSchool creek.

5. UCMP locality 1036. Glen Ellen quadrangle (1954) 1: 24000. Sec. 12, T 5 N, R 7 W, unsurveyed. Old coal mine about 100 yards southeast of Lawler Ranch house on hillside west of barn. Type locality of *Neohipparion gidleyi* Merriam. Indeterminate mollusks mentioned by Osmont (1905: 57).

6. CIT locality 134. Glen Ellen quadrangle (1954) 1: 24000. Sec. 29, T 5 N, R 6 W, unsurveyed. West bank of gulch 1000 ft N 68°E from Witt-Decker No. 2 oil well and 8400 ft due east of Petaluma Adobe State Historical Monument. *Neohipparion* cf *N. gidleyi* Merriam (Morse and Bailey, 1935: 1447).

7. CAS locality 418. Petaluma River quadrangle (1954) 1: 24000. About sec. 29, T 5 N, R 6 W, unsurveyed. Ravine 0.4 mile S 20° W from Sartori ranch house; mollusks (Hanna, 1923). The locality has not been relocated precisely.

8. UCMP locality V3647. Petaluma River quadrangle (1954) 1: 24000. Sec. 5, T 4 N, R 6 W, unsurveyed. Road cut on southeast side of Stage Gulch Road at head of Stage Gulch. Horse (Stirton, 1939: 389-390).

9. Petaluma River quadrangle (1954) 1: 24000. Sec. 5, T 4 N, R 6 W, unsurveyed. "Middle of the first large road cut along the county road, directly east of the Lakeville School"; plants recorded by Axelrod (1944a).

10. UCMP locality P 158. Petaluma River quadrangle (1954) 1: 24000. Sec. 8, T 4 N, R 6 W, unsurveyed. "Exposure of buff-colored, tufaceous sandstone a half mile southeast of Lakeville in a cut on the dirt road which runs eastward a quarter mile south of that town"; plants recorded by Dorf (1930).

11. UCMP B-1372. Kenwood quadrangle (1954) 1: 24000. SW 1/4 sec. 35, T 8 N, R 7 W, in road cut 0.1 mile from house at end of road. D. Rose, 1954. *Coretus,* referable to *C. Nenus* (Hanna).

12. UCMP locality V-5230. Kenwood quadrangle (1954) 1: 24000. South center of NE 1/4 sec. 10, T 6 N, R 7 W, in northwest-facing exposure on ridge 1/2 mile S 20° E of Jacobs Ranch. Matrix is brownish gray mudstone of a sequence of slumping mudstones and fine-grained sandy sediments mapped as approximately the top of the Petaluma Formation here. Leo Herrera and Wayne Moen, 1952. Plesippine *Equus,* Blancan.

13. UCMP locality V-5231. Mare Island quadrangle (1942 CE) 1: 62500. Progressive grid coordinates 859,300-1,718,100; 3000 yards northwest of Sears Point road junction of state highways 48 and 37. Fossil at 350-400 ft elevation on east wall and near head of small valley that parallels Tolay Creek for 1.2 miles and then joins that creek just

east of highway 37 and 700 yards north of Sears Point junction. Mapped as Merced Formation by Weaver (1949a,b) but probably Petaluma Formation. Plesippine *Equus*, Blancan.

Molluscan Fauna

The following revised list of the mollusks of the Petaluma Formation includes both limited taxonomic revision and nomenclatural changes.

Sphaeriidae
- *Sphaerium cynodon* Hanna
- *Pisidium compressum* Prime

Corbiculidae
- *Corbicula gabbiana* Henderson

Hydrobiidae
- *Nematurella euzona* Hanna

Pleuroceridae
- *Juga chrysopylica* Taylor, new name

Lymnaeidae
- *Bulimnea petaluma* Hanna (probably includes *Lymnaea contracosta* Cooper as recorded by Hanna)
- *Lymnaea filocosta* Hanna
- *Lymnaea limatula* Hanna

Planorbidae
- *Coretus plenus* (Hanna)
- *Gyraulus pleiopleurus* (Hanna)

Physidae
- *Physa*

Juga chrysopylica Taylor, new name

1922 "*Bittium rodeoensis* (Clark)": Dickerson, Proc. Calif. Acad. Sci. , ser. 4, 11: 542.
1923 "*Goniobasis rodeoensis* (Clark)": Hanna, Proc. Calif. Acad. Sci., ser. 4, 12: 34, pl. 1, fig. 3.
1935 "*Goniobasis rodeoensis* (Clark)": Henderson, Spec. Pap. geol. Soc. Am., 3: 45, 268.
1949 "*Goniobasis rodeoensis* (Clark)": Weaver, Mem. geol. Soc. Am. ,- 35: 89-90.
1949 "*Goniobasis rodeoensis*": Weaver, Bull. Calif. Div. Mines, 149: 46.
1952 "*Bittium rodeoensis* (Clark)": Stirton, Bull. Am. Assoc. Petrol. Geol. , 36: 2014.

The genus *Juga* H. and A. Adams (1854) has scarcely been used since its proposal. The type designation by H. B. Baker (1963c) fixes it on the group of Pleuroceridae living in northwestern North America, for which no other generic name is surely available, although *Namrutua* Abbott (1943) of China is possibly synonymous. Separation of the western American species as a genus from the eastern American forms would not be justified on shell characters alone; *Juga* is distinguished by the structure of the oviducal groove.

The species of *Juga* found in the Petaluma Formation has been recorded consistently as "*rodeoensis*" of B. L. Clark (1915; described as *Cerithium).* Study of the holotype and a paratype of Clark's species (Pl. 1, Figs. 1-4) convinces me that they are not Pleuroceridae, but probably Potamididae. Particularly distinctive features are the shouldered whorls that are relatively wide for their height, the gently inclined suture and the strongly sinuous growth line. The illustrations published by Hanna (1923), as well as specimens collected personally from the Petaluma Formation, clearly represent one of the Pleuroceridae and hence a species lacking a valid name. *Juga chrysopylica* is proposed here as a substitute for *"Goniobasis rodeoensis"* of Hanna (1923), not of Clark (1915). The specific name comes from the Greek words meaning Golden Gate.

The grouping of species of *Juga is* most practicable by the ontogeny of sculpture. This conclusion comes partly from study of *Juga,* partly from experience with other genera and families, and supports the opinion of Henderson (1936b). Among the living species 3 groups can be recognized that are formalized here as subgenera, but the Petaluma species represents still another subgenus.

PLEUROCERIDAE

Juga H. and A. Adams, 1854

Genera of Recent Mollusca, 1: 304. Type (H. B. Baker, 1963, Nautilus, 77: 35): *Melania silicula* Gould. The

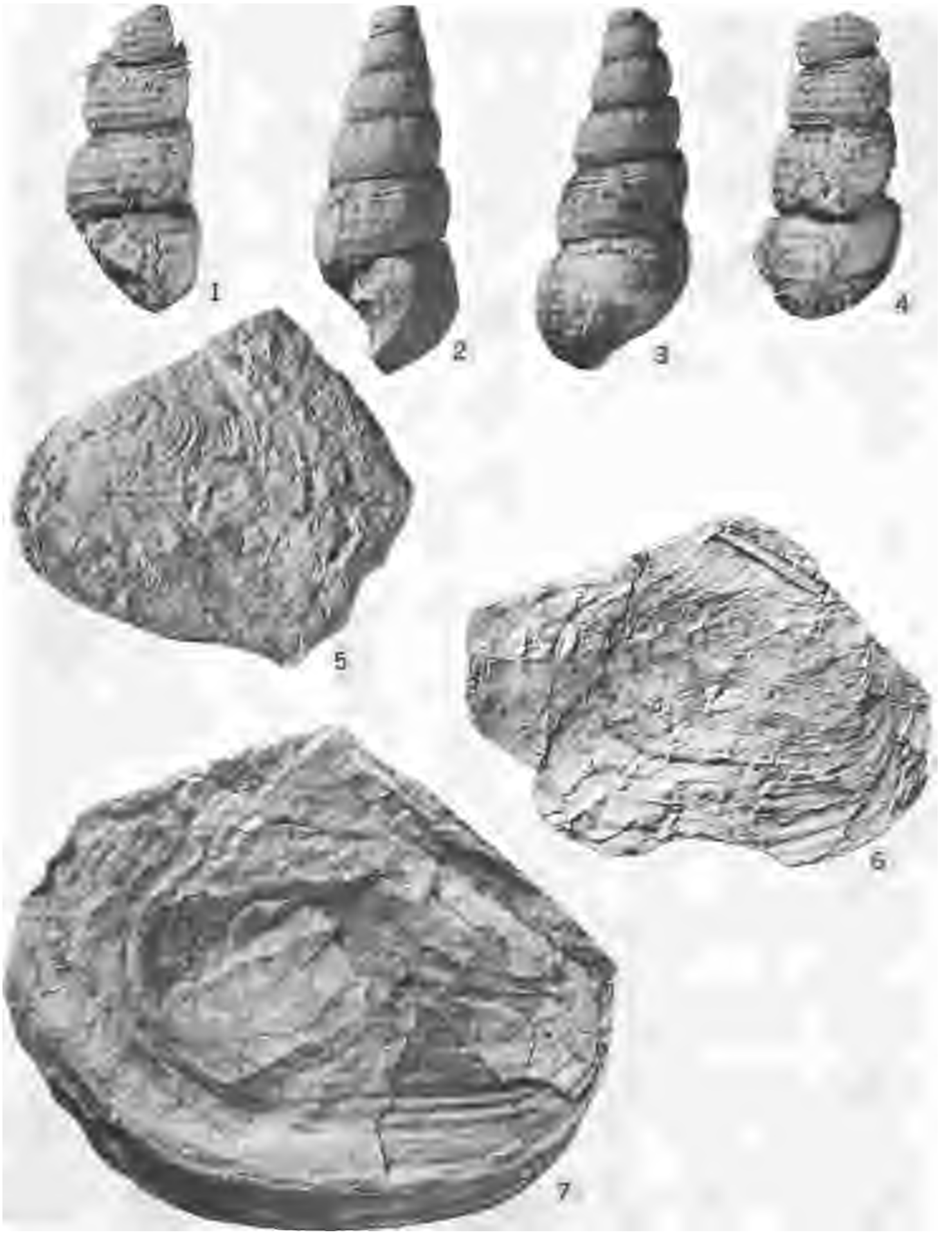


PLATE 1

FIGS. 1-4. *"Cerithium" rodeoense* Clark, X 3. Figs. 1, 4, UCMP 1617/11652, paratype. Figs. 2, 3, UCMP 1617/11651, holotype.

FIGS. 5-7. *Anodonta wahlamatensis* Lea, X 1. Figs. 5, 7, USGS Cenozoic locality 222, Cache Formation, Lake County, California. Figured specimens, USNM. Fig. 6, USGS Cenozoic locality 21061, Santa Clara Formation, Santa Clara County, California. Figured specimen, USNM.

prior designation by Hannibal (1912b: 174) of *Buccinum virginicum* Gmelin as type species is invalid, for that species was not originally listed in the genus.

The shell is turriform, 20-50 mm long, with an elongate, oval aperture, simple lip and gently sinuous growth line. It may be smooth except for growth lines, or strongly plicate, lirate or cancellate. Color in the shell may be evenly distributed, or in a few spiralbands. Operculum paucispiral. Mantle edge smooth. An oviducal groove on the right side of the body stalk extends ventrally to the sole. At about the level of the operculum (when the snail is crawling) the groove flares into a broad, shallow triangular depression overhung along its anterior border by a flap of tissue.

Subgenus *Juga s. s.*: The first 1-3 whorls are smooth; then strong ribs that may be shouldered appear. Fine spiral cords may occur on later whorls, especially marked on and below the periphery. The spiral cords override the axial ribs without change in strength, and are conspicuously narrower and lower than the ribs. Recent distribution, northern California to Washington, U. S. A.; also China, if *Namrutua* Abbott (1948) is a synonym.

Subgenus *Calibasis* Taylor, new subgenus: Sculpture begins as a peripheral carina to which others, equally strong, are added. The spiral ridges become relatively high and waved, especially on the shoulder, giving a frilly appearance. Spiral sculpture may be lost on later whorls, so that decollate adults show no trace of it. Type: *Juga acutifilosa* (Stearns), 1890. Recent distribution, northern California, in the Sacramento River and Great Basin drainages.

Subgenus *Oreobasis* Taylor, new subgenus: Sculpture consists only of fine growth lines at all stages of growth. Type: *Melania newberryi* Lea, 1860, probably a synonym of *Melania bulbosa* Gould, 1847. Recent distribution: northern California to Washington, U. S. A.

Subgenus *Idabasis* Taylor, new subgenus: Sculpture begins as a peripheral carina to which spiral ridges and axial ribs are soon added, giving the early whorls a cancellate or reticulate appearance. On later whorls only the ribs or only spiral cords may be present. The early ribs distinguish this group from some species of *Calibasis* that may be otherwise similar in adult sculpture. Type: *Juga chrysopylica* Taylor. Known only from Pliocene rocks in California and Idaho.

According to this subdivision of *Juga* the Petaluma species is not closely related to any of the geographically nearby forms. The only other species in the subgenus *Idabasis* occur in the Glenns Ferry Formation, southwestern Idaho (Fig. 1, locality 34). One of these species was recorded (Taylor, 1960a) as *Ceriphasia* aff *C. acutifilosa* (Stearns) before the critical significance of sculptural ontogeny was appreciated.

11. Santa Clara Formation, California (NJ 10-8 [San Francisco] B-1, C-2, NJ 10-9 [San Jose] A-8, B-8, C-8, NJ 10-5 [Santa Rosa] A-6)

Mollusks from the Santa Clara Formation have been recordedby Cooper (1888, 1894a, b), Arnold (1908), Branner et al. (1909), Hannibal (1909, 1910, 1911, 1912b), Pilsbry (1935) and Glen (1960). Distribution of the Santa Clara Formation has been mapped by Branner et al. (1909) and Lawson (1914), and is shown by the Geologic Map of California, Olaf P. Jenkins edition, San Francisco sheet (1961). About 15 species are known. Other described fossils include 17 species of plants (Hannibal, 1911; Chaney, 1925: 45; Dorf, 1930; Axelrod, 1944b: 216-217). The transitional latest Pliocene-earliest Pleistocene age assigned to the Santa Clara Formation (Geologic Map of California) is accepted here. Fossils are in ANSP, CAS, SU, UCMP and USGS collections. Most recent topographic maps: U. S. Geological Survey quadrangles, 1: 24000: Cupertino (1961), Los Gatos (1953), Milpitas (1961), Mountain View (1961), Niles (1961), Palo Alto (1961), Petaluma Point (1959), San Jose East

TABLE 2. Distribution of mollusks in the Santa Clara Formation

Locality	W side Sta. Clara valley		Subsurface					E side Sta. Clara valley	
	Los Gatos	22330				2 575	abloBay	Mission San Jose	2 061
Anodonta wahlamatensis Lea (pl. 1, fig. 6)									X
Sphaerium									X
Pisidium casertanum (Poli)			?						
Pisidium compressum Prime		X	X	X					?
Lithoglyphus sanmateoensis (Glen)		TL							?
Savaginius yatesianus (Cooper)			X	X	X		X	TL	X
Savaginius aff *S. yatesianus* (Cooper)	X								
Pyrgulopsis tropidogyra Pilsbry	TL								
Lymnaea			X			X			
Gyraulus circumstriatus (Tryon)			X			X			
Menetus centervillensis (Tryon)			X		X				
Helisoma sanctaeclarae (Hannibal)	TL								X
Planorbella (Pierosoma)			X						
Vorticifex durhami (Glen)		TL							

X = occurrence
TL = type locality

(1961), San Mateo (1956).

Mollusks from Santa Clara Formation

The mollusks in USGS collections from surface outcrop of the Santa Clara Formation are summarized in Table 2. Subsurface occurrences from probably equivalent rocks in the Santa Clara Valley and San Pablo Bay are included.

Localities

21061 (UCMP V5313). Santa Clara Co., California. San Jose quad. (1943) 1: 62500. Prog. grid coordinates 913,700-913,900 E, 1,632,400-1,632,500 N. 500 ft elev. Medium bedded silty sand and sandy silt with some clay shale lenses, moderately to poorly indurated, tilted and faulted. Exposures in a large aggregate quarry on north side of Scott Creek. D. W. Taylor, 1957.

22330 (CAS locality 36724). San Mateo Co., California. San Mateo quad. (1956) 1: 24000. 300 yards N 45° W of entrance on Skyline Blvd. to Skyline Materials Plant No. 1. Gray fossiliferous mudstone. N. J. Silberling, D. Jones, 1960. Locality from which fossils were described by Glen (1960).

22865. Santa Clara Co., California. Mountain View quad. (1953) 1: 24000. NW 1/4 sec. 24, T 6 S, R 2 W, unsurveyed; 3400 ft W of east section line, about 900 ft S of extended north line. Well 6S/2W-24C7, at intersection of Bayshore Highway and Mountain View-Alviso highway, BM 38. Depth 759.8-760.3 ft. USGS Ground-Water Branch, 1960.

22866. Same well, depth 872.0 ftplus.

22867. Same well, depth 937.8-938.2 ft.

23575. Santa Clara Co., California. San Jose East quad. (1961) 1: 24000. NW 1/4 sec. 16, T 7 S, R 1 E, unsurveyed. Well 7S/1E-16C6, about 500 ft north of

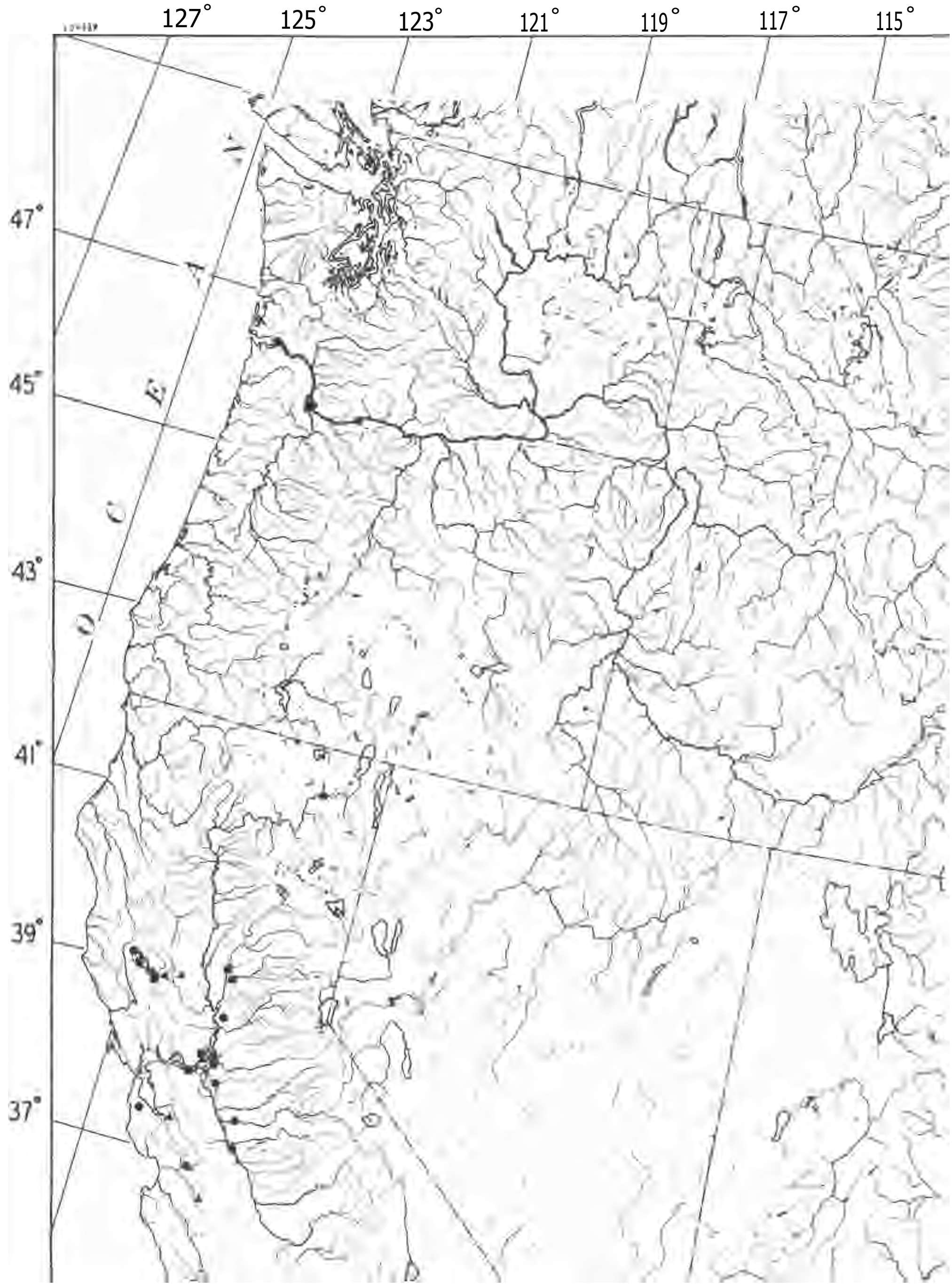


FIG. 15. Distribution of *Anodonta wahlamate,;sis* Lea, 1838, family Unionidae, a freshwater mussel of lakes and rivers. From specimens in collections AGS, CAS, SSB, UCMNH, UCMP, USGS, USNM and WOG; except that the southernmost triangle is based on a record by Wilson (1943). Living, dots; fossil, triangles. All fossil occurrences are Blancan.

corner of 12th and Martha Streets, San Jose, depth 834 ft. USGS Ground-Water Branch, 1963.

Mission San Jose. Type locality of *Savaginius yatesianus* (Cooper, 1894a). The locality was assigned by C. A. Hall (1958) to the Irvington Gravels, not Santa Clara Formation.

Near Los Gatos. Type locality of *Helisoma sanctaeclarae* (Hannibal, 1909) and *Pyrgulopsis tropidogyra* Pilsbry (1935).

Sonoma Co., California. Petaluma Point quad. (1959) 1: 24000. Tubbs Island, San Pablo Bay. Specimens in the collection of A. G. Smith (no. 9237), from Tidewater-Associated Oil Co. seismohole 46A-157, given by Charles Sturz, 1952.

Distribution of *Anodonta wahlamatensis*

The fossil record of *Anodonta wahlamatensis* is relatively full compared with the number of known modern occurrences, and compared with the fossil record of most other living species of freshwater mollusks. Consideration of its ecology, and both Recent and fossil distribution, supports previous ideas about drainage changes in the California Coast Ranges and shows that its present distribution is geologically significant.

Figure 15 shows the known distribution of *Anodonta wahlamatensis*. The collections examined include most of the known specimens, and are adequate to show that *A. wahlamatensis* is unusual among western American species of the genus in its widely disjunct distribution. Virtually all others inhabit a single drainage, or contiguous drainages. The restriction to lakes and large streams may be due to its own habitat requirements, but is probably influenced more by ecology of the fishes that are its larval hosts. Judging by the distribution of the mussel, R. R. Miller (personal communication, 1965) considered the cyprinid *Ptychocheilus* as a highly probably host.

In central California *A. wahlamatensis* is known from 4 structural basins. The fossil record shows that the species was in Clear Lake basin, the San Benito-Santa Clara Valley and the Sacramento Valley during Blancan time, and presumably has survived in these places since. The occurrences in the San Benito-Santa Clara Valley are significant because of their bearing on previous interpretations of drainage history in that area.

The southernmost records of *Anodonta wahlamatensis* are in the San Benito River drainage, draining into Monterey Bay by way of the Pajaro River. If these outlying occurrences were formerly continuous with the main range of the species, and if it has spread only through lakes and large streams such as it inhabits today, then there was a drainage connection northward from the San Benito Valley at or before the time of deposition of part of the San Benito Gravels (probably early or middle Pleistocene).

Drainage relationships of San Benito Valley and Santa Clara Valley have been considered by Allen (1946), Branner (1907), W. W. Clark (1924), Savage (1951) and Snyder (1913) on the basis of geology and fish distribution. Branner (1907) thought the similarity of fish faunas in the Pajaro River drainage (tributary to Monterey Bay) and in the Santa Clara Valley (tributary to San Francisco Bay) could be explained by shifts in the course of Coyote Creek. This tributary of the Santa Clara Valley probably has been alternately connected with the Santa Clara Valley to the north, and the Pajaro River drainage to the south. Such an explanation of fish distribution might seem an adequate hypothesis to account for the occurrences of the mussel, yet the fossil record shows the mussel distribution is substantially older than the geologically young lower course of Coyote Creek.

Inferences from the composition of sediments of the Santa Clara Formation provide independent suggestion of former drainage connection between the San Benito Valley and the Santa Clara Valley. "The possibility is strongly suggested, however, that some of the Irvington rocks were derived from the area of San Juan Bautista-Hollister-San Benito and that during the early Pleistocene there was an integrated drainage straight through from the San Benito Valley to San Francisco Bay, as Lawson proposed" (Savage, 1951: 224). These geologic data corroborate the inferences from mussel distribution about former drainage continuity. Seemingly icthyologists have assumed a younger spread of fish faunas in the area than is probable, through belief in relatively rapid differentiation of species.

12. Tassajero Formation, California
(NJ 10-9 [San Jose] D-8)

Stearns (1881: 109) mentioned the snail *Carinifex* from a locality that is probably in the Tassajero Formation of Clark (1933). C. A. Hall (1958) mapped Orinda Formation in the area, but did not mention Clark's Tassajero Formation. The fossils recorded by Stearns were collected by J. G. Cooper, and were formerly in the State Geological Survey collection at the University of California.

The locality recorded by Stearns is in the "hills north of Martin's, near Tassajara". Several landowners named Martin are shown in the vicinity by the "Official map of Alameda County, California, compiled from official surveys and records and private surveys and published by authority of the Board of Supervisors of Alameda County by C. F. Allardt, C. E. 1874. Scale forty chains (2640 ft or half mile) to the inch". The settlement of Tassajara is not shown on the companion map of Contra Costa County, but presumably was along the lower course of Tassajara Creek. Probably Stearn's locality is in the southwestern part of the U. S. Geological Survey Tassajara quadrangle (1953) 1: 24000.

A Blancan age is plausible but not certain for part of the Tassajero Formation. Near Walnut Creek (San Francisco D-1) Savage (1948) reported a Blancan horse from what might be the same unit. This occurrence is consistent with the middle Pliocene to early Pleistocene age that Clark (1933) assigned to the Tassajero Formation.

13. Livermore Gravels, California
(NJ 10-9 [San Jose] C-7, C-8)

Mollusks have been reported explicitly from the Livermore Gravels only by Branner (1912b: 216), but those from an indefinite locality in the vicinity (Cooper, 1888, 1894a: 170; Call, 1888, 1889; Lawson, 1914: 13) may be from this unit.

Cooper (1894a: 170) listed 12 species from "along a small branch of Walnut Creek, in Alameda County, north of Livermore", giving more data for species recorded earlier simply from "Walnut Creek" (Cooper, 1888) and "Tassajara Hills" (Call, 1888). This locality description is inconsistent, for tributaries of Walnut Creek do not head as far south as Alameda County, and a locality in Alameda County north of Livermore would be about 7 miles southeast of the nearest part of Walnut Creek drainage where the fossils might occur. If the data "a small branch of Walnut Creek" are accurate, the locality is in Contra Costa County and might be in San Ramon Valley. Lawson (1914) listed the species recorded by Cooper as "collected north of Livermore, from beds that are probably the extension of the Orinda formation across the Mt. Diablo quadrangle into the Pleasanton quadrangle". This location is outside the drainage of Walnut Creek.

The high spire of *Vorticifex whitei* (Call) is interpreted to indicate a geologic age of Blancan or younger. The known fossil record of *Vorticifex* and its close relative *Perrinilla* is consistent with the hypothesis that the development of a high-spired hyperstrophic shell is a progressive character that evolved during and since the Pliocene. The earliest member of this lineage, *Perrinilla cordillerana* Hannibal (1912b), is planispiral, and only in younger, post-Hemphillian forms does the conical high-spired form appear. *Vorticifex whitei* is more like *V. durhami* (Glen) from the Santa Clara Formation (Fig. 1, locality 11) than any other fossil species of the region. For this reason I think the type lot of *Vorticifex whitei* (Call, 1888) came from a Blancan or younger unit that is younger than the Orinda or Tassajero Formations; hence the Livermore Gravels.

The Livermore Gravels have been described and mapped by Branner (1912a, b), Lawson (1912), Huey (1948) and C. A. Hall (1958). If Cooper's (1894a: 170) locality description "north of Livermore" is correct, and if the fossils are from the Livermore Gravels, then probably they came from within about a mile of the town of Livermore, in the hills along Arroyo Las Positas that are formed by erosional remnants of Livermore Gravels. This is the same area in which the only fossil mammals from the gravels have been found; they indicate post-Blancan age (Savage, 1951).

No fossil mollusks from the Livermore Gravels are known to be preserved in a museum. The localities are probably within the U. S. Geological Survey Livermore quadrangle (1961) 1: 24000 and Altamont quadrangle (1953) 1: 24000.

14. Purisima Group, California (NJ 10-12 [Santa Cruz] D-7)

The one locality is in the Lomerias Muertas, about 4 miles north of San Juan Bautista. Krauskopf et al. (1939) reported 3 species of freshwater mollusks; 8 are listed herein. No other associated nonmarine organisms have been recorded. The fossiliferous unit is mapped as Purisima Group by Allen (1946, pl. 1 and 8); and as middle and/or lower Pliocene marine (but close to undivided Pliocene nonmarine) on the Geologic Map of California (Olaf P. Jenkins edition), Santa Cruz sheet (1959) 1: 250000. The late Pliocene age assigned by Krauskopf et al. (1939) is supported here. Fossils are in the collection of Stanford University. Most recent topographic map: U. S. Geological Survey Chittenden quadrangle (1955) 1: 24000.

Fossil Mollusks from Gilroy Slide

San Benito County, California. San Juan Bautista quadrangle (1939)1: 62500. 22 mm south of lat. 36° 55' north, 52 mm west of long. 121° 30' west on map. Lomerias Muertas, where the 600-ft contour crosses the creek entering the Pajaro River just south of Sargent, approximately 0.5 mile north of BM 1137, in west wall of Gilroy slide. K. B. Krauskopf, 1939.

- Sphaeriidae
  - *Sphaerium striatinum* (Lamarck)
  - *Pisidium*
- Unionacea indeterminate, fragments presumably referable to *Anodonta* or *Gonidea*
- Valvatidae
  - *Valvata humeralis* Say
- Hydrobiidae
  - *Savaginius* cf *S. pilula* (Pilsbry)
  - *Savaginius puteanus* (Pilsbry)
- Lymnaeidae
  - *Bakerilymnaea* cf *B. cockerelli* (Pilsbry and Ferriss)
  - 1 or 2 other indeterminate species

The 2 species of locally restricted distribution, the 2 *Savaginius,* have their affinities with late Pliocene localities to the south, in the southern San Joaquin Valley.

15. San Benito Gravels, California (NJ 10-12 [Santa Cruz] C-5)

Two species of mollusks were reported from the San Benito Gravels by Kerr and Schenck (1925) and Wilson (1943). The fossiliferous unit was described and mapped as the San Benito Gravels by Wilson (1943), and is shown on the Geologic Map of California, Olaf P. Jenkins edition, Santa Cruz sheet (1959) 1: 250000 as Plio-Pleistocene nonmarine. The only published record of non-molluscan fossils from the formation is that of *Equus* near *occidentalis* Leidy (Wilson, 1943: 248) of probable Blancan age. The significance of the formation is that it places an upper age limit on the last marine waters in the strait that connected the southern San Joaquin Valley with the Pacific Ocean through the Coast Ranges (N. T. Hall, 1965: 153). Fossil mollusks collected by Wilson were at one time in the UCMP collection, but could not be found there in February, 1965. Most recent topographic map: U. S. Army Map Service San Benito quadrangle (1947) 1: 62500.

Fossils from San Benito Gravels

The following collections are all those in the University of California Museum of Paleontology that have precise locality data. Identifications of vertebrates are by D. E. Savage.

UCMP B-2147. San Benito Co., Calif. San Benito quadrangle (1917) 1: 62500. SW 1/4 NW 1/4 sec. 14, T 15 S, R 7 E. I. F. Wilson, 1938. Fossil mollusks recorded by Wilson (1943).

UCMP V2407. San Benito Co., Calif. San Benito quadrangle (1917) 1: 62500. NW 1/4 NW 1/4 sec. 10, T 15 S, R 7 E, 2 1/2 miles due east of Live Oak School, and 1/4 mile SSE of hill 2243.

Equus sa.; Blancan or younger.

UCMP V2408. San Benito Co., Calif. San Benito quadrangle (1917) 1: 62500. SE 1/4 SW 1/4 sec. 35, T 14 S, R 7 E, on Tres Pinos Creek road about 3 1/2 miles SE of Cottonwood School, about 175 yards north of 40-minute parallel, in red gravel, about 3/4 mile northwest of Emmett Station.

Equus s.l.; Blancan or younger.

UCMP V2409. San Benito Co., Calif. San Benito quadrangle (1917) 1: 62500. W 1/2 SW 1/4 sec. 1, T 15 S, R 7 E, on Tres Pinos Creek road about 4 1/2 miles SE of Cottonwood School, between Emmett Station and Emmett School, in red, bedded gravel.

Equus s. 1.; Blancan or younger.

The available fossils can be dated only as Blancan or post-Blancan, so it seems the formation might be entirely Pleistocene and perhaps all post-Blancan.

16. Northeast of Kettleman Hills, California
(NJ 10-12 [Santa Cruz] B-1, NJ 11-10 [Fresno] A-7, A-8)

Davis and Poland (1957: 425-426) mentioned freshwater mollusks from the Tulare Formation beneath the Corcoran Clay Member in wells. No specific localities were given.

Boston Land Company well "C"

Pilsbry (1935: 550, 559, 566)recorded 3 species of freshwater snails from Boston Land Company well "C", sec. 27, T 19 S, R 18 E, Fresno County, depth 772-792 feet. Stratigraphic data summarized by Davis et al. (1959) indicate the fossils are from within or immediately above the widespread Corcoran Clay Member of the Tulare Formation. The age of these mollusks is determined as post-Blancan, middle to late Pleistocene, from their relationship to the Corcoran Clay. Rhyolitic ash correlative with the clay yielded a potassium-argon radiogenic date of 600,000± 20,000 years (Janda, 1965; Wahrhaftig & Birman, 1965: 316). Fossil mammals diagnostic of post-Blancan age have been found at 3 localities in the Tulare Formation stratigraphically beneath the Corcoran (Reiche, 1950; Frink & Kues, 1954) and at 1 locality within the Corcoran (D. W. Carpenter, 1965; Janda, 1965; Wahrhaftig & Birman, 1965).

Fossil mollusks are in ANSP collections. Most recent topographic map: U. S. Geological Survey Calflax quadrangle (1956) 1: 24000.

Lambertson's well

Watts (1894: 20) mentioned a well drilled in 1889 at the Lambertson ranch near Tulare Lake. From the lower 200+ feet of a total depth of 1058 feet came 2 species of freshwater mollusks, cited under various names by Watts (1894: 20), Cooper (1894a: 171, 1894b: 55), Hannibal (1912b: 190) and Pilsbry (1935: 554, pl. 22, fig. 6-7). If this is the same well mentioned by Arnold and Anderson (1910: 152) the freshwater mollusks are from sec. 12, T 22 S, R 22 E, Kings County, not far above a horizon that yielded brackish-water or marine mollusks. In any case the freshwater mollusks are probably from below the Corcoran Clay Member, a widely rocognized subsurface unit in the region (Davis et al., 1959; Davis and Green, 1962; Frink and Kues, 1954). The brackish-water or marine mollusks may represent a temporary reestablishment of connections between the ocean to the west and the San Joaquin Valley. Traces of such an environment have been noted in the Kettleman Hills, above the freshwater horizons in the lower part of the Tulare Formation (Arnold, 1910: 48; Arnold and Anderson, 1910: 151; Woodring et al., 1941: 102). The freshwater fossils from Lambertson's well are the only ones identified from the Tulare Formation below the Corcoran Clay and above the brackish-water horizon. Perhaps it is significant that one of the species, *Savaginius yatesianus* (Cooper), is unknown from the Tulare Formation in the Kettleman Hills but is common in the Tehama and Santa Clara Formations (Fig. 1, localities 8, 11).

Fossils are in the ANSP collection. Most recent topographic map: U. S. Geological Survey Corcoran quadrangle (1954) 1: 24000.

U. S. Bureau of Reclamation drillhole 844

Kings County, California. Westhaven quadrangle (1956) 1: 24000. SW 1/4 sec. 31, T 20 S, R 19 E. U. S. B. R. drillhole 844, depth 601-602 feet. Tulare Formation, 42 feet above top of Corcoran Clay Member. Magleby and Johnson of U. S. Bureau of Reclamation, 1963.

Sphaeriidae
Sphaerium kettlemanense Arnold
Valvatidae
Valvata utahensis Call
Hydrobiidae
Lithoglyphus seminalis (Hinds)
Tryonia?

This assemblage is different from those known previously from stratigraphically lower parts of the Tulare Formation. *Sphaerium kettlemanense* is known from the basal part of the formation, but none of the others has been found in the Tulare previously. *Lithoglyphus seminalis* lives in the Sacramento River, but has not been known as a fossil. *Valvata utahensis* is known as a Pleistocene fossil from western Nevada, southeastern California and the northern borders of the Great Basin (Fig. 6), but it has not been found previously west of the Sierra-Cascade range.

If one assumes that the present range of *Lithoglyphus seminalis* in the Sacramento Valley is its ancestral range also, then this fossil occurrence in the San Joaquin Valley represents a former southward extension of range. This extension might be due to the confluence of the Sacramento and San Joaquin Rivers after the elevation of the Coast Ranges blocked westward drainage and diverted the waters of the San Joaquin Valley northward.

The age of the mollusks is determined as post-Blancan, and middle or late Pleistocene, by their relation to the Corcoran Clay.

Blakeley well

U. S. Geological Survey Cenozoic locality 23613. Kings County, California. Stratford quadrangle (1940) 1: 24000. NW 1/4 sec. 13, T 21 S, R 19 E. Blakeley well, in sand at depth 1413 ft.

Only one species is representedby the 14 specimens: *Savaginius williamsi* (Hannibal, 1912b). It has not been found above the San Joaquin Formation previously, and the depth in the well is consistent with this stratigraphic position.

17. Tulare Formation,
Kreyenhagen Hills, California
(NI 10-3 [San Luis Obispo] D-1)

Arnold (1910: 47, 93) and Arnold and Anderson (1910: 153) recordedthe freshwater clam *Gonidea* from the base of the Tulare Formation. Distribution of the Tulare Formation was mapped by Stewart (1947, pl. 9) and is shown by the Geologic Map of California, Olaf P. Jenkins edition, San Luis Obispo sheet (1959). No other nonmarine organisms have been recorded from the formation in the immediate area. The late Pliocene age assigned to the basal part of the Tulare Formation in the Kettleman Hills 3 miles northeast applies here. Fossils are in USGS collections. Most recent topographic map: U. S. Geological Survey Kettleman Plain quadrangle (1953) 1: 24000.

18. Kettleman Hills, California
(NI 11-1 [Bakersfield] D-8,
NJ 11-10 [Fresno] A-8,
NI 10-3 [San Luis Obispo] D-1,
NJ 10-12 [Santa Cruz] A-1)

Blancan freshwater mollusks in the Kettleman Hills occur in the Tulare Formation and upper part of the San Joaquin Formation. Woodring et al. (1941) have mapped these units and discussed their stratigraphy and correlation. The distribution of the formations is shown on sheets of the Geologic Map of California, Olaf P. Jenkins edition: San Luis Obispo (1959) and Santa Cruz (1959). The nonmarine mollusks lived in streams around the edges of an inland sea that was connected to the Pacific Ocean by a strait through the present Coast Ranges. This sea gradually became shallower and finally was a large freshwater lake in which lived the fauna found in the basal part of the Tulare Formation. Hoots et al. (1954) summarized the structural history of the basin and published paleogeographic maps. Most recent topographic maps: U. S. Geological Survey quadrangles, 1: 24000: Avenal (1954), Avenal Gap (1954), Kettleman City (1954), Kettleman Plain (1953), La Cima (1954), Los Viejos (1954).

Tulare Formation, Kettleman Hills

Nonmarine mollusks from the Tulare Formation in the Kettleman Hills are listed in Table 1 (p 11). Descriptions, illustrations or lists of species have been published by Cooper (1894a), Watts (1894), Anderson (1905), Arnold (1910), Arnold and Anderson (1910), Hannibal (1910, 1912b), Barbat and Galloway (1934), Pilsbry (1934b, 1935), Woodring et al. (1941), Hanna and Hertlein (1943) and Schenck and Keen (1950). All 31 species are aquatic; the subgenus *Menetus* (*Planorbifex*) and the genus *Calipyrgula* are endemic. Other nonmarine organisms in the formation include diatoms (Lohman, 1938; Woodring et al., 1941). A horse tooth, *Plesippus (?)*, may be from the Tulare Formation or a lower horizon (Woodring et al., 1941: 23, 104). The mollusks come from only the basal part of the Tulare Formation. They are generally considered late Pliocene on the basis of the high percentage of extinct forms (Woodring et al., 1941). Most of the molluscan fossils are in ANSP, CAS, SU, UCMP and USGS collections.

San Joaquin Formation, Kettleman Hills

According to the faunal criteria proposed here, *Scalez* is restricted to pre-Blancan rocks. The single outcrop occurrence of *Scalez* in the Kettleman Hills is below the *Pecten* zone, in the lower part of the San Joaquin Formation as subdivided by Woodring et al. (1941: 28). Drawing the Hemphillian-Blancan boundary (middle Pliocene -late Pliocene division as currently accepted in America) at the base of the *Pecten* zone is consistent with the evidence of faunal change in both echinoids and mammals. According to this correlation the echinoid *Dendraster (Merriamaster)* and horse *Plesippus* are known locally only above the boundary. The relationships between the faunal successions of larger marine invertebrates and terrestrial mammals in the Kettleman Hills and neighboring areas have been discussed by Durham et al. (1954).

Freshwater mollusks from the upper part of the San Joaquin Formation, of Blancan age as here correlated, have been recorded by Arnold (1910: 47, 48, 96, 100), Arnold and Anderson (1910: 153), Barbat and Galloway (1934) and Woodring et al. (1941: 30, 38 and table facing p 38). Only 4 species are known: *Anodonta* sp., *Juga kettlemanensis* (Arnold), *Lithoglyphus kettlemanensis* (Pilsbry) and *Menetus vanvlecki* (Arnold). *Juga kettlemanensis* and *Lithoglyphus kettlemenensis* occur also in the lower part of the San Joaquin Formation of Hemphillian age, but are unknown in the overlying Tulare Formation.

Other nonmarine fossils from the upper part of the San Joaquin Formation are all from the *Pecten* zone. They include one bird (a cormorant), and several mammals: a beaver, *Castor californicus* Kellogg; mastodont; peccary; horse, *Plesippus;* camel; and deer (Kellogg, 1911; Nomland, 1917: 217; Stirton, 1935: 445-446; Woodring et al., 1941: 97 and table facing p 38). The mastodont might be *Pliomastodon vexillarius* Matthew, described from slightly below the base of the *Pecten* zone (Matthew, 1930). A similar assemblage is known from the same stratigraphic interval north of the Kettleman Hills (Merriam, 1915, 1916, 1917; Nomland, 1916, 1917).

Fossil mollusks are in USGS collections.

19. Paso Robles Formation, California (NI 10-3 [San Luis Obispo] C-1, NI 10-6 [Santa Maria] C-2, D-3)

Arnold (1907), Arnold and Anderson (1907) and Woodring and Bramlette (1950) recorded mollusks from 2 outcrop areas of the Paso Robles Formation. One locality is in the Casmalia Hills about 6 miles southeast of Guadalupe, the other in the Purisima Hills about 3 miles west of Los Alamos. Woodring and Bramlette (1950) and Muir (1964) mapped and described the formation in these areas, and it is shown as nonmarine Plio-Pleistocene on the Geologic Map of California, Olaf P. Jenkins edition, Santa Maria sheet (1959). The fauna includes 6 species, probably all living in southern California. At one locality Woodring and Bramlette (1950) found an unidentified rodent and ostracodes; no other nonmarine organisms are known in the area from the Paso Robles Formation. The late Pliocene(?) and Pleistocene age assignment by Woodring and Bramlette (1950: 108) is accepted here. Fossils are in USGS collections. Most recent topographic maps: U. S. Geological Survey quadrangles 1: 24000, Guadalupe (1959) and Los Alamos (1959).

F. M. Anderson and Martin (1914: 48) recorded mollusks from a third locality in the Paso Robles Formation. The data published by those authors are not precise, but indicate the fossils came from an area on the southwest side of the Temblor Range, in canyons east of San Juan Ranch, in either the Grant Lake quadrangle (1: 24000) or La Panza quadrangle (1: 62500). So far as one can tell from the published identifications the species might all be living locally. The formation is shown as "Plio-Pleistocene nonmarine" on the Geologic Map of California, Olaf P. Jenkins edition, San Luis Obispo sheet (1959).

Lymnaea alamosensis Arnold (1907)

Arnold (1907: 430) and Arnold and Anderson (1907: 59) recorded *Lymnaea alamosensis* from USGS locality 4483, 1 mile southeast of bench-mark 425, Los Alamos Valley, Santa Barbara County, California. The locality record book of the Geological Survey includes the additional information that the locality is on the top of a 1200 foot hill. Comparison of the geologic map by Arnold and Anderson (1907) with U. S. Geological Survey Lompoc quadrangle (1959) 1: 62500 enables one to identify the locality closely. It is on the top of a small hill with 1200 foot closure, progressive grid coordinates about 459,500 ft north, 1,299,200 ft east. The locality is in Paso Robles Formation as mapped by Woodring and Bramlette (1950, pl. 1, sheet 4) and Muir (1964, pl. 1).

Arnold's type specimens and the individual figured by Woodring and Bramlette (1950) are all immature. They offer no differential features to separate them from living representatives of the *Lymnaea "palustris"* group, and probably should be referred to a living Californian species. Even the living species cannot be identified in the present state of knowledge, hence disposition of the fossil must await a revision of the recent fauna.

20. Lost Hills oil field, California
(NI 11-1 [Bakersfield] C-7)

Hannibal (1912b: 190) and Pilsbry (1934b, 1935) described 5 species of *Savaginius* from subsurface samples of the San Joaquin Formation. Gester (1917: 221-223) listed 5 species in subsurface collections from the Tulare Formation. Follansbee (1943) summarized the structure and stratigraphy of the field. Pilsbry's material is in ANSP collections, Hannibal's at Stanford University. Most recent topographic map: U. S. Geological Survey Lost Hills quadrangle (1953) 1: 24000.

21. Buttonwillow gas field, California
(NI 11-1 [Bakersfield] B-6, C-7)

Freshwater mollusks have been found during well-drilling in the Buttonwillow field in both the Tulare Formation and the upper part of the San Joaquin Formation. The occurrence mentioned by Musser (1930: 12) in the second *Mya* zone is in the upper part of the San Joaquin Formation as correlated by Woodring et al. (1941: 107). Fossils reported from the Tulare Formation are all from the lower part, in about the same stratigraphic position as those in the Kettleman Hills. Musser (1930) and Chambers (1943) mentioned *Anodonta* and *Amnicola;* Pilsbry (1934b, 1935: 555, 559) described *Pyrgulopsis? polynematica* and *Savaginius puteanus.* Stratigraphic data are accessible through Chambers (1943) and references therein. An unusual fossil occurrence is a vole from a core in the Buttonwillow field (Barbat and Galloway, 1934; Hesse, 1934). It is from the upper part of the San Joaquin Formation. Molluscan fossils are in ANSP collections. Most recent topographic maps: U. S. Geological Survey quadrangles, 1: 24000, Buttonwillow (1954) and Semitropic (1954).

22. McKittrick area, California
(NI 11-1 [Bakersfield] B-7)

Freshwater mollusks from the McKittrick area have been reported from the Tulare Formation in the Belridge oil field (subsurface) and in the foothills of the Temblor Range (outcrop), and from the San Joaquin Formation in the McKittrick oil field (subsurface).

Belridge oil field

Gester (1917: 215) recorded mollusks thought to be derived from the Tulare Formation in the Belridge oil field. Literature on the stratigraphy and development of the field is available through Wharton (1943). Most recent topographic map: U. S. Geological Survey Belridge quadrangle (1953) 1: 24000.

Cymric area of McKittrick oil field

Pilsbry (1935: 550) recorded *Savaginius spiralis* from Cymric wells 4 and 5. The depths indicate the shells came from the uppermost part of the San Joaquin Formation according to the stratigraphic section by Atwill (1943). Fossils are in ANSP collections. Most recent topographic map: U. S. Geological Survey Reward quadrangle (1950) 1: 24000.

Foothills of Temblor Range

Freshwater mollusks from outcrops of the Tulare Formation in the foothills of the Temblor Range have been recorded by Cooper (1894a), Watts (1894), Anderson (1905: 182), Arnold and Johnson (1910: 78), Hannibal (1912b: 191), Gester (1917: 213, 215) and Pilsbry (1935: 550). The localities are within 3 miles northwest and southeast of McKittrick. The Tulare Formation was mapped and described in this area by Gester (1917). About 6 species have been listed, most or all of which occur also in the basal part of the Tulare Formation in the Kettleman Hills.

Blancan mammals have been described from the dumps of asphalt mines in this area (Matthew and Stirton, 1930: 179-180; Merriam, 1903, 1905, 1917). They have usually been assigned to the Tulare Formation, but Barbat and Galloway (1934: 496) regarded at least one of the species as coming from the upper part of the San Joaquin Formation. The most nearly precise stratigraphic location of mammals is by Watts (1894: 49), who described some as coming from below the freshwater mollusks, but these specimens have not been described. Gester (1917) described the local outcrops of Tulare Formation as unconformable upon marine strata that were correlated with the Cascajo Conglomerate Member at the base of the San Joaquin Formation in the Kettleman Hills (Fig. 1, locality 18) by Woodring et al. (1941: 106). Hence Blancan mammals from the McKittrick area come from the Tulare Formation as previously described. Most recent topographic maps: U. S. Geological Survey quadrangles, 1: 24000, Reward (1951) and West Elk Hills (1954).

23. Elk Hills and Midway-Sunset oil fields, California (NI 11-1 [Bakersfield] A-6, B-6, 7)

Elk Hills oil field

Woodring et al. (1932: 26) recorded freshwater mollusks from the Tulare Formation in the Elk Hills. The subsurface and surface stratigraphy have been mapped and described by Woodring et al. (1932), Porter (1943) and references therein. At least 3 genera of mollusks are known. Several genera of mammals, including *Plesippus*, have been found in outcrops of the Tulare Formation in the Elk Hills (Woodring et al., 1932: 25-26) stratigraphically above the mollusks. Blancan age is indicated both by correlation with the Kettleman Hills and McKittrick areas (Fig. 1, localities 18, 22) and by the mammals in the Elk Hills. Fossil mollusks are in CAS collections. Most recent topographic maps: U. S. Geological Survey quadrangles, 1: 24000, East Elk Hills (1954) and West Elk Hills (1954).

Buena Vista Hills

Gester (1917: 226) mentioned freshwater mollusks from surface outcrop of the Tulare Formation in the Buena Vista Hills. Literature on the stratigraphy and development of the oil field is available through McMasters (1943). Most recent topographic maps: U. S. Geological Survey quadrangles, 1: 24000, Mouth of Kern (1950) and Taft (1950).

Midway-Sunset oil field

Gester (1917: 226) recorded freshwater mollusks from the Tulare Formation outcropping in the Midway-Sunset oil field. Literature on the stratigraphy and development of the field is available through California Division of Mines Bulletin 118 (p 521), 1943. Most recent topographic map: U. S. Geological Survey Pentland quadrangle (1953) 1: 24000.

24. San Pedro Sand, California (NI 11-7 [Long Beach] C-2)

Arnold (1903: 22, 44, 195-196, 305-306), Burch (1947), Oldroyd (1924) and Woodring et al. (1946: 66-67) recorded freshwater mollusks from the San Pedro Sand in San Pedro. Woodring et al. (1946) described and mapped the San Pedro Sand; Arnold's and Oldroyd's localities had been destroyed by the time their report was published. Seven species, perhaps all still living, are known. The only other nonmarine fossils recorded from this marine deposit are turtle and mammal remains mentioned by Brattstrom and Sturn (1959), and by Woodring et al. (1946: 86); and horse teeth identified as *Equus* cf *E. occidentalis* (Woodring, 1952: 405). The early Pleistocene age generally assigned to the San Pedro Sand (Woodring et al., 1946; Woodring, 1952; Geologic Map of California, Olaf P. Jenkins edition, Long

Beach sheet, 1962) is in terms of the sequence of marine invertebrate faunas on the west coast. The known fossil mammals do not permit correlation with the chronology based on mammalian faunas (Durham et al., 1954: 69). K-Ar dates on glauconite from the underlying Lomita Marl yielded a mean of 3.04 million years (Obradovich, 1965). Fossil freshwater mollusks are in USGS and USNM collections. Most recent topographic map: U. S. Geological Survey San Pedro quadrangle (1951) 1: 24000. Arnold (1903, pl. 23) published a map showing the area as it was before waterfront improvements destroyed the fossil locality.

Freshwater mollusks from San Pedro Sand

Previous identifications of freshwater mollusks from the San Pedro Sand have been revised in the following list. Some of the changes are nomenclatural but others are based on reinterpretation of fossils. Arnold (1903: 195) listed a land snail as *Helix (Epiphragmophora)* sp. indet. from the "lower San Pedro series" (San Pedro Sand), but on pages 28 and 41 assigned it to the upper San Pedro series (Palos Verdes Sand). Presumably it is one of the local living genera of Helminthoglyptidae, *Helminthoglypta* or *Micrarionta*.

HYDROBIIDAE

"Hydrobia" imitator (Pilsbry)

1903 P[illegible], sp. [illegible].: Arnold, Mem. Calif. Acad. S[illegible]., 3: 22, 23, 44, 305, pl. 8, fig. 2.
1912 *P.* [[illegible]][illegible], Arnold: Hannibal, Bull. So. Calif. Acad. S[illegible]., 11: 34 (as synonym of *P.* [illegible]).
1912 *P.* [*aludestrina*][illegible], Arnold: Hannibal, P[illegible]. [illegible]. Soc. London, 10: 186 (as synonym of *P.* [illegible]).
1924 P[illegible] Arnold: Old[illegible], P[illegible]. U. S. natl. M[illegible]., 65(22): 17.
1946 P[illegible]: W[illegible] et al., U. S. geol. Survey Prof. Pap., 207: 66 (as synonym of H[illegible]).
1947 P[illegible] Arnold: Burch, Min. Conch. Club So. Calif., 73: 18.

In the present state of knowledge *Paludestrina curta is* most reasonably considered a synonym of the brackish-water species *"Hydrobia" imitator,* described from the San Francisco Bay area (Pilsbry, 1899). If more than 1 species should be found to possess similar shells, then possibly *P. curta* should be maintained separate nomenclaturally even though it would be unidentifiable. The diagnostic features of the species are the truncate apex, deep sutures, fine spiral sculpture and absence of axial ribs or spiral cords. These characters separate it from living species of *Fontelicella* in southern California (to which Hannibal referred it) and from *Tryonia protea* (to which Woodring et al. referred it).

Tryonia stokesi (Arnold)

1903 P[illegible], sp. [illegible].: Arnold, Mem. Calif. Acad. S[illegible]., 3: 22, 23, 44, 305, pl. 8, fig. 3.
1911 A[illegible] *to*, new species: Bartsch, Proc. U. S. natl. M[illegible]., 39: 415, pl. 61, fig. 1.
1912 *P.* [[illegible]][illegible] Arnold: Hannibal, Bull. So. Calif. Acad. S[illegible]., 11: 33 (synonym of P[illegible]).
1912 *P.*[[illegible]][illegible], Arnold: Hannibal, Proc. [illegible]. Soc. London, 10: 186 (synonym of P[illegible]).
1924 P[illegible] cf. [illegible] Arnold: O[illegible], Proc. U. S. natl. M[illegible]., 65(22): 17.
1945 A[illegible] Bartsch: Burch, Min., Conch. Club So. Calif., 54: 27.
1946 P[illegible]: W[illegible] et al., U. S. geol. Survey Prof. Pap.; 207: 66 (synonym of H[illegible]).
1946 A[illegible] *to:* W[illegible] et al., U. S. geol. Survey Prof. Pap., 207: 67 (synonym of H[illegible]).
1947 [P[illegible]][illegible] Arnold: Burch, Min. Conch. Club So. Calif., 73: 18.

Living snails that have been referred to *Tryonia protea* (Gould) in the Colorado

Desert area, the type locality, may represent one or several species. The correlation of shell characters with biological groups can be determined only after study of numerous living series, and even the best-preserved fossils cannot be identified surely in the present state of knowledge. Hence the relationships of the few worn specimens found in the San Pedro Sand are doubtful. I see no reason to recognize more than one fossil species in coastal southern California. The concept of *Tryonia protea* is vague, and since the name *stokesi* is available it is employed. If a synonym of *T. protea* in the broad sense, the species is living in southeastern California. In any case it is unknown along the coast of either Upper or Lower California.

Alabina io Bartsch (1911) was described as if from the Pleistocene of San Diego, but according to Woodring et al. (1946: 67) is from San Pedro. The stratigraphic horizon of Bartsch's type is uncertain, but *T. stokesi* is known from both the San Pedro Sand and Palos Verdes Sand.

PLANORBIDAE

Gyraulus parvus (Say)

1924 *?Planorbis deflectus* Say: Oldroyd, Proc. U. S. natl. Mus., 65(22): 23.

This small freshwater snail is common in coastal and montane southern California (Hannibal, 1912a). Probably Oldroyd's record of the remote *Gyraulus deflectus* refers to this species. I have seen specimens from the Palos Verdes Sand, but none from the San Pedro Sand.

Planorbella tenuis californienis (Baker)

1903 *"Planorbis tumidus* Pfeiffer": Arnold, Mem. Calif. Acad. Sci., 3: 22, 23, 44, 195, pl. 9, fig. 13.
1903 *"Planorbis vermicularis* Gould": Arnold, Mem. Calif. Acad. Sci., 3: 22, 23, 44, 195, pl. 9, fig. 14.
1924 *"Planorbis trivolvis* Say": Oldroyd, Proc. U. S. natl. Mus., 65(22): 23.

The classification of this genus is full of uncertainties, so that no satisfactory nomenclature is available in the present state of knowledge. The fossils represent the common living *Planorbella* of coastal southern California, many localities for which were cited by Hannibal (1912a). The species is probably a member of the *tenuis* group of species, and may include *P. ammon* Gould (1855a). Defining species more narrowly than Hannibal (1912a), I consider that the *P. trivolvis* group of species is not native to western North America.

Planorbis vermicularis Gould is probably a synonym of *Gyraulus parvus* (Say), but the description, measurements and illustration published by Arnold (1903) are clearly *Planorbella.*

PHYSIDAE

Physa virgatu Gould

1903 *"Physa heterostropha* Say": Arnold, Mem. Calif. Acad. Sci., 3: 22, 23, 44, 196.

Only one species of *Physa* surely lives in coastal southern California, for which *P. virgata* Gould (1855a) is the earliest clearly applicable name. "*Physa* is without exception the most widely and abundantly distributed fresh-water mollusk in southern California. No stream, pond, or swamp outside the highest mountains is without it. It is capable of thriving in moist situations flooded but three or four months a year" (Hannibal, 1912a: 29).

ENDODONTIDAE

Discus cronkhitei (Newcomb)

1924 *Pyramidula cronkhitei* Newcomb: Oldroyd, Proc. U. S. natl. Mus., 65(22): 22.

This land snail is widespread in North America; mainly northern in distribution, it occurs at higher elevations in mountains toward the south. In California the southernmost occurrences are in the San Gabriel and San Bernardino Mountains. S. S. Berry (1909: 76) recorded it from the San Bernardino Mountains, San Bernardino County, and Gregg (1949: 6) listed it from Los Angeles County. Although the specimen recorded by Oldroyd might have been carried from the mountains by floodwaters, more likely the species lived at lower elevations during early Pleistocene time than now.

ZONITIDAE
Zonitoides arboreus (Say)

1924 *Zonitoides arboreus* Say: Oldroyd, Proc. U. S. natl. Mus., 65(22): 22.

Edson and Hannibal (1911: 60) and Gregg (1949) have listed localities where this common North American land snail is found in southern California. It is more widespread and found at lower elevations than *Discus cronkhitei.*

25. Bautista Formation, California
(NI 11-8 [Santa Ana] D-4)

The one known mollusk locality, first recorded here, is in the San Jacinto Mountains 3 1/2 miles east of San Jacinto. The formation was mapped by Fraser (1931) as "Bautista beds". Fossil mammals (Frick, 1921) from the formation are of Irvingtonian age (Hibbard et al., 1965), but the mollusks are from stratigraphically lower and might be late Blancan. Associated plants, the Soboba flora, are under study by D. I. Axelrod. Fossil mollusks are in USGS and UMMZ collections. Most recent topographic map: U. S. Geological Survey Banning quadrangle (1956) 1: 62500.

Fossil mollusks from Bautista Formation

U. S. Geological Survey Cenozoic locality 23610. Riverside County, California. 1150 ft east, 1500 ft south, sec. 28, T 4 S R 1 E. About 150 yards past road junction that leads up to Castile Canyon. North side of road near base of high cut through the saddle. About 400 ft above base of Bautista Formation, associated with Soboba flora. D. I. Axelrod, 1964.

Sphaeriidae
Sphaerium cf *S. striatinum* (Lamarck)
Hydrobiidae
Fontelicella n. sp.
Physidae
Physa cf *P. virgata* Gould

26. Brawley Formation, California
(NI 11-9 [Salton Sea] A-6, A-7, A-8, B-7, NI 11-8 [Santa Ana] B-1)

Mollusks were explicitly reported (but not identified) from the Brawley Formation by Dibblee (1954). Most of the occurrences of the brackish-water clam *Rangia lecontei* are herein considerea to be from this formation, either in place or reworked. Primary records of *Rangia* in the area are by Blake (1855, 1857), Bowers (1901), Conrad (1853), Easter (1857), Gould (1855b, 1857), Hubbs and Miller (1948), LeConte (1851, 1855) and Orcutt (1890, 1915). Distribution of the Brawley Formation has been mapped by Dibblee (1954), and is shown on the Geological Map of California (Olaf P. Jenkins edition) San Diego-El Centro sheet (1962) 1: 250000. A transitional Pliocene-Pleistocene age was assigned by Dibblee (1954, pl. 2), and a Pleistocene age by the Geologic Map of California. Most of the extant material is in USGS collections. Most recent topographic maps: U. S. Geological Survey quadrangles (1956) 1: 24000: Calipatria SW, Frink, Frink NW, Iris, Kane Spring, Kane Spring NE and Oasis.

Rangia lecontei (Conrad)
Pl. 2 & 3

The first attempt to locate the type locality of this species soon led to discovery that no one had ever assembled the pertinent literature, or considered the stratigraphic range of the species. I have used available maps and my knowledge of the area to recover the original localities as precisely as possible

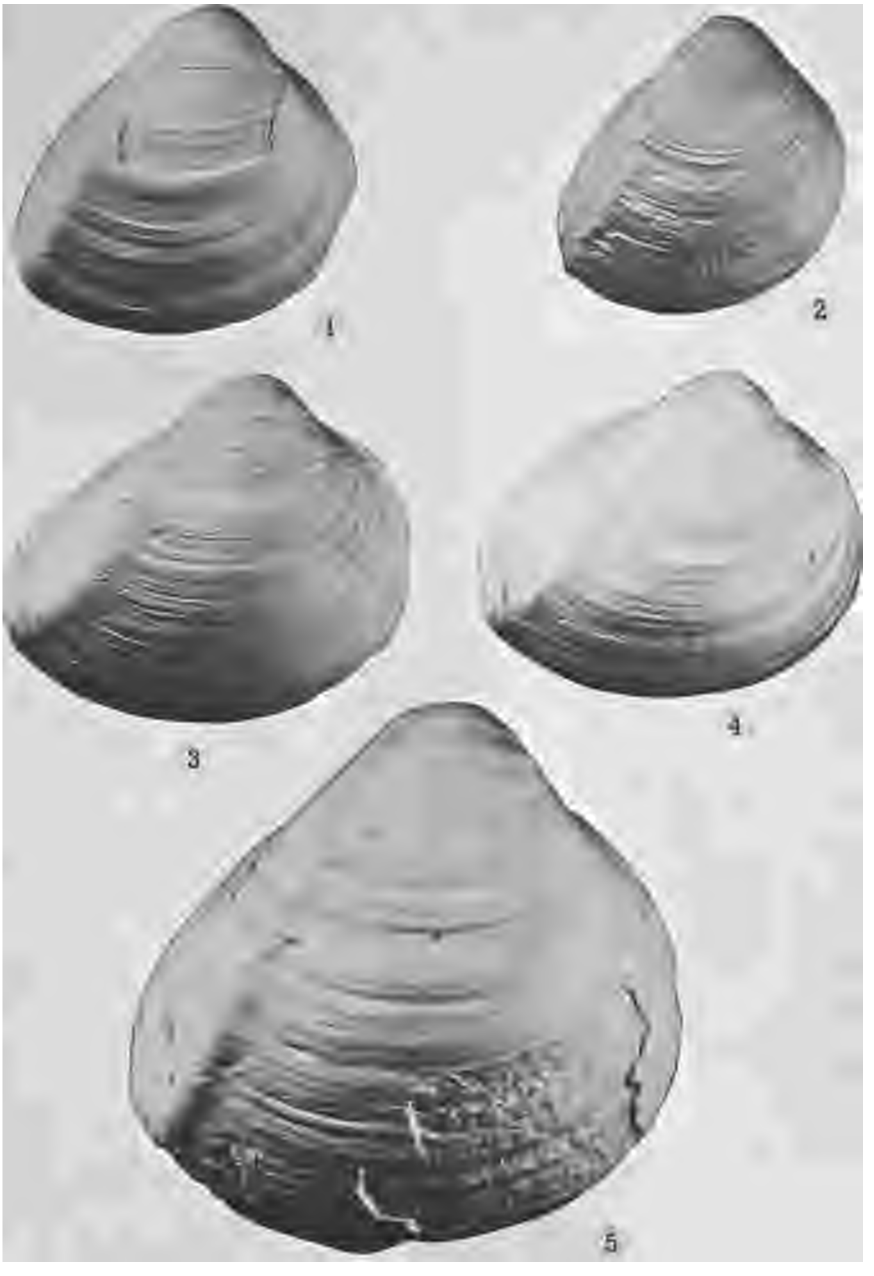


PLATE 2

Rangia lecontei (Conrad), X 3. Imperial County, California. 800 ft north, 100 ft east, sec. 28, T 9 S, R 12 E; D. W. Taylor, 1949. Figured specimens, UMMZ 220093. Pl. 2, Fig. 3 illustrates the same specimen as Pl. 3, Fig. 2; Pl. 2, Fig. 5 illustrates the same specimen as Pl. 3, Fig. 1; other specimens are illustrated by only 1 view each.

PLATE 3

Rangia lecontei (Conrad), X 3. Imperial County, California. 800 ft north, 100 ft east, sec. 28, T 9 S, R 12 E; D. W. Taylor, 1949. Figured specimens, UMMZ 220093. Pl. 2, Fig. 3 illustrates the same specimen as Pl. 3, Fig. 2; Pl. 2, Fig. 5 illustrates the same specimen as Pl. 3, Fig. 1; other specimens are illustrated by only 1 view each.

[illegible] O[illegible] stratigraphic [illegible].

T[illegible] C[illegible] D[illegible] Irvingtonian [illegible] G[illegible] C[illegible] (D[illegible] W[illegible], 1962; W[illegible], 1962). T[illegible] Rangia [illegible] G[illegible].

B[illegible]

1851 G[illegible]: LeConte, P[illegible]. Acad. nat. S[illegible]. P[illegible]., 5: 264 ("north of C[illegible] Creek, ... limestone beds composed almost entirely of G[illegible], and farther in the desert the same shell was found in strata of clay, lying almost vertically").

1853 G[illegible] L[illegible]: Conrad, J. Acad. nat. Sci. Phila., [illegible]. 2, 2: 273, pl. 24, fig. 1-2 ("north of C[illegible] creek, in limestone beds formed almost entirely of the species, and further in the desert it occurred in clay, lying almost horizontally. This is at a distance of 120 miles from the Gulf of California, and 150 miles from the Pacific.").

1855 Cyclas: Blake, U. S. Explorations and surveys for a railroad route to the Pacific Ocean, Preliminary geological report: 35 ("Salt Creek," now San Felipe Creek).

1855 G[illegible] L[illegible], Conrad: Gould, U. S. Explorations and surveys for a railroad route to the Pacific Ocean, Appendix to the preliminary geological report of W. P. Blake: 22(C[illegible] Desert).

1855 G. [[illegible]] L[illegible] Conrad: L[illegible]C[illegible], Am. J. S[illegible]., 69: 6 (Superstition Hills, Imperial County, California).

1857 G[illegible] L[illegible], Conrad: Gould, Rep. U. S. Explorations and surveys for a railroad route to the Pacific Ocean, 5(2): 330 (Colorado Desert).

1857 G[illegible] L[illegible], Conrad: Blake, Rep. U. S. Explorations and surveys for a railroad route to the Pacific Ocean, 5(2): 103, 105, 235, 236 ("near Salt Creek, about twenty miles north of the entrance to C[illegible] Creek," and near the entrance to C[illegible] Creek, Imperial County, California).

1857 G[illegible], L[illegible], Conrad: Easter, Rep. U. S. Explorations and surveys for a railroad route to the Pacific Ocean, 5(2): 354 (Colorado Desert).

1860 R. [angia] L[illegible], Conrad: Conrad, Proc. A[illegible]. nat. S[illegible]. Phila., 12: 232.

1860 R[illegible] L[illegible], Conrad: Prime, Proc. Boston Soc. nat. Hist., 7: 348 (N. America).

1861 G[illegible]: Newberry, U. S. Engineer Dept., Report upon the Colorado River: 16 (North of C[illegible] Creek: from LeConte, 1855).

1864 G[illegible] L[illegible], C[illegible].: Carpenter, Rep. British Assoc. Adv. Sci., 1863: 592 (Colorado Desert).

1864 R[illegible] L[illegible], Conrad: Meek, Smithson. Misc. Coll., 183: 11 (California).

1872 G[illegible] L[illegible], C[illegible].: Carpenter, Smithson. Misc. Coll., 252: 78 (Colorado Desert).

1882 G[illegible], Con.: Hanks, Rep. Calif. State Mineralogist, 2: 235 (Colorado Desert).

1888 "G[illegible] Gould": Cooper, Rep. Calif. State Mineralogist, 7: 242, in part (Colorado Desert).

1890 "G[illegible] Gould": O[illegible], Rep. Calif. State Mineralogist, 10: 912, in part (near Salton).

1892 "G[illegible] Gould": Cooper, Zoe, 3: 23, in part ("Living, Colorado estuary, Dr. J. L. Leconte").

1894 "G[illegible] Gould": Cooper, Catalogue of west North American shells, in part (Colorado estuary).

1894 G[illegible], Conrad: Dall, Proc. U. S. nat. M[illegible]., 17: 100, pl. 7, fig. 4 ("C[illegible] creek, Colorado Desert, Arizona, Dr. Leconte").

1901 "R[illegible]": Bowers, Reconnaissance of Colorado Desert Mining District: 15 (near San Felipe Creek).

1901 "G[illegible] Gould": O[illegible], West American M[illegible]: 62, in part (Quaternary, north of C[illegible] creek, Colorado Desert, California; from LeConte, 1855).

1901 "G[illegible] Gould": O[illegible], West Amer. S[illegible]., 12: 11, in part (Quaternary, north of C[illegible] creek, Colorado Desert, California; from L[illegible]C[illegible], 1855).

1905 *Gnathodon lecontei* Conrad: Schuchert, Bull. U. S. Nat. Mus. , 53(1): 290 (Holotype listed as in USNM, erroneously).

1915 *Rangia Le Contei* Conr. : Orcutt, Molluscan world: 182 (Flowing Wells, Colorado Desert, Cal. ; Mrs. Stephens).

1931 *Rangia lecontei* (Conrad): Grant and Gale, Mem. San Diego Soc. nat. Hist. , 1: 410.

1932 *R. [angia] lecontei* (Conrad): Woodring, Carnegie Inst. Washington Publ. , 418: 10 (Specimen found by Blake on Carrizo Creek was from beds here assigned to Palm Spring Formation).

1948 *Rangia:* Hubbs and Miller, Bull. Utah Univ. , 38(20): 109 (north of Pope).

1950 *?Mulinia* pallida(Broderip and Sowerby): Durham, Mem. geol. Soc. Am., 43(2): 23 (Borrego Formation).

1960 *?Mulinia pallida:* Durham and Allison, Syst. Zool. , 9: 63 (Borrego Formation).

The records of *Mulinia pallida* from the Borrego Formation by Durham (1950) and Durham and Allison (1960) may well be based on *Rangia lecontei,* for both are brackish-water mactrids of similar gross appearance. *Mulinia* is otherwise unknown from the area, and *Rangia* might reasonably be expected. Regardless of the identification of these clams, their stratigraphic position is doubtful. The records from the Borrego Formation are based on a stratigraphic succession established before the work by Dibblee (1954), who described the Brawley Formation. Possibly the fossils are from the Brawley, rather than the Borrego as restricted by Dibblee.

Type of *Rangia lecontei*

Dall (1894: 100) identified the type of *Rangia lecontei* as USNM 6833, and cited the specimen he figured (1894, pl. 7, fig. 4) as "one of the typical specimens". Schuchert (1905) went so far as to call it the holotype. This figured specimen, USNM 6833, does not agree with the original illustrations published by Conrad (1853, pl. 24, fig. 1-2). The original catalogue entry of USNM 6833 records 1 valve of *"Gnathodon lecontii"* from Alabama, received from Stimpson. The only lot of *R. lecontei* that has been in USNM collections more than a few years includes 2 valves: one is the specimen figured by Dall (1894), and is numbered 6833; the other is not numbered, surely not from the same locality to judge by features of preservation, and is probably *R. cuneata* (Gray). Under these circumstances I consider it improbable that the specimen figured by Dall, USNM 6833, is from Conrad's original lot, and identify it as only a figured specimen and not a primary type. The morphology and preservation of this specimen agree with other material from the Colorado Desert, California, and hence the original data are erroneous.

Type locality of *Rangia lecontei*

J. L. LeConte collected the original lot of *Rangia lecontei* during a trip to the mud volcanoes at the southern end of the Salton Sea. His narrative (LeConte, 1855)permits approximate relocation of the localities where he found the species. Dr. LeConte and a party of soldiers started from San Felipe, probably San Felipe Ranch in Valle de San Felipe, T 12 S, R 4 E, San Diego County, October 28, 1850. They followed the valley of San Felipe Creek eastward, approximately along the course of state highway 78, to Borego Valley. LeConte's description of the scenery here is vivid:

"It is no wonder that Government reports abound with names of plants, which suggest nothing but linguistic difficulties, for there is little else in the vast deserts of Western America to occupy the attention of the intelligent traveller; and with the determination of one resolved to struggle with the dull sublimity of inorganic matter, he frequently breaks off and preserves a piece of some hideous vegetable, whose only charms are the ugliness of its form, the lifelessness of its color, and the apparent absence of flower, and foliage, and every thing else that renders a plant attractive. "

The party camped on Carrizo ("Cariso") Creek near its junction with San Felipe Creek, went on to an Indian village near the end of New River, about 8 miles south of the volcanoes, and thence northward. The return journey was from the Indian village up Carrizo Creek via Vallecitos. LeConte collected the *Rangia* on this part of the journey; his narrative is as follows:

"About nine or ten miles from the village, we passed some mounds covered with cinders and pumice, and on the top of one of them found a crater-like hollow, in which grow some very large canes. Shortly afterwards the strata of fresh water deposit were seen to be vertical and were filled with a species of Gnathodon (G. Lecontei Conrad). About 4 p. m., we skirted along the northern edge of a long curved range of hills the base of which was composed of strata of limestone dipping outwardly, and containing also Gnathodon; around these hills and mounds were concentric lines of small stones from the mountains arranged by aqueous action.

"About half past five, we encamped in the bed of Cariso creek, here entirely dry. . . . "

The "long curved range of hills" is identifiable as the Superstition Hills, T 13 S, R 11-12 E, Imperial County, andthe "concentric lines of small stones" are features of former Lake Coahuila. The vertical strata containing *Rangia* encountered east of the hills are evidently faulted and indurated outliers of the Brawley Formation as mapped by Dibblee (1954, pl. 2).

Dall (1894) attributed to LeConte a cription of the type locality of *Rangia lecontei* as "a layer of rock two feet thick in the bank of the creek, where they occurred in the greatest profusion". No published source of this description has been found.

Localities of *Rangia lecontei*

Outcrop collections

Only a few of the previous collections of *Rangia lecontei* have been made from outcrops, and none of them is known to be preserved in museums. Judging from published accounts most specimens collected in place are from the Brawley Formation, one from the Palm Springs Formation.

1. (NI 11-9 [Salton Sea] A-8). San Felipe Creek, about sec. 18, T 12 S, R 11 E; W. P. Blake, Nov. 20, 1853. "Salt Creek, about twenty miles north of the entrance to Carrizo Creek" (Blake, 1857: 103, 235) was a flowing stream. The only such occurrence in the area shown by J. S. Brown (1923), pl. 2) is in San Felipe Creek, and this identification is consistent with the location of Salt Creek by Blake (1857, map facing p 228). Dibblee (1954, pl. 2) mapped Brawley Formation north and south of San Felipe Creek, and the unit would be expected in the walls of that creek.

2. (NI 11-9 [Salton Sea] A-7 or A-8). Northwestern part of T 13 S, R 12 E, below the highest features of Lake Coahuila; J. L. LeConte, Oct. 30, 1850. The vertical strata noted by LeConte (1855) are identified as Brawley Formation.

3. (NI 11-9 [Salton Sea] A-8). Northern edge of Superstition Hills, T 13 S, R 11 E, below the highest features of Lake Coahuila; J. L. LeConte, Oct. 30, 1850. The limestone strata dipping outward described by LeConte (1855) are identified as Brawley Formation.

4. (NI 11-12 [El Centro] D-8). Near mouth of Carrizo Creek, about SW 1/4 sec. 7, T 15S, T 10 E; W. P. Blake, Nov. 21, 1853. Blake (1857: 104-105) described the locality as along the emigrant road, east of the sudden descent into Carrizo Creek. The specimen collected by Blake may not have been in place, but was almost surely derived from one of the outcrops of Palm Spring Formation shown along the old road on the Geologic Map of California, Olaf P. Jenkins edition, San Diego-El Centro sheet (1962) 1: 250000.

Surface collections

5. (NI 11-8 [Santa Ana] B-1). USGS Cenozoic locality 23574. Oasis quadrangle (1956) 1: 24000. NE 1/4 sec. 8, T 9 S, R 9 E, about 1 mile south of Travertine Rock; D. W. Taylor, 1949.

6. (NI 11-12 [El Centro] D-8). CAS locality 22619. Superstition Mountain

quadrangle (1956) 1: 24000. Superstition Mountain; G. D. Hanna, 1921.

7. (NI 11-12 [El Centro] D-8). CAS locality 22663. Superstition Mountain quadrangle (1956) 1: 24000. One mile south of Supersition Mountain; G. D. Hanna, 1921.

8. (NI 11-9 [Salton Sea] B-8). Durmid quadrangle (1956) 1: 24000. Near Durmid Station. Pinkerton; Stanford University, ex San Diego Society of Natural History.

9. (NI 11-9 [Salton Sea] B-7). USGS Cenozoic locality 23568.□Frink NW quadrangle (1956) 1: 24000.□000 ft west, 1000 ft south, sec. 15, T 9 S, R 12 E; D. W. Taylor, 1949.

10. (NI 11-9 [Salton Sea] B-7). USGS Cenozoic locality 23571. FrinkNW quadrangle (1956) 1: 24000. NW 1/4 sec. 28 and SW 1/4 sec. 21, T 9S, R 12 E; D. W. Taylor, 1949. Specimens recorded by Hubbs and Miller (1948: 109) are at or close by this locality.

11. (NI 11-9 [Salton Sea] B-7). USGS Cenozoic locality 23570. Frink quadrangle (1956) 1: 24000. 800 ft north, 100 ft east, sec. 28, T 9 S, R 12 E, beside road to Bombay Beach 300 ft south of state highway 111; D. W. Taylor, 1949.

12. (NI 11-9 [Salton Sea] B-7). USGS Cenozoic locality 23569. Frink quadrangle (1956) 1: 24000. NE 1/4 sec. 32 and NW 1/4 sec. 33, T 9S, R 12 E. Shells along edge of Salton Sea at end of dirt road to Bombay Beach; D. W. Taylor, 1949.

13. (NI 11-9 [Salton Sea] A-6). "Flowing Wells", perhaps Flowing Wells Siding, sec 18, T 11 S, R 15 E (Orcutt, 1915: 182).

14. (About NI 11-12 [El Centro] C-3). Yuma Desert; Mr. Brandegee, in Henry Hemphill collection, Stanford University.

27. Palm Spring Formation, California (NI 11-8 [Santa Ana] D-1, NI 11-11 [San Diego] D-1, D-2, NI 11-12 [El Centro] D-8)

Most of the localities are about 30 miles southwest of the Salton Sea, in the Vallecito Mountains; one is in the Indio Hills about 4 miles north of Indio and 20 miles northwest of the Salton Sea. One of the few known outcrop localities of *Rangia lecontei* (loc. 4, p 60), reported by Blake (1857), was assigned by Woodring (1932: 10) to the Palm Spring Formation; the other localities have not been published. The formation has been described and mappedby Woodring (1932) and Dibblee (1954), with revision by Woodard (1962). Part of the formation is shown on the Geologic Map of California, Olaf P. Jenkins edition, San Diego-El Centro sheet (1962) 1: 250000 as nonmarine Pliocene. About 5 species of mollusks are known, none surely extinct. Associated vertebrates include 28 species of birds (Howard, 1963), and about 40 mammals (Downs, 1957; Downs and Woodard, 1962; White and Downs, 1961 and in progress). Most of the mammals are Irvingtonian, some Blancan; the formation may be entirely Pleistocene. Fossil mollusks are in the collections of the Los Angeles County Museum and USGS. Most recent topographic maps: U. S. Geological Survey quadrangles Agua Caliente Springs (1959)□1: 24000, Arroyo Tapiado (1959) 1: 24000, Lost Horse Mountain (1958) 1: 62500 and Plaster City NW (1956) 1: 24000.

28. Mopung Hills local fauna, Nevada (NJ 11-1 [Reno] D-3, D-4)

The fossil localities are within a radius of about 1 mile, at the southwestern end of the Mopung Hills (the western tip of the West Humboldt Range), about 25 miles southwest of Lovelock. The fossiliferous unit has not been mapped; it may be part of the upper Truckee Formation as described by Axelrod (1956). The fauna includes about 8 species of freshwater mollusks, interpreted as late Pliocene (Taylor, unpublished data). Fossils are in CAS, UCMP UMMZ, and USGS collections. Most recent topographic maps: U. S. Geological Survey quadrangles (1951) 1: 62500, Carson Sink and Desert Peak.

UCMP collection B-932 is labelled

PLATE 4

FIGS. 1-7. *Vorticifex gesteri* (Hanna), X 4. USGS Cenozoic locality 14729, Mono Lake basin, California. Figs. 1-3, Figured specimen, USNM. Figs. 4, 5, Figured specimen, USNM. Figs. 6, 7, Figured specimen, USNM.

PLATE 5

FIGS. 1-10. Freshwater snails, all X 4, from USGS Cenozoic locality 14729, Mono Lake basin, California. Figs. 1, 2, *Vorticifex gesteri* (Hanna). Figured specimen, USNM. FIGS. 3-10, *Helisoma newberryi* (Lea). Figs. 3, 6, 8, Figured specimen, USNM. Figs. 4, 7, 10, Figured specimen, USNM. Figs. 5, 9, Figured specimen, USNM.

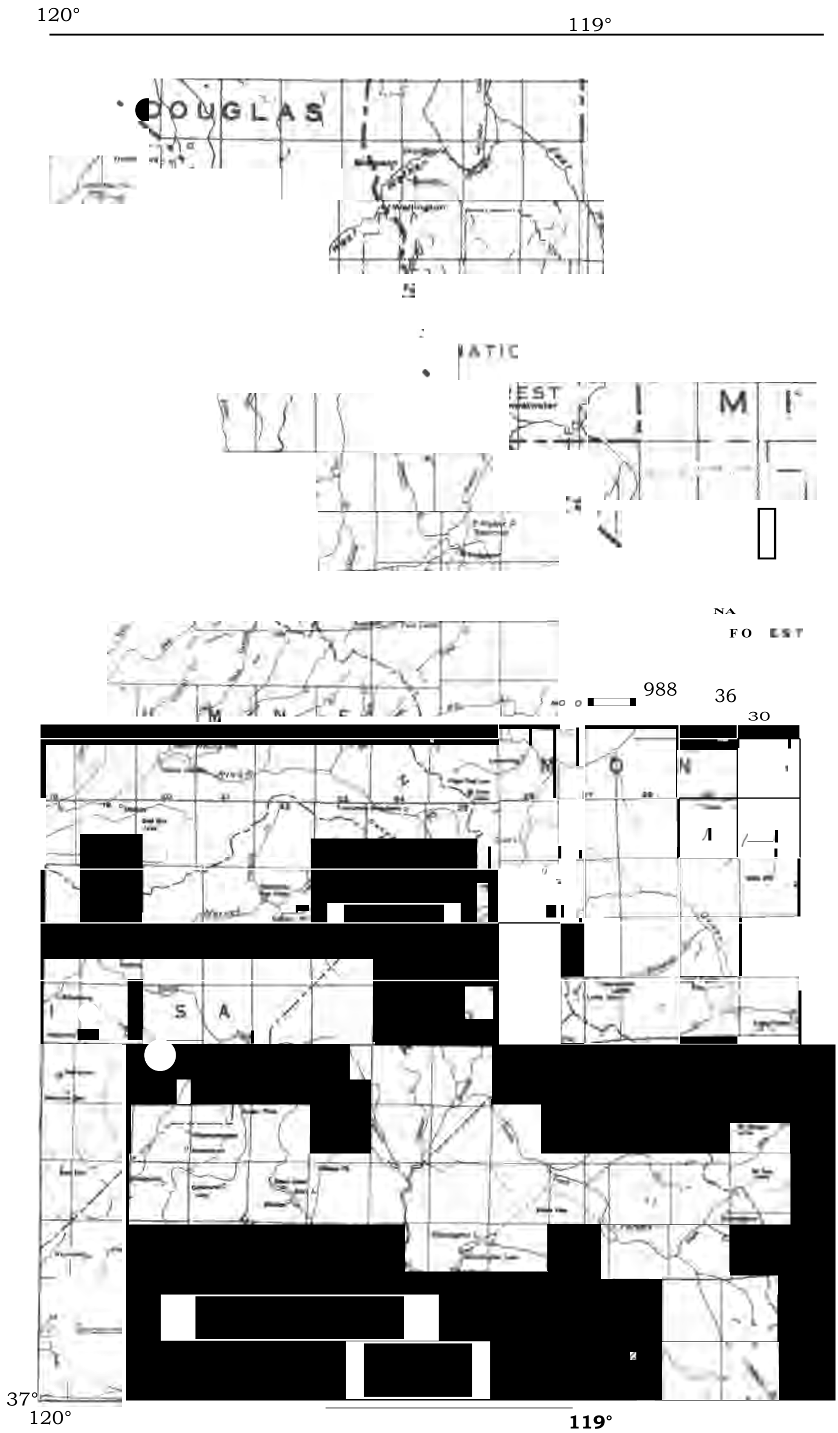
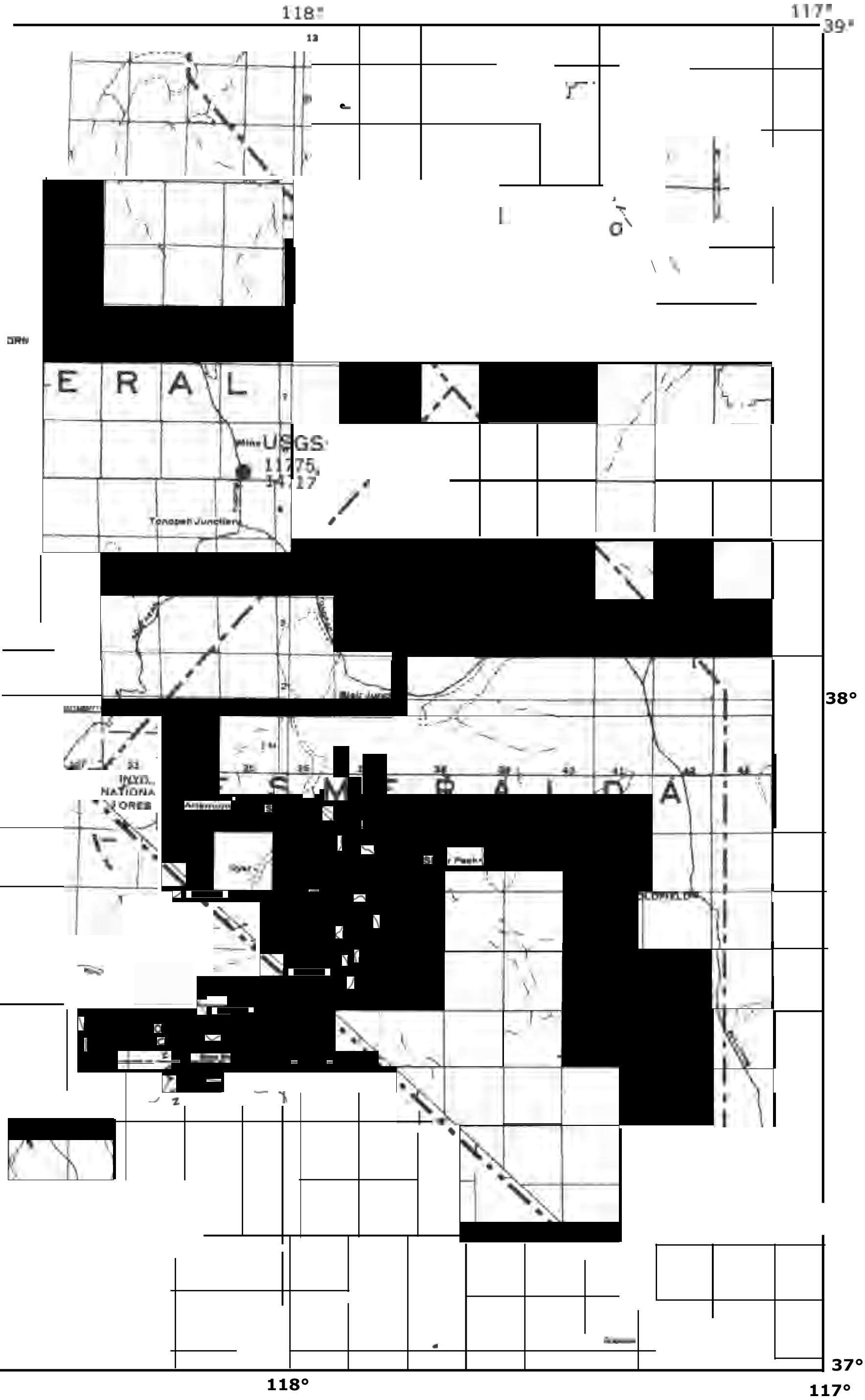


FIG. 16. Blancan fossil localities in Mono Basin, California, and at Sodaville, Nevada. These appear as localities 29 and 30 on Fig. 1.


118°
117°
39°
38°
37°
118°
117°
USGS
Tonopah Junction
A
GOLDFIELD

"Central Utah, near line of R.R." On closer inspection of the label one can see it read originally "Nevada", and Utah was written in after erasure. Both matrix and fossils can be duplicated readily in outcrops at the southwestern end of the Mopung Hills, close to the railroad, and there seems to be no reasonable doubt that this is the provenance of the specimens. On this evidence, the record by Hannibal (1910: 107) of *Valvata calli* Hannibal from "Central Nevada, near R.R." is probably based on this collection. I consider the *Valvata* at this locality is not V. *calli,* but an undescribed species.

29. Lake beds in Mono Basin, California
(NJ 11-4 [Walker Lake] A-4)

The known fossil localities are all within a radius of about 3 miles, in the Mono Lake basin east of Mono Lake (Fig. 3). Mollusks have been described and illustrated by Hanna (1963) and Taylor (this paper). The fossiliferous unit is shown as nonmarine undivided Pliocene on the Geologic Map of California, Olaf P. Jenkins edition, Walker Lake sheet (1963). The fauna consists of two species of freshwater snails, one living and one extinct. No other fossils have been described from this unit. A Blancan age is assigned here. The material described by Hanna (1963) is in the CAS collections; that described here, in USGS collections. Most recent topographic map: U. S. Geological Survey, Trench Canyon quadrangle (1958), 1: 62500.

Freshwater mollusks from Mono Lake basin

USGS Cenozoic locality 14729. Mono County, California. Under basalt north of Adobe Meadows and east of Mono Lake; W. F. Foshag, 1924.

Planorbidae
- *Helisoma (Carinifex) newberryi* (Lea) (Pl. 5, fig. 3-10)
- *Vorticifex gesteri* (Hanna) (Pl. 4; Pl. 5, fig. 1-2)

A collection of fossils in USGS collections records a third locality in the Mono Lake basin for *Vorticifex gesteri* (Hanna). The locality cannot be located precisely (Fig. 16), but is significant for several reasons. The shells have weathered free from the matrix, offering hope for collection of other species. The fossils are from below basalt, indicating the possibility of K/A radiogenic dates and assignment to a geomagnetic polarity epoch. The occurrance of *Helisoma newberryi* is the geologically oldest known record of that species, and provides information pertinent to the structural history of the basin.

Helisoma newberryi is a freshwater snail living in rivers and lakes around the edges of the northern Great Basin (distribution map, Fig. 8). Fossil localities are more numerous than living occurrences, and show a widely discontinuous distribution in parts of several major drainage basins. All fossil occurrences outside of the Mono Lake basin are of middle or late Pleistocene age, younger than any reasonable set of inferred former river and lake connections joining the separate localities. The Mono Lake basin locality extends the geologic range downward, and provides a geographic link between the localities in southeastern California and those to the north. In so doing it also provides a minimum date for the presumed river connection between these separate occurrences. Such a drainage connection through the Mono Lake basin to the south was inferred by Hubbs and Miller (1948: 79) on the basis of fish distribution.

The Blancan age assignment is based on *Vorticifex gesteri.* The most similar species occur in other Blancan faunas; and in *Vorticifex* the development of a high-spired, hyperstrophic shell with little or no spire-pit seems to be a progressive character that developed during and after the Pliocene.

30. Lake beds at Sodaville, Nevada
(NJ 11-4 [Walker Lake] B-1)

The two known fossil localities are

within a quarter-mile of each other at Sodaville. Mollusks are the only known fossils, and are recorded for the first time. This snail, *Vorticifex gesteri* is the only one of the two forms that is identifiable specifically. A Blancan age is assigned here. All material is in USGS collections. Most recent topographic map: U. S. Geological Survey Walker Lake quadrangle (1964) 1: 250000.

USGS Cenozoic locality 11775 (HF 299). Mineral Co., Nevada. Sodaville, east of railroad at old mill [about NE 1/4 sec. 32, T 6 N, R 35 E]. H. G. Ferguson, 1929.

The fossils are preserved as casts and internal and external molds in a limey coquina made up primarily by *Vorticifex gesteri* (Hanna). One poorly preserved specimen of *Pisidium* is unidentifiable specifically.

USGS Cenozoic locality 14717 (HGF 29-298). Mineral Co., Nevada. Lake beds 1/4 mile east of Sodaville [about NW 1/4 sec. 33, T 6 N, R 35 E]. H. G. Ferguson, 1929.

This collection might have come from the same bed as that represented at locality 11775, but the fossils are more weathered. The only species represented is *Vorticifex gesteri* (Hanna).

The only localities from which *Vorticifex gesteri* is known besides these two at Sodaville are east of Mono Lake (Fig. 16), at CAS 36730, 36988 and USGS 14729. Hence the lake beds at Sodaville are correlated with the localities in the Mono Basin and thought to be of Blancan age.

The localities at which *Vorticifex gesteri* is known in the Mono Basin are at about 7000 feet elevation, whereas those at Sodaville, over 40 miles away, are at about 4600 feet elevation. The known range of the species offers the hope that it may aid in measuring relative displacement in this tectonically active area.

31. Lake beds in Owens Valley, California
(NJ 11-7 [Mariposa] A-1, B-2)

The known fossil localities are on the east side of Owens Valley, from 5-20 miles east and southeast of Bishop. Mollusks have been recorded by Walcott (1897), Knopf (1914), Knopf and Kirk (1918) and Pakiser et al. (1964). The fossiliferous unit has been described by these authors and by Pakiser et al. (1964: 9), and mapped by Knopf and Kirk (1918, pl. 1). Schultz (193'7: 83-84) recorded a Blancan horse that is probably from the same stratigraphic unit. A Pleistocene, late Blancan or Irvingtonian, age is assigned here. The mollusks recorded by Walcott (1897) have evidently been lost; others are in USGS collections. Most recent topographic maps: U. S. Geological Survey quadrangles, scale 1: 62500, Bishop (1949) and Waucoba Mountain (1951).

Fossil mollusks from lake beds in Owens Valley

USGS Cenozoic locality 7580. Inyo County, California. Waucoba Mountain quadrangle (1951) 1: 62500. "Lake beds, Owens Valley"; Edwin Kirk, 1912. Probably from sec. 11 or 12, T 9 S, R 34 E, on south side of road to Graham Spring. Fossils cited by Knopf and Kirk (1918: 49) as *"Cincinnatis cincinnatiensis* Anthony"; reidentified as *Fontelicella,* large species.

USGS Cenozoic locality 19197. Inyo County, California. Bishop quadrangle (1949) 1: 62500. Cut bank on north side of Poleta Canyon, NW corner sec. 18, T 7 S, R 34 E; P. C. Bateman, 1956. This collection includes the same large species of *Fontelicella* as the preceeding.

Mollusks recorded by Walcott (1897: 342) from tilted lake beds exposed 3 miles above the mouth of Waucoba Can-. yon (about sec. 20, T 9 S, R 35 E, Waucoba Mountain quadrangle) could not be found in USGS or USNM collections during 1964.

The stratigraphic relation of the fossil mollusks and the horse recorded by Schultz (1937) is uncertain, and it may be that some of the mollusks are younger than the Blancan horse. The Coso Mountain local fauna from the southern end of Owens Valley (Schultz, 1937) has been correlated with K/A radiogenic dates that show it is among the youngest of Blancan faunas (Evernden et al., 1964; Hibbard et al., 1965), and of early Pleistocene age. The fossils from the lake beds farther north in Owens Valley may be stratigraphically equivalent, or younger (Pakiser et al., 1964: 9). Hence all fossils are Pleistocene, and some of the mollusks might be post-Blancan.

32. Allison Ranch, Nevada
NK 11-11 [Winnemucca] A-2)

The 2 localities are at the southwest end of the Cortez Mountains, 42 miles southwest of Carlin. Two species of freshwater snails are reported for the first time. The fossiliferous unit has been mapped by Harold Masursky (unpublished), who tentatively assigned a late Pliocene age. Hemphillian age is assigned here. Fossils are in USGS collections. Most recent topographic map: U. S. Geological Survey Horse Creek Valley quadrangle (1957) 1: 62500.

Fossil Mollusks from Allison Ranch

USGS Cenozoic locality 23232 (HFC 181). Eureka County, Nevada. Horse Creek Valley quadrangle (1957)1: 62500. 4500 ft north, 4800 ft west, sec. 5, T 26 N, R 49 E. West of Allison Ranch. Elevation 6460 ft. Shells in calcareous sandstone interbedded with gravel below basalt. Harold Masursky, 1962.

Lymnaeidae

Radix intermontana Taylor, new name

USGS Cenozoic locality 23233 (HFC 182). Eureka County, Nevada. Horse Creek Valley quadrangle (1957)1: 62500. 0 ft north, 800 ft west, sec. 5, T 26 N, R 49 E. Elevation 6080 ft. Harold Masursky, 1962.

Lymnaeidae

Radix intermontana Taylor, new name (Pl. 6, Fig. 8-11)

Planorbidae

Coretus (Pl. 6, Fig. 7)

The age assignment of the mollusks from Allison Ranch depends partly on the composition of the assemblage, and partly on the inferred specific relationships of the *Radix.* Since only 2 species are known, some of the interpretation rests on negative evidence. USGS collections from southern Idaho and the Great Basin region commonly include *Coretus* in Barstovian to Hemphillian (late Miocene to middle Pliocene) assemblages. The specimens from Allison Ranch are not specifically identifiable, but are not C. *plenus* (Hanna) of California. The sparse assemblage, with only 2 species that are both pulmonates, is more consistent with the meager pre-Blancan faunas known in the area than with Blancan faunas.

Native, living species of *Radix* are unknown in North America and virtually unknown in the Western Hemisphere. Four fossil species have been described previously, showing that the genus was present in northwestern North America during much of the Tertiary. These occurrences are all surely or probably older than late Pliocene, so that the presence of *Radix* at Allison Ranch reinforces the evidence of *Coretus* that the fauna is pre-Blancan. The previously described American species of *Radix* are as follows:

Lymnaea idahoensis Yen, 1946. Salt Lake Group, Pliocene, Bear Lake County, Idaho. Type in USNM, and other specimens in USGS collections examined. The species includes *"Lymnaea petaluma* Hanna" as illustrated and described by Yen (1946) from the same locality. Preoccupied by *Lymnaea idahoensis* Henderson (1931b); here renamed *Radix intermontana* Taylor, new name.

Radix junturae Taylor, 1963. Black Butte local fauna, early Pliocene, Juntura Formation, Malheur County, Oregon.

Radix malheurensis (Henderson and Rodeck), 1934. Pliocene, probably Hemphillian, Malheur County, Oregon. Described as *"Payettia (?)",* but referred here to Lymnaeidae on the basis of topotypes and other material in USGS collections.

PLATE 6

FIGS. 1-6. *Savaginius nannus* (Chamberlin and Berry), X16. Figured specimens USNM. USGS Cenozoic locality 20093, Cache Valley Formation, Cache Valley, Utah, Topotypes of *Fluminicola yatesiana utahensis* Yen.

FIG. 7. *Coretus,* X4. USGS Cenozoic locality 23233, Allison Ranch, Eureka County, Nevada. Figured specimen, USNM.

FIGS. 8-11. *Radix intermontana* Taylor, new name, X2.4. Figured specimens, USNM. USGS Cenozoic locality 23233, Allison Ranch, Eureka County, Nevada. Figs. 8 & 10 are of one specimen; Figs. 9 & 11 are of another specimen.

Radix venusta (Russell), 1938. Antero Formation, Oligocene, South Park, Park County, Colorado. Described as *Pseudo-succinea,* but referred here to *Radix* on the basis of the type (in USNM) and other material in USGS collections.

The fauna at the type locality of *Radix intermontana,* in southeastern Idaho, is strikingly different from the Blancan assemblage in the Cache Valley Formation of the same area (Fig. 1, localities 36, 37). This contrast is the principal basis for considering the *Radix* and its associates as pre-Blancan. Occurrence of some other snails, such as *Menetus, Brannerillus,* and *Vorticifex tryoni* with the *Radix,* favors an age no greater than early or middle Pliocene. On this evidence from several sources the fauna from Allison Ranch is dated as Hemphillian.

33. Hay Ranch, Nevada
(NK 11-11 [Winnemucca] A-2)

The locality is in southern Pine Valley, 40 miles south-southwest of Carlin. Six species of mollusks are known, reported here for the first time. The fossiliferous unit has been mapped by Harold Masursky (unpublished). Undescribed fossil mammals indicate possibly Blancan age. Fossils are in USGS collections. Most recent topographic map: U.S. Geological Survey Horse Creek Valley quadrangle (1957) 1: 62500.

Fossil Mollusks from Hay Ranch

USGS Cenozoic locality 23234 (HFC 200a). Eureka County, Nevada. Horse Creek Valley quadrangle (1957)1: 62500. 1600 ft north, 3500 ft west, sec. 7, 26 N, R 51 E. Elevation 5520 ft. North of JD Ranch. Harold Masursky, 1962.

Sphaeriidae
Pisidium compressum Prime
Valvatidae
Valvata humeralis Say
Lymnaeidae
Lymnaea
Planorbidae
Gyraulus parvus (Say)
Planorbella subcrenata (Carpenter)
Succineidae
cf *Succinea*

34. Glenns Ferry Formation, Oregon-Idaho
(NL 11-11, NK 11-2, 3, 5, 6 [Baker, Boise, Hailey, Jordan Valley, Twin Falls] quadrangles)

The Glenns Ferry Formation outcrops over an area of several thousand square miles in southwestern Idaho and adjacent Oregon (Fig. 1), but most of the fossil localities are near the Snake River along about 75 miles of its course between Castle Creek, Idaho and Hagerman Valley, Idaho. Mollusks have been described or listed from rocks now included in the formation by the following authors (in chronological order): Hall 1845, Gabb 1866-1869, Meek 1870, Newberry 1870a,b,c, Conrad 1871, Newberry 1871a,b, Meek 1877, White 1882, Dall and Harris 1892, Lindgren and Knowlton 1898, Lindgren 1900, Russell 1902, Lindgren and Drake 1904, Dall 1924a,b, Kirkham 1931, Henderson and Rodeck 1934, Stearns et al. 1939, Yen 1944, Youngquist and Kilsgaard 1951, Littleton and Crosthwaite 1958, Taylor 1958, Herrington and Taylor 1958, Hibbard 1959, Hibbard and Taylor 1960, Taylor 1960a, Malde and Powers 1962, Keith and Weber 1964, Weber and La Rocque 1964. The Glenns Ferry Formation is included within the Idaho Group as mapped by Malde (1965), Malde et al. (1963) and Malde and Powers (1962, pl. 1), whose papers should be consulted for a summary of stratigraphy, index map of geographic localities and access to geologic literature.

The age range of the formation is late Pliocene through middle Pleistocene; most of the mollusks are Pliocene. The fossils described by Henderson and Rodeck (1934) are in UCMNH collections; those by Yen (1944)in CAS; practically all others in UMMZ or USGS collections. Types of species described by Meek (1870, 1877), Conrad (1871), White (1882) and Dall (1924b) are in the USNM. Most of the molluscan localities are in areas covered by recent topographic maps published by the U. S. Geological Survey at scales of 1: 24000 or 1: 62500.

Facies

The Glenns Ferry Formation is a thick, widespread body of lake and stream deposits. The fossil assemblages are correlated with differences in facies as well as stratigraphic position, so that the interpretation of the fossils and their interrelationship to other sources of geologic dates depend upon an understanding of both physical and biological features.

The greatest thickness and volume of the formation is included within the lacustrine facies, which underlies or outcrops over most of the basin (Fig. 1, locality 34). The other facies (flood-plain and fluviatile) are practically restricted to the axis of the basin, but are locally thick. The lacustrine facies was deposited in a large lake, Lake Idaho, or the Idaho Lake, of Cope (1883 a,b). Most of the mollusks in this facies were apparently restricted to, or most abundant in, the lake. There was no endemic sublittoral fauna, perhaps because of the soft, oozy character of the silt and fine sand bottom in deeper parts of the lake. The richest molluscan fauna lived on firmer substrata (coarse sand, oolitic sand, cinders derived from volcanic eruptions, reefs of calcareous algae) of the littoral zone. Many fishes were endemic to the lake (R. R. Miller, 1965), although they are not as striking as mollusks in this respect.

Practically no mammals are known from the lacustrine facies or from stratigraphically equivalent beds; most of the species of mollusks of the Glenns Ferry Formation are restricted to the lacustrine facies and thus are stratigraphically lower. One of the rare mammals from the lacustrine facies is a desman mole, representing a group that (except for a mid-Pliocene occurrence in Oregon) is otherwise known only from the late Cenozoic of Europe. In broad outlines this pattern of distribution is like that of the snails *Orygoceras* and *Gyraulus (Idahoella),* which are similarly disjunct.

The deposits of rivers flowing into this former lake are represented by part of the flood-plain facies of the Glenns Ferry Formation bordering the eastern end of the area of outcrop of the lacustrine facies. The molluscan fossils of the two facies are so different that evidently there was little mingling of species of the immediately adjacent lake shore and tributary streams. A similarly sharp boundary between the endemic fauna of modern lakes and the more widespread fauna of tributaries has been noted in Lake Ohrid, Yugoslavia-Albania (Stanković, 1960); Lake Tanganyika, Africa (Leloup, 1950, 1953); and Lake Titicaca, Bolivia-Peru (Haas, 1955; Hubendick, 1955). The late Pliocene (Dacian) fauna of the Bra§ov basin, Romania, shows this relationship clearly. The fauna of the lacustrine facies there is virtually all extinct and mostly endemic. The fauna of the marginal facies, representing shallow ponds and tributaries, is sharply distinct and dominated by species still living that also may occur earlier than the late Pliocene (Jekelius, 1932). These statements apply also to the mollusks in the flood-plain facies of the Glenns Ferry Formation.

The precise correlation between the lacustrine and flood-plain facies at the eastern end of the outcrop area of the Glenns Ferry Formation is possible by tracing a widespread bassalt flow. Whole-rock analysis of sample KA 1173 from this flow gave a potassium-argon radiogenic date of $3.48 \pm 0.27 \times 10^{6}$ years (Evernden et al., 1964). Virtually all the species restricted to the lacustrine facies of the formation, and most of those known in the flood-plain facies, occur below the horizon of this basalt and hence lived about 3.5 million years ago. Probably little if any of the lacustrine facies is as young as 3.0 million years. All basalt samples from the formation belong to the Gilbert epoch of reversed geomagnetic polarity (Cox et al., 1965), but the samples are all stratigraphically low in the formation.

Most of the fossil mammals from the flood-plain facies at the eastern end of the Glenns Ferry Formation come from the classic "horse quarry" in Hagerman Valley, about 60 feet above the basalt flow mentioned. In this immediate area practically no mollusks are found so high stratigraphically. The mammals are interpreted as late Pliocene (Hibbard et al., 1965), but have frequently been regarded as early Pleistocene, and are in any case close to the Pliocene -Plistocene boundary of current American usage.

The fluviatile facies of the Glenns Ferry Formation is partly the deposits of large tributaries to the lake, and partly the deposits of an intermediate stage in the history of the lake. As the eastern end of the lake was filled the environment changed from lacustrine to fluviatile. Subsidence contemporaneous with deposition is responsible for accumulation of a thick section of lacustrine and then fluviatile sediments in the axis of the basin, while only a small fraction of this amount was deposited by streams on the stable southeastern margin of the basin in Hagerman Valley and westward. Thus the mollusks and vertebrates from near Hammett (Hibbard, 1959, "Sand Point local fauna") are scarcely different in age from those of the Hagerman horse quarry (compare my earlier, erroneous opinion in Hibbard, 1959: 20-21), and might even be slightly younger.

The only strong evidence for Pleistocene age of part of the Glenns Ferry Formation comes from the mammals of the area between Froman Ferry and Jackass Butte, near Grandview, about 75 miles west of Hagerman and about at midlength of the basin. The mammals are Irvingtonian and distinctly different from those of Hagerman Valley although in the same flood-plain facies. Apparently by this time the lake had been filled completely, and the entire basin was a river valley receiving sediments in the center like those that at first accumulated only at the margin. Unfortunately the only mollusk from this stratigraphically highest part of the formation is the common extant snail *Valvata humeralis* Say.

Correlation

The mollusks from the lacustrine facies of the Glenns Ferry Formation are most similar to those of the Cache Valley Formation and Salt Lake Group in southeastern Idaho and northern Utah (Fig. 1, localities 35-37). A number of species, or vicariant pairs of closely related species, are found only in these two formations. Such related forms occur in *Anodonta* (Unionidae), Payettiidae, *Pliopholyx* (Pliopholygidae), *Lithoglyphus* (Hydrobiidae), *Vorticifex* (Planorbidae), and the pair of species *Gyraulus multicarinatus* (Yen) and *G. monocarinatus* Chamberlin and Berry (Planorbidae). The faunal similarities are so close that they indicate geologic contemporaneity for the two units, and show that substantially similar facies are represented.

The molluscan fauna next most similar to that of the Glenns Ferry Formation is from the basal part of the Tulare Formation in the Kettleman Hills, California (Fig. 1, locality 18). The following lists summarize the species common or closely related in the two formations:

Glenns Ferry Formation, Idaho

Gonidea malheurensis (Henderson and Rodeck)
Sphaerium kettlemanense Arnold
**Sphaerium striatinum* (Lamarck)
**Pisidium punctatum* Sterki
Pisidium supinum Schmidt
**Valvata humeralis* Say
Pyrgulopsis n. sp.
Menetus n. sp.

Tulare Formation, California

Gonidea coalingensis Arnold
Sphaerium kettlemanense Arnold
Sphaerium striatinum (Lamarck)
Pisidium punctatum Sterki
Pisidium supinum Schmidt
Valvata humeralis Say
Pyrgulopsis vincta Pilsbry
**Menetus centervillensis* (Tryon)

An asterisk marks species that are so widespread that they do not show a particular relationship between the faunas of the two areas. The number of common species, or of pairs of related species, is due to both approximate contemporaneity and similar facies, the relative effects of which cannot be distinguished now. The biogeographic relations of these 2 areas have been discussed previously (p 17-27).

Blancan Fossils from Glenns Ferry Formation

The following list includes all of the vertebrates, and the previously described species of mollusks, known from the stratigraphically lower (Blancan) part of the Glenns Ferry Formation. The fossils excluded are those from the volumetrically small middle Pleistocene part of the formation, along the Snake River from Froman Ferry to Jackass Butte. The list of mammals includes the unpublished results of collecting by C. W. Hibbard and parties from the University of Michigan Museum of Paleontology. Records or descriptions of fossils from this part of the Glenns Ferry Formation are included in the following papers: Boss (1932), Brodkorb (1958, 1963, 1964a), Conrad (1871), Cope (1870a, b, 1871, 1883a, b), Dall (1924a, b), Dall and Harris (1892), Fine (1964), Gabb (1866-1869), Gazin (1933a, b, 1934a, b, 1935a, b, c, 1936, 1937a, 1938), Gidley (1930a, b, 1931), Gilmore (1933, 1938), Hall (1845), Henderson and Rodeck (1934), Herrington (1962), Herrington and Taylor (1958), Hibbard (1958a, b, 1959, 1962), Hibbard and Taylor (1960), Keith and Weber (1964), Kirkham (1931), Leidy (1870a, b, 1871, 1873), Lindgren (1900), Lindgren and Drake (1904), Lindgren and Knowlton (1898), Littleton and Crosthwaite (1958), Malde and Powers (1962), Meek (1870, 1877), A. H. Miller (1948), L. Miller (1944), R. R. Miller (1958, 1965), Newberry (1870a, b, c, 1871a, b), Russell (1902), Stearns et al. (1939), Stirton (1935), Taylor (1958, 1960a), Uyeno (1961), Uyeno and Miller (1963), Weber and La Rocque (1964), Wetmore (1933), White (1882), Wilson (1933, 1937), Yen (1944), Youngquist and Kilsgaard (1951).

A diverse pollen flora is under study by E. B. Leopold, who mentioned briefly (Leopold *in* Weber, 1965) some climatic inferences from this and other late Cenozoic floras from Idaho.

Class Pelecypoda
- Order Schizodonta
  - Margaritiferidae
    - *Gonidea malheurensis* (Henderson and Rodeck)
  - Unionidae
    - *Anodonta*
- Order Heterodonta
  - Sphaeriidae
    - *Sphaerium idahoense* Meek
    - *Sphaerium kettlemanense* Arnold
    - *Sphaerium striatinum* (Lamarck)
    - *Pisidium compressum* Prime
    - *Pisidium punctatum* Sterki
    - *Pisidium supinum* Schmidt
    - *Pisidium woodringi* Yen

Class Gastropoda
- Order Archaeogastropoda
  - Payettiidae
    - *Payettia dallii* (White)
- Order Mesogastropoda
  - Valvatidae
    - *Valvata humeralis* Say
    - *"Aphanotylus" whitei* Dall
  - Pliopholygidae
    - *Pliopholyx campbelli* (Dall)
    - *Pliopholyx idahoensis* Yen
  - Orygoceratidae
    - *Orygoceras arcuatum* Dall
    - *Orygoceras crenulatum* Dall
    - *Orygoceras idahoense* Dall
    - *Orygoceras tuba* Dall
  - Hydrobiidae
    - *"Amnicola" bithynoides* Yen
    - *Fontelicella idahoensis* (Pilsbry)
    - *Lithoglyphus occidentalis* (Hall)
    - *Lithoglyphus superbus* (Yen)
    - *Lithoglyphus weaveri* (Yen)
    - *"Pyrgulopsis" carinata* Yen
    - *Pyrgulopsis*
  - Pleuroceridae
    - *"Melania" taylori* Gabb

Order Basommatophora
Lymnaeidae
Lymnaea occidentalis Hemphill
Bakerilymnaea cockerelli (Pilsbry and Ferriss)
Planorbidae
Omalodiscus pattersoni (Baker)
Gyraulus multzcarinatus (Yen)
Gyraulus parvus (Say)
Promenetus exacuous kansasensis (Baker)
Promenetus umbilicatellus (Cockerell)
Planorbula campestris (Dawson)?
Menetus
Physidae
Physa gyrina Say
Order Stylommatophora
Zonitidae
Hawaiia minuscula (Binney)
Class Crustacea
Order Decapoda
Astacidae
Pacifastacus? breviforceps (Cope)
Pacifastacus? chenoderma (Cope)
Class Osteichthyes
Salmonidae
Salmo copei Uyeno and Miller
Salmo
Cyprinidae
Diastichus macrodon Cope
Diastichus parvidens Cope
Mylocyprinus robustus Leidy
Mylopharodon hagermanensis Uyeno
Mylopharodon? condonianus (Cope)
Ptychocheilus cf *P. oregonensis* (Richardson)
Sigmopharyngodon idahoensis Uyeno
Acrocheilus
Catostomidae
Catostomus cristatus Cope
Catostomus reddingi Cope
Catostomus shoshonensis Cope
Catostomus (Pantosteus)
Deltistes
Chasmistes
Ictaluridae
Ictalurus
Centrarchidae
Archoplites
Cottidae
Cottus divaricatus Cope
Class Amphibia
Order Salientia
Frogs
Class Reptilia
Order Chelonia
Kinosternidae
Kinosternon
Emydidae
Pseudemys idahoensis Gilmore
Order Squamata
Colubridae
Thamnophis
Class Ayes
Order Podicipethformes
Podicipedidae
Podiceps
Aechmophorus
Podilymbus
Order Pelecaniformes
Phalacrocoracidae
Phalacrocorax auritus (Lesson)
Phalacrocorax idahensis (Marsh)
Phalacrocorax macer Brodkorb
Pelecanidae
Pelecanus halieus Wetmore
Order Ardeiformes
Ciconiidae
Ciconia maltha L. Miller
Order Anseriformes
Anatidae
Olor columbianus (Ord)
Olor hibbardi (Brodkorb)
Anser pressus (Wetmore)
Anas platyrhynchos Linnaeus
Querquedula
Nettion bunkeri Wetmore
Order Gruiformes
Gruidae, indeterminate
Rallidae
Gallinula chloropus (Linnaeus)
Porzana lacustris Brodkorb
Order Strigiformes
Strigidae
Speotyto
Asio
Class Mammalia
Order Insectivora
Soricidae
Blarina gidleyi Gazin
Talpidae
Desmana moschata (Linnaeus)
Order Chiroptera

Vespertilionidae
Antrozous
Order Edentata
Megalonychidae
Megalonyx leptonyx (Marsh)?
Order Rodentia
Sciuridae
Marmot
Citellus
Geomyidae
Thomomys gidleyi Wilson
Heteromyidae
Perognathus
Prodipodomys idahoensis Hibbard
Castoridae
Castor cf *C. californicus* Kellogg
Procastoroides
Cricetidae
Peromyscus hagermanensis Hibbard
Cosomys primus Wilson
Nebraskomys? taylori Hibbard (including *Pliophenacomys idahoensis* Hibbard)
Pliopotamys minor (Wilson)
Pliopotamys
Order Carnivora
Canidae
Canis cf *C. latrans* Say
Borophagus
Ursidae
Arctotherium
Ursidae sp.
Mustelidae
Mustela gazini Hibbard
Lutra piscinaria Leidy
Canimartes? cookii (Gazin)
Canimartes ? idahoensis (Gazin)
Felidae
Felis lacustris Gazin
Machairodontidae
Machairodus? hesperus Gazin
Order Proboscidea
Mammutidae
Mammut
Order Lagomorpha
Leporidae
Hypolagus limnetus Gazin
Hypolagus cf *H. vetus* (Kellogg)
Pratilepus vagus (Gazin)
Order Artiodactyla
Tayassuidae
Platygonus pearcei Gazin
Camelidae
?Came lops arenarum Hay
?Procamelus or *Tanupolama*
Cervidae, indeterminate
Antilocapridae
Ceratomeryx prenticei Gazin
Order Perissodactyla
Equidae
Plesippus shoshonensis Gidley

Type Localities of Mollusks Described from Glenns Ferry Formation

By curious coincidence, every species of mollusk that has been first described from the Glenns Ferry Formation was ascribed to a locality either seriously wrong ("Colorado", Conrad, 1871) or vague ("Hammett", Yen, 1944). Even more curiously, the species described first (Hall, 1845) are the only ones whose type locality can be located surely and precisely from the original publication. The type localities of the species are discussed in following sections in the order of their description.

Hall (1845)

Among the first fossil freshwater mollusks described from North America were 3 species now known to have come from the Glenns Ferry Formation. Hall (1845) described *Cytherea parvula, Natica* (?) *occidentalis* and *Turritella bilineata* from samples 16 and 21 collected by J. C. Frémont, "longitude 115°, latitude 43°". The lithologic description of the samples by Hall (1845: 300) and the narrative by Frémont (1845: 169-170) together with the description of the fossils enable a relatively precise relocation of the spot where Frémont collected.

The "numberless streams and springs" issuing from cliffs beside the Snake River along a distance of about 7 miles (Frémont, 1845: 169) are the series of springs from Thousand Springs southward in T 8 S, R 14 E, Gooding County, Idaho. The "most beautiful and picturesque fall" below which there is a "remarkable bend" (Frémont, 1845: 169) is Thousand Springs, in sec. 8, T 8

S, R 14 E, and the bend of the Snake River is in sec. 34, T 7 S, R 13 E, and secs. 3 and 4, T 8 S, R 13 E. The Oregon Trail that Frémont followed is marked on the U. S. Geological Survey Pasadena Valley quadrangle (1949) 1: 62500. Deer Gulch, crossed by the trail in NW 1/4 sec. 28, T 6 S, R 11 E, is the only gulch deep enough to expose Glenns Ferry Formation along the trail for several miles. The ford on the Snake River, "expanded into a little bay, in which there are two islands" (Fremont, 1845: 170), where Frémont arrived about 2 o'clock on October 3, 1842, is identifiable as in the SE 1/4 sec. 31, T 5 S, R 10 E, Elmore Co., Idaho, about half a mile south of the town of Glenns Ferry.

Although the Glenns Ferry formation in the area traversed by Frémont is not commonly indurated, the lower parts of the lacustrine facies frequently contain concretions. These are common in Deer Gulch where crossed by the Oregon Trail, and it seems practically certain that some of these were sampled by Frémont. There is no question of any other formation, for the others in the vicinity are Pleistocene, not indurated, and do not contain fossils like those described by Hall.

Cytherea parvula Hall might be either of two species of *Sphaerium* that occur in the Glenns Ferry Formation—either *S. idahoense* or an undescribed species. Hall's types have been lost (Henderson, 1935: 36) and the species is considered unrecognizable (Herrington and Taylor, 1958).

Natica (?) occidentalis Hall is identified as the species later described as *Lithasia antiqua* Gabb (1866).

Turritella bilineata Hall is surely the species later described as *Melania taylori* Gabb (1866), but is preoccupied by *Turritella bilineata* von Dechen, in De La Beche (1832), now *Murchisonia bilineata* (von Dechen).

Gabb (1866)

Gabb (1866) described two species, *Melania taylori* and *Lithasia antiqua*, and mentioned "a little bivalve, perhaps a species of *Sphaerium*" from southwestern Idaho. "Locality: From a fresh-water Tertiary deposit on Snake River, Idaho Territory, on the road from Fort Boise to the Owyhee mining country. Collected by Mr. A. Taylor." Lindgren and Knowlton (1898: 628) identified this as probably Walters Ferry. The site of the ferry, now abandoned, is shown on the U. S. Geological Survey Walters Butte quadrangle (1957) 1: 24000 in the N 1/2 sec. 17, T 1 S, R 2 W, Canyon and Owyhee Counties, Idaho.

The volume in which Gabb described these species was issued partly in 1866, partly in 1869 (Stewart, 1927: 310).

Meek (1870, 1877)

Meek (1870, 1877) described *Sphaerium idahoense* from 2 localities: "Fossil Hill, Kaw-soh Mountains, Nevada," and Castle Creek, Idaho. The only specimens of Meek's material still in the U. S. National Museum are a single lot, USNM 12520, that might be from one bed. The field label with the specimens identifies them as coming from Fossil Hill, Hot Spring Mts., Nevada, camp 12, collected by A. Hague.

The specimen figured by Meek (1877, pl. 16, fig. 1) is in a piece of poorly sorted coarse, oolitic shelly sandstone that is unlike the matrix of other fossils described by Meek from Fossil Hill, and unlike any rock at Fossil Hill. Other mollusks in this block include *Orygoceras* and *"Melania" taylori* Gabb, unknown outside the Glenns Ferry Formation in southwestern Idaho. Surely all these fossils came from Idaho, not Nevada, and probably all from Castle Creek. Clarence King, who was in that area in 1867 and 1868, may have obtained these specimens there. Transposition or mislabeling of specimens may have occurred. The matrix, preservation, morphology and variety of fossils indicate the types of *Sphaerium idahoense* Meek came from the basal oolitic sandstone of the lacustrine facies of the Glenns Ferry Formation, probably along Castle Creek south of the Orana 1: 62500 quadrangle, in an area not yet mapped topographically, nor thoroughly explored paleontologically.

Conrad (1871)

The two freshwater fossil mollusks described by Conrad (1871) as coming from Colorado can now be recognized as from the Pliocene of southwestern Idaho. Only one is from the Glenns Ferry Formation, but because Conrad described them in the same paper and gave grounds for inference they were associated in the field, both species are discussed here.

Anodonta decurtata Conrad was described from "a cast in a yellow arenaceous rock" that is now USNM 13574. The features of the shell, preservation and matrix are all distinctive. They agree closely with specimens from USGS 2970, collected by N. F. Drake in 1897 from "white sandstone in a south branch of Castle Creek whence Oreana bears N 16° W 6 1/2-7 miles distant", thus about sec. 28, 29 or 33, T 5 S, R 1 E, Owyhee Co., Idaho, in the middle Pliocene Chalk Hills Formation. The species is distinctive, unlike any in the Glenns Ferry Formation, and most like *Anodonta kettlemanensis* Arnold from the lowei part of the Tulare Formation, California (Fig. 1, locality 18).

Melania decursa Conrad "accompanied the *Anodonta,* but the rock in which it occurs is a mixture of sand and shell fragments, in which many specimens of these shells are replaced by chalcedony." The description of the species as well as the matrix agree with fossils from the oolitic basal sandstone of the lacustrine facies of the Glenns Ferry Formation in the vicinity of Castle Creek, Owyhee Co., Idaho. The species is almost certainly the one described by Gabb (1866) as *Melania taylori.* The type has not been found in USNM collections.

Possibly the types of *Anodonta decurtata* and *Melania decursa* were collected by Clarence King in 1867 or 1868 during a visit to the region of Castle Creek and Sinker Creek, at the time he collected the type of *Sphaerium idahoense* Meek. (Wilkins (1958: 120) in his biography of King noted that King misdated one of the visits to Idaho as 1869.) If so, all three species collected by King were published with seriously erroneous type localities.

White (1882)

Two old labels with the syntypes of *Payettia dallii* (White, 1882) (USNM 11547) read " 50 m. below Salmon left bank Snake R. Idaho" and "50 mi. below Salmon Falls Snake river Idaho ". The types of *Payettia dallii* evidently came from blocks of indurated shelly fine sandstone (USNM 11548) including many specimens of *Lithoglyphus occidentalis* (Hall) and several of *"Melania" taylori* Gabb. Perhaps the earliest of all labels on this material is pasted to one of these blocks and reads "50 miles below Salmon Falls—left bank Snake Riv." The details of preservation, lithology and morphology of the fossils can be matched most closely in USGS collections by specimens from locality 3485, from concretions in the Glenns Ferry Formation collected by I. C. Russell in 1901, at "Shell Mountain" (Russell, 1902: 54-55, unit 5 of stratigraphic section). The locality is identified as a promontory locally known as Sand Point, between Wilson Grade and the Snake River, on the south side (left bank) of the river in the S 1/2 sec. 1, T 6 S, R 8 E, Owyhee Co., Idaho.

Dall (1924)

Dall (1924b) described mollusks from 3 localities in the Glenns Ferry Formation that have been relocated with varying success.

USGS Cenozoic locality 3486. Mouth of King Hill Creek, near Glenns Ferry, Idaho. I. C. Russell, 1901. Type locality of *Pliopholyx camp belli* (Dall). The details of preservation, matrix, morphology of the fossils and abundance of species can be so precisely duplicated within part of USGS 21510 that there is little doubt that this is the site of Russell's collection. USGS Cenozoic locality 21510: Elmore Co., Idaho. Pasadena Valley quadrangle (1948) 1: 24000. 50-100 ft S, 1350-1700 ft E of NW corner sec. 14, T 5 S, R 10 E, 2615 ft elev. Silt and fine sand 15-20 ft below a prominent 4-ft bed of basaltic glass sand. D. W. Taylor, 1956.

USGS Cenozoic locality 10302. Bluff on south side of Snake River, about one mile west of Slick Bridge. F. C. Calkins, 1922. Type locality of *"Goniobasis" taylori* var. *calkinsi* Dall. The published description gives the locality as "1 mile east of Slick Bridge", but the original field label with the collection reads "west". Slick Bridge is shown on the U. S. Geological Survey Glenns Ferry quadrangle (1951) 1: 62500 in the SE 1/4 sec. 26, T 5 S, R 9 E, Elmore Co., Idaho. The locality has not been found either east or west of the bridge.

USGS Cenozoic locality 14728. Castle Creek, Owyhee Co., Idaho. W. H. Campbell. Type locality of *Sphaerium meeki* Dall, *Orygoceras arcuatum* Dall, *O. crenulatum* Dall, *O. idahoense* Dall, *O. tuba* Dall and *"Aphanotylus" whitei* Dall. The assemblage of fossils and matrix show the locality is in the basal oolitic sandstone of the lacustrine facies of the Glenns Ferry Formation, probably along Castle Creek south of the Oreana 1: 62500 quadrangle, in an area not yet mapped topographically nor thoroughly explored paleontologically.

Yen (1944)

Yen (1944) described mollusks "from Hammett in Elmore County, southern Idaho. The material was collected by Mr. A. Altha but no field information other than a precise locality was attached to the collection." The records of the CAS, and information from L. G. Hertlein (personal communication), are that the collection described by Yen was given to the Academy by Albert Atha (correct spelling) when a student at the University of California, Berkeley. He collected the fossils on the Atha farm near Hammett. The "precise locality" mentioned by Yen is only "near Hammett".

Local inquiry in Hammett revealed that the Atha family moved some years ago but formerly lived in the house shown on the U. S. Geological Survey Hammett quadrangle (1948) 1: 24000 600 ft S, 100 ft E, sec. 1, T 6 S, R 8 E, Elmore Co., Idaho, about half a mile south of Hammett. Efforts to correspond with a member of the family were in vain.

The fossils described by Yen are well preserved shells having a slight pink color indicating they had not weathered long on the surface. They are uncrushed, and washed free from a loose matrix of fine sand. The details of preservation, matrix and the assemblage of the fossils are like those in the fulviatile facies of the Glenns Ferry Formation, particularly south of the Snake River opposite Hammett, at USGS 19129 (Hibbard 1959, Malde and Powers 1962). At this locality the slopes are steep and fossils can weather at the surface only a short time. More probably the Atha collection came from a similar, nearby locality in this part of the formation, or possibly from an excavation near the Atha farmhouse.

35. Salt Lake Group,
Marsh Creek Valley, Idaho
(NK 12-4 [Pocatello] C-1)

The one known fossil locality is on the west side of Marsh Creek Valley 6 miles south of Inkom. Mollusks are reported here for the first time. The fossiliferous unit is shown as Salt Lake Formation on the geologic map of Idaho (Ross and Forrester, 1947). The fauna includes about 10 species that are interpreted as late Pliocene. All fossils are in USGS collections. Most recent topographic map: U. S. Geological Survey Pocatello quadrangle (1958) 1: 250000.

Stratigraphic Section of Salt Lake Group, SW 1/4 SW 1/4 sec. 15, T 8 S, R 36 E, Bannock Co., Idaho

Unit	Description	Thickness (feet)	Total (feet)
Top not exposed			
8	Siliceous ash, light gray (5Y 7/1) when dry, massive, compact, calcareous, weathers into large flat blocks and forms slight ledge at top of road cut; has numerous fine flecks of limonite stain, carbonized plant fragments and ostracodes; lower 0.2 ft silty; basal . 05 ft slightly limonite stained	2. 0	8.75
7	Silt, light olive gray (5Y 6/2) when moist, massive, compact, calcareous limonite-flecked; shells common, poorly preserved	0.5	6.75
6	Sand, very fine grained, pale yellow (5Y 7/3) when dry, olive (5Y 5/3) when moist, well sorted, grains subrounded to well rounded, massive, compact, calcareous; scattered, well rounded pebbles; abundant, well preserved shells, mostly *Pliopholyx;* few carbonized plant fragments; top . 05 ft limonite stained	1.2	6.25
5	Silt and ash, mixed, light gray (5Y 7/2) dry, light olive gray (5Y 6/2) moist, thin-bedded, compact, calcareous, fissile, thinly laminated, limonite-flecked; abundant ostracodes, poorly preserved shells and carbonized plant fragments	0.45	5.05
4	Siliceous ash, light gray (5Y 7/1), massive, compact, calcareous, with numerous fine flecks and streaks of limonite stain; few shells; abundant ostracodes; 0.35 ft above base a fine sand bed 0. 05 ft thick that rests with minor erosional uncomformity on lower part of ash and grades upward into more ash	1.85	4.60
3	Silt, gray-brown to light olive-brown (2. 5Y 5/3) when moist, thin-bedded, compact, limey, limonite-streaked, with carbonized plant fragments, ostracodes, and abundant poorly preserved shells; in middle fissile, thinly laminated, and light brown-gray (2. 5Y 6/2) when dry	1. 15	2.75
2	Gypsum crystals and silt like that of unit 1	0. 05	1.69
1	Silt, gray-brown to light olive-brown (2. 5Y 5/3) when moist, thin-bedded, compact, limey, limonite-streaked, with carbonized plant fragments, ostracodes, and abundant poorly preserved shells.		1.55
Base not exposed			

Mollusks from the Salt Lake Group

Only one locality is known, and in the absence of geologic mapping it is not related to the regional stratigraphy except in a crude way. The fossils are like those in the Cache Valley Formation to the south, but only future stratigraphic study will show whether rocks in Marsh Creek Valley are to be included in this unit.

U. S. Geological Survey Cenozoic locality 20147 (DWT 471). Bannock Co., Idaho. South side of SW 1/4 SW 1/4 sec. 15, T 8S, R36 E. Road cut about 100 feet long on the west side of Marsh Creek road; 6.0 miles south of the junction of Marsh Creek road and Portneuf road on the southwestern edge of the town of Inkom; 0.55 mile south of Walker Creek. No apparent dip in the exposure. Some shells were collected as float at the base of the exposure, but most of them were collected from unit 6 of the measured section. H. A. Powers andD. W. Taylor, 1955.

The stratigraphic section seen on p 79 was measured by D. W. Taylor in 1955. Color notations are those of the Munsell system.

The mollusks from this locality are significant for two reasons: they are the youngest Tertiary fossils from the Snake River drainage in southeastern Idaho; and although the locality is now in Snake River drainage the affinities of the fossils are almost entirely with faunas to the south, in Great Basin drainage.

The fauna from locality 20147 is compared with those from other localities

TABLE 3. Mollusks occurring in Cache Valley Formation and Salt Lake Group in southeastern Idaho and northern Utah

Species	Locality			
	20093	20094	20147	22428
Sphaerium striatinum (Lamarck)	X	X	X	X
Pisidium compressum Prime	X	X	X	X
Pisidium punctatum Sterki	X	X	X	X
"Payettia" micra Yen	TL	X	X	X
Valvata humeralis Say			X	X
Valvata incerta Yen	TL	X		
Savaginius nannus (Chamberlin and Berry)	X	TL		X
Lithoglyphus utahensis (Yen)	TL			
Anculopsis bicarinata Yen	TL			
Anculopsis houghterlingi Yen	TL			
Anculopsis utahensis (Yen)	TL			
Pliopholyx reesidei Yen	TL			
Lymnaea kingii Meek		X		
Lymnaea occidentalis Hemphill	?			?
Gyraulus monocarinatus (Chamberlin and Berry)	X	TL		
Gyraulus parvus (Say)				X
Omalodiscus pattersoni (Baker)	X			
Vorticifex minimus (Yen)	TL			
Vorticifex utahensis (Yen)	TL	X		
Promenetus exacuous kansasensis (Baker)				X
Promenetus umbilicatellus (Cockerell)	X			X
Vallonia gracilicosta Reinhardt	X			

X = occurrence
TL = type locality

to the south in the Cache Valley Formation in Table 3. Only the fossils identifiable as previously described species are listed (5 of about 10), but all are either characteristic of the Cache Valley Formation, or are widespread. This marked community of fauna with localities to the south is interpreted as indicating that at this time Marsh Creek Valley was part of the same drainage basin as Cache Valley, Idaho-Utah, to the south.

36. Cache Valley Formation,
Gentile Valley, Idaho
(NK 12-5 [Preston] B-8)

The one known fossil locality is on the west side of the south end of Gentile Valley, about 5 miles northwest of Cleveland. Mollusks are the only fossils known and are reported here for the first time. The fossiliferous unit is shown as an island of Salt Lake Group and older rocks surrounded by Lake Thatcher Formation by Bright (1963, pl. 3), and as Salt Lake Formation on the geologic map of Idaho (Ross and Forrester, 1947). The fauna includes about 18 species that are interpreted as late Pliocene. Fossils are in UMMZ and USGS collections. Most recent topographic map: U. S. Geological Survey Preston quadrangle (1918) 1: 125000. Revised county boundaries are shown by the U. S. Geological Survay Preston quadrangle (1958)1: 250000.

Mollusks from the Cache Valley Formation

Only one fossil locality is known. It is assigned to the Cache Valley Formation, traced northward from the type area in Cache Valley, by Bright (1960, 1963).

USGS Cenozoic locality 22428 (DWT T61-64). Franklin Co., Idaho. South center of NW 1/4 sec. 10, T 12 S, R 40 E. Tuffaceous claystone exposed at old prospect on north side of valley of unnamed creek. About 40 feet below top of ridge. Strike about N 40° W, dip 15° NE. D. W. Taylor, R. C. Bright, 1961.

Previously described species found at this locality are listed in Table 3, showing the similarity of the fauna to other localitites in the Cache Valley Formation. As with the fauna at locality 20147 in Marsh Creek Valley to the west, all of the species are either characteristic of the Cache Valley Formation, or are widespread. Hence Gentile Valley, like Marsh Creek Valley, was probably part of the same drainage basin as Cache Valley, Idaho-Utah, when the Cache Valley Formation was being deposited.

Locality 22428 in Gentile Valley is now drained by the Bear River, which flows southward through Cache Valley and then into Great Salt Lake. This part of the course of Bear River is a late Pleistocene feature due to lava damming of the river (Bright, 1963). During the Pleistocene, before volcanism brought about this drainage reversal, the Bear River was a tributary of the Snake River to the north.

Thus the history of both Marsh Creek Valley and Gentile Valley was similar during the late Pliocene and most of the Pleistocene. The late Pliocene sediments were deposited in valleys that drained southward into Cache Valley, or into a lake basin that included Cache Valley, but Pleistocene tectonic activity reversed the drainage pattern so that the valleys drained northward into the Snake River. This drainage reversal was probably associated with the episode of uplift and faulting recognized by Bright (1960) in the Gentile Valley region, during which about 3000 feet of Mink Creek Formation was deposited.

The late Pliocene age assigned to the Cache Valley Formation, and the probable correlation with the upper part of an unnamed formation in western Wyoming (Fig. 1, localities 38, 39), provides a basis for suggesting the regional correlation of some overlying thick conglomeratic units that have been less precisely dated previously. They are all thought to be early Pleistocene, late Blancan and/or early post-Blancan. These units are as follows:

Bivouac Formation, Jackson Hole,

Wyoming (Love 1956a, b) (Fig. 1, locality 38). The formation is about 1000 feet thick, dips up to 8°, overlies unconformably the upper part of an unnamed formation of late Pliocene and/or earliest Pleistocene age, and is unconformably overlain by the oldest glacial deposits of the area.

Long Spring Formation, Grand Valley, Idaho (Merritt, 1956). The formation is up to 200 feet thick, dips up to 10°, and overlies unconformably the upper part of an unnamed formation of late Pliocene and Pleistocene age.

Mink Creek Formation, northern end of Cache Valley and southern end of Gentile Valley, Idaho (Adamson et al., 1955; Bright, 1960). The formation locally exceeds 3000 feet in thickness, and is cut by faults with up to 1500-2000 feet displacement. It overlies the Cache Valley Formation conformably or with no significant unconformity.

37. Cache Valley Formation, Utah (NK 12-7 [Brigham City] C-1, D-1, NK 12-8 [Ogden] C-8)

The described fossil localities occur within a distance of about 25 miles, in the southern part of Cache Valley and in the hills on the west side of that valley. Mollusks have been described or listed from localities within the Cache Valley Formation in the sense of Adamson et al. (1955) by Meek (1877), Chamberlin and Berry (1933), Yen (1947), Adamson et al. (1955), Taylor (1958), Hibbard and Taylor (1960) and Mullens and Izett (1964). Distribution of the Cache Valley Formation has been mapped by Adamson et al. (1955), Williams (1958) and Mullens and Izett (1964, as Salt Lake Formation). The fauna includes about 25 species, several endemic but with close relatives in the Glenns Ferry Formation of southwestern Idaho, and the endemic genus *Anculopsis*. Swain (1947) described ostracodes from the same locality from which Yen (1947) described mollusks; and Brown (1949) described leaves from another site. Adamson et al. (1955) considered the formation middle to late Pliocene in age. The mollusks are interpreted as being equivalent in age to the lacustrine facies of the Glenns Ferry Formation, Idaho, and hence late Pliocene. Most of the fossils are in the collections of the University of Utah, UMMZ and USGS. Most recent topographic maps: U. S. Geological Survey quadrangles—Brigham City (1958) 1: 250000, Ogden (1958) 1: 250000, Paradise (1955) 1: 24000.

The previously described species known from the Cache Valley Formation on the west side of Cache Valley are listed in Table 3. Locality data are as follows:

USGS Cenozoic locality 20093. Box Elder County, Utah. SE 1/4 sec. 16, T 13 N, R 2 W. Oolitic limestone and conglomerate (Adamson et al., 1955: 13, unit 2) along the west edge of the Junction Hills where abruptly truncated by a fault scarp. Well-preserved fossils weather free in abundance on steep slopes, about 100 yards south of an eastward-trending draw tributary to the cultivated area east of the hills, and immediately north of the summit. This locality description applies to the collection made by D. W. Taylor, 1956, following directions given by J. S. Williams, and is surely the locality from which Williams collected the fossils described by Yen (1947). Another collection was made here by R. M. Alf and others in 1951, also following directions provided by Williams.

USGS Cenozoic locality 20094. Box Elder County, Utah. SE 1/4 sec. 19, T 12 N, R 2 W. Small hill east of Collinston (Chamberlin and Berry, 1933, pl. 4), mapped as outlier of Cache Valley Formation by Adamson et al. (1955, Fig. 3) and considered stratigraphically equivalent to locality 20093 (Adamson et al., 1955: 12). J. S. Williams, 1949.

Type locality of *Lymnaea kingii*

Meek (1877: 192-193) described *Lymnaea kingii* as coming from "Cache Valley, Utah; Tertiary, probably of Miocene age". The field label, still with the type, gives the locality as Mendon. The unique type (USNM 8097) is an external mold in a piece of oolitic tuffaceous coarse sandstone similar to that found in the Cache Valley Formation. External molds of other snails are not surely identifiable but can be referred to other species described by Chamberlin and Berry (1933) and Yen (1947) from the formation nearby. Adamson et al. (1955: 9, fig. 3) mapped Cache Valley Formation within two miles of Mendon and thence northward for several miles. From these data it is reasonable to conclude that the type of *Lymnaea kingii* Meek came from the Cache Valley Formation on the west side of Cache Valley, northwest of Mendon, about sec. 1, T 11 N, R 2 W, Cache County, Utah. Fig. 10 (p 25) shows the distribution of *Lymnaea kingii,* both fossil and living.

38. Unnamed formation,
Jackson Hole, Wyoming
(NK 12-2 [Driggs] B-4, C-3)

The 3 known fossil localities are 6 miles northeast and 4 miles southwest of Jackson. Some of the mollusks were listed and illustrated by Taylor (1956), and Taylor, Walter and Burch (1963). The fossiliferous unit is partly included in the Teewinot Formation, partly in glacial deposits, on the geologic map of Teton County, Wyoming (Love, 1956b); it is called "Lower(?) Pleistocene lacustrine and fluviatile beds" by Love et al. (1965, Fig. 16). The fauna includes 19 species of mollusks and 2 species of microtine rodents. Blancan age is assigned here. Fossils are in USGS and University of Michigan collections. Most recent topographic maps: U. S. Geological Survey Grand Teton National Park sheet (1948) 1: 62500, Jackson (1935) 1: 125000.

Stratigraphy

The sediments that have yielded the Blancan fossils recorded herein are exposed in two local areas 10 miles apart. Their correlation as one unit is a matter of interpretation, based on fossils, degree of tilting, lithologic composition, and contrast with the stratigraphically lower Teewinot Formation.

Localities 1 and 2 were included by Love (1956a, b) in the upper member of the Teewinot Formation. They are in a sequence of about 150 ft of conglomerate, sandstone, siltstone and claystone whose contact with the underlying Teewinot Formation is concealed. The thin-bedded, fine-grained pumicite and claystone sequence of the underlying Teewinot half a mile to the west includes a substantially different molluscan fauna including *Scalez* (Taylor, 1956), and obsidian here was dated as 9.2 million years old (Evernden et al., 1964; sample KA 929). Thus there is probably a gap of several million years in the local stratigraphic sequence. On the geologic cross-section by Love et al. (1965, Fig. 16) locality 1 is designated "Land snail and rodent fossils"; the unnamed unit is "Lower (?) Pleistocene lacustrine and fluviatile beds"; and the underlying Teewinot Formation is designated "Middle Pliocene beds".

Two species of microtine rodents are represented by a few isolated teeth from locality 1. One of these species has well-developed dentine tracts on both posterior and anterior loops of the tooth. C. W. Hibbard (personal communications, 1965) interprets these features to indicate an age younger than that of the species from locality 4 in Star Valley (Fig. 1, locality 39), and younger than that of the Blancan mammals of the Glenns Ferry Formation in Idaho (Fig. 1, locality 34), but probably still within the span of Blancan time. This correlation indicates that the unnamed formation may be early Pleistocene, or if Pliocene is very close to the end of that epoch.

Locality 3 is at the south end of a linear hill about 2 miles long, shown as glacial deposits by Love (1956b, map). Subsequent exposures have revealed that the beds are similar in composition to the sequence at localities 1 and 2, are tilted and have fossil shells consistent with a correlation of the 3 localities. The few species found at locality 3 might be correlative with the middle Pleistocene mollusks found in sediments overridden by the earliest glaciation of Jackson Hole (Love and Taylor, 1962), so far as known stratigraphic ranges indicate. But those middle Pleistocene mollusks indicate a lacustrine environment that probably would be recognizable at locality 3 if the assemblages were contemporaneous. The "early Quaternary molluscan fauna" mentioned by Love et al. (1965: 39) is from locality 3. Evidently this unnamed formation is correlative with part of the sequence in Star Valley, but only further study will reveal more precise correspondence.

Localities in unnamed formation,
Jackson Hole, Wyoming

The species found at the following localities are listed in Table 4, p 86.

1. Teton County, Wyoming. 800 ft west, 800 ft north, sec. 25, T 42N, R 116 W. Exposure along irrigation ditch in National Elk Refuge; tilted sequence of sand and clayey sand below gravel. Locality 1 of Taylor (1956); USGS Cenozoic locality 19105.—C. W. Hibbard, J. D. Love, D. W. Taylor, 1955-1962.

2. Teton County, Wyoming. 1250 ft west, 650 ft north, sec. 25, T 42 N, R 116 W. Claystone 43 ft stratigraphically above locality 1; USGS Cenozoic locality 23327.

3. Teton County, Wyoming. Center of W 1/2 sec. 19, T 40 N, R 116 W. North-dipping silt, clay and conglomerate exposed in road cut on south end of linear hill. Fossils from dark brown clay and silty clay about 3 ft above road level, and 6 ft below pebble conglomerate. USGS Cenozoic locality 23585.—D. W. Taylor, J. D. Love, 1959-1961.

The modern aspect of the fossil assemblage can be seen readily by comparison with the local living fauna. The Recent mollusks of Jackson Hole are known from the papers by Beetle (1957, 1962) and references therein. Pleistocene mollusks nave been listed by Love and Taylor (1962).

The mollusks from locality 1 all belong to living species so far as they are identified, although the *Menetus* may represent an extinct species. Four species *(Lymnaea montanensis, Hawaiia minus cula, Oreohelix peripherica* and *O.* cf *O. yavapai)* are living in nearby areas but not in Jackson Hole. The freshwater snail *Menetus* occurs in Blancan assemblages in Star Valley (Fig. 1, locality 39) and in the Glenns Ferry Formation (Fig. 1, locality 34), but is now practically confined to the Pacific Coast area. Perhaps its disappearance over a wide area of Idaho and Wyoming will prove to have regional stratigraphic value.

The 4 species of land snails found at locality 1 that also live in Jackson Hole are found together in only 1 of the plant associations recognized by Beetle (1957). This is the aspen association, the richest of the terrestrial snail habitats.

39. Unnamed formation, Star Valley,
Wyoming
(NK 12-5 [Preston] D-4)

The known fossil localities are within a distance of about 3 miles, on the east side of Star Valley at and north of the Narrows, 8 miles north of Afton. Some of the mollusks were listed and illustrated by Taylor (1956, 1958). No small-scale geologic maps have been published. Seventeen species of mollusks are known from a series of stratigraphically distinct localities. Associated fossils include 3 rodents and a bird. Blancan and post-Blancan age is assigned here. Fossils are in USGS and University of Michigan collections. Most recent topographic maps: U. S. Geological Survey Afton quadrangle (1921) 1: 125000; Preston quadrangle (1958) 1: 250000.

Stratigraphy

Fresh road-cut exposures made during 1961 provided an opportunity to observe the poorly indurated sediments previously referred to the upper conglomerate facies of the Teewinot Formation. The unit was exposed in 3 road-cuts along a distance of about 1 mile; fossil collections were made also in 1962 by C. W. Hibbard. No detailed correlations between the road-cuts were possible, on account of rapid vertical and horizontal change in composition, but in gross appearance the sequence is similar to the upper conglomerate facies of the Teewinot Formation in Grand Valley, Wyoming-Idaho, as described by Merritt (1956). The road-cut exposures are described in north-south sequence, an order believed to be also older to younger.

The first cut south of Thayne (including locality 4) is about 1000 ft long. It exposes reddish-brown pebble gravel and conglomerate as well as finer-grained lenses in crossbedded and lenticular sequences. The strike is about N 30° E, dip N 60° W 15° maximum, perhaps less. The sediments are subangular pebble gravel and conglomerate of mixed Paleozoic derivation with lenses of fine sand, grit, silt and clay. Locally there are well-rounded cobbles as much as 1 ft long. At the top of the conglomeratic section is about 50 ft of dark brown silt, limey toward the top, with scattered subangular pebbles.

Locality 4 in this cut yielded an indeterminate bird and 2 species of microtine rodents. M^3 of 1 species has 2 roots, a condition interpreted by C. W. Hibbard as indicating Blancan age, younger than that of the Rexroad local fauna (Fig. 1, locality 51) and about correlative with the lower part of the Glenns Ferry Formation (Fig. 1, locality 34). Out of 6 species of mollusks 2 are extinct. The occurrence of the snail *Bulimnea* is the latest record of the genus in western North America. *Menetus* is not living nearby, but is found in the Blancan assemblages of the Glenns Ferry Formation (Fig. 1, locality 34) and Jackson Hole (Fig. 1, locality 38). Both of these occurrences favor an earlier Blancan rather than later Blancan age.

The second cut south of Thayne (including localities 5 and 6) is about 3/4 mile south of the first cut and across a minor stream valley. The cut exposes about 100 ft of medium-to-coarse-bedded lenticular pebble conglomerate, sand, silt and clay, variable both vertically and laterally. It is cut by a few minor faults with about 30 ft of total throw, down to the north. At the south end of the cut, at least, the beds are flat-lying or perhaps dip slightly southwestward.

Locality 6 in the cut yielded a different kind of microtine rodent. It has ever-growing teeth, an interrupted enamel pattern, and cement in the reentrant angles of the teeth, features interpreted by C. C. Hibbard to indicate probably post-Blancan age. Of the 8 species of mollusks at localities 5 and 6 all are living nearby, so that in the interval above locality 4 the local molluscan fauna became fully modern.

The third cut south of Thayne (including locality 7) is about 1/8 mile southeast of the second cut. It exposes about 50 ft of sediments dipping 10°-15° south or southwest. The upper 30 ft of sediments are medium-to-thin-bedded tan sand and silt, olive and dark gray clay in relatively persistent beds generally 1-3 ft thick, with scattered limey nodules in the clay. This fine-grained sequence is conformable on 20 ft of subangular pebble and cobble gravel. The persistent bedding and fine grain size of the upper part of the exposed beds are in marked contrast to the conglomeratic beds in more northern cuts.

The 5 species of mollusks at locality 7 are all extant, and the assemblage could be duplicated in middle or late Pleistocene deposits in southern Idaho. The appearance of *Lithoglyphus hindsii* may be significant, for the species is unknown in Blancan sediments in the region.

The inferred ages of the fossil mammals, the trend toward modernization of molluscan fauna, the southward decrease in sedimentary grain-size and the observed dips are consistent with a decrease in age from north to south. Furthermore, both fossils and sediments are in marked contrast to those in the Teewinot along the Snake River in Grand Valley to the north. There tuffaceous and diatomitic beds are conspicuous, but are absent in the road-cuts described; and in the Teewinot there are extinct species of *Lymnaea, Valvata, Sphaerium* and Planorbidae (Taylor, 1956), and mammals dated as Hemphillian (Merritt, 1956).

If localities 8-10 are correlative with part of the section represented by localities 4-7, they probably correspond to the older part. Locality 8 yielded 1 species locally extinct, and 1 absolutely extinct, out of a total of 9.

Localities in unnamed formation,
Star Valley, Wyoming

Numbers in the following list continue the sequence listed for Jackson Hole (p 84), and correspond to those in Table 4.

4. Lincoln County, Wyoming. SE 1/4 NE 1/4 sec. 35, T 34 N, R 119 W. Road cut on east side of U. S. highway 89; first cut south of Thayne. Fossils from

TABLE 4. Locality occurrence of mollusks in unnamed formation, Jackson Hole and Star Valley, Wyoming.

Species	Jackson Hole			Star Valley						
	1	2	3	4	5	6	7	8	9	10
Anodonta?							X			
Sphaerium striatinum (Lamarck)							X			
Sphaerium cf *S. lacustre* (Müller)				X		X				
Pisidium casertanum (Poli)	X									
Pisidium compressum Prime	X					X		X		
Pisidium obtusale (Lamarck)	X									
Valvata humeralis Say	X		X	X	X	X	X	X	X	X
Lithoglyphus hindsii (Baird)							X			
Bulimnea				X						?
Fossaria obrussa (Say)	X									
Lymnaea montanensis (Baker)	X	?								
Lymnaea cf *L. elodes* Say	X		X	X		X	X	X	X	X
Ferrissia						X		X		
Omalodiscus pattersoni (Baker)								X		
Gyraulus parvus (Say)						X		X		
Planorbella (*Pierosoma*)									X	X
Planorbula cf *P. campestris* (Dawson)			X					X		
Promenetus umbilicatellus (Cockerell)	X					X		X		
Menetus	X			X						
Physa				X				X		?
Aplexa hypnorum (Linnaeus)	X									
Vertigo gouldi (Binney)	X									
Vertigo modesta Say	X									
Pupilla muscorum (Linnaeus)	X	?								
Vallonia cyclophorella Sterki	X									
cf *Succinea* (2 spp)	X									
Discus cronkhitei (Newcomb)	X									
Hawaiia minuscula (Binney)	X									
Oreohelix peripherica (Ancey)	X				X					
Oreohelix cf *O. yavapai* Pilsbry	X									

olive clay exposed in ditch about 200 ft north of south end of road cut, and 3-4 ft above the base of the cut farther to the south. Exposed sediments are pebble gravel and conglomerate with finer-grained lenses in crossbedded and lenticular sequences. C. W. Hibbard, D. W. Taylor, 1961-1962.

5. Lincoln County, Wyoming. South-[redacted]t corner of sec. 36, T 34N, R 119W. Road cut on east side of U. S. highway 89; second cut south of Thayne. Fossils from dark brown claystone lens with shells in claystone and conglomerate sequence about 100 ft south of north end of cut. Nearly equivalent stratigraphically to locality 6. C. W. Hibbard, D. W. Taylor, 1961-1962.

6. Lincoln County, Wyoming. Northwest corner of *sec* 1, T 33 N, R 119 W. Road cut on east side of U. S. highway 89; second cut south of Thayne. Fossils from lens of dark olive clay, in sequence of medium-to-coarse-bedded lenticular pebble conglomerate, sand, silt and clay, about 150 ft north of south end of cut. C. W. Hibbard, D. W. Taylor, 1961-1962.

7. Lincoln County, Wyoming. Center of NW 1/4 sec. 1, T 33 N, R 119 W. Road cut on east side of U. S. highway 89; third cut south of Thayne. Shells from tan silt and sand and olive and dark gray clay in lower 30 ft of cut. C. W. Hibbard, D. W. Taylor, 1961-1962.

8. Lincoln County, Wyoming. SE 1/4 NE 1/4 sec. 13, T 33 N, R 119 W. Shells from old mine entry on south side of Willow Creek; E. M. Parks and C. S. Lavington, 1923. Locality 11 of Taylor (1956); USGS Cenozoic locality 19180.

9. Lincoln County, Wyoming. SE 1/4 NE 1/4 sec. 13, T 33 N, R 119W. Caved-in old mine entry, same as locality 8. Dark gray, clayey silt with many shell fragments. W. W. Rubey, 1933. Locality 15 of Taylor (1956); USGS Cenozoic locality 19181.

10. Lincoln County, Wyoming. SW 1/4 NW 1/4 sec 13, T 33 N, R 119 W. North side of divide between Willow Creek and Salt River at The Narrows. Dark gray clayey silt with shell fragments. W. W. Rubey et al., 1949. Locality 16 of Taylor (1956); USGS Cenozoic locality 19183.

Mollusks from unnamed formation, Jackson Hole and Star Valley

Since the publication of a preliminary report (Taylor, 1956) on the mollusks from the Teewinot Formation, additional specimens and stratigraphic data have become available from the area and from other places as well. The following notes indicate changes in identification or interpretation, and references to the published records. They refer only to mollusks from the upper (post-Hemphillian) formation.

Anodonta?

A few fragments from locality 7 belong to a thin-shelled mussel, hence probably *Anodonta. Anodonta californiensis* Lea lives in the Snake River of southern Idaho, and in the Bear River, Wyoming-Idaho, but is not known from the Salt River running through Star Valley. Its apparent absence might be due only to lack of collecting.

Pisidium casertanum (Poli)

Pisidium: Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123, in part (loc. 1); not Fig. 12. Love, 1956, Wyo. Geol. Assoc. Guidebook: 91, in part. Love, 1956, Bull. Am. Assoc. Petrol. Geol., 40: 1910, in part.

Pisidium compressum Prime

Pisidium: Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123, in part (loc. 1, 11), Fig. 12. Love, 1956, Wyo. Geol. Assoc. Guidebook: 91, in part. Love, 1956, Bull. Am. Assoc. Petrol. Geol., 40: 1910, in part.

Valvata humeralis Say

Valvata humeralis (Say): Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123 (loc. 1, 11, 15, 16), Fig. 10-11. Love, 1956, Wyo. Geol. Assoc. Guidebook: 92. Love, 1956, Bull. Am. Assoc. Petrol. Geol., 40: 1910.

Lithoglyphus hinds ii (Baird)

The fossil occurrence at locality 7 in Star Valley may be the oldest one in the region, although it is younger than that in the Danforth Formation, Oregon

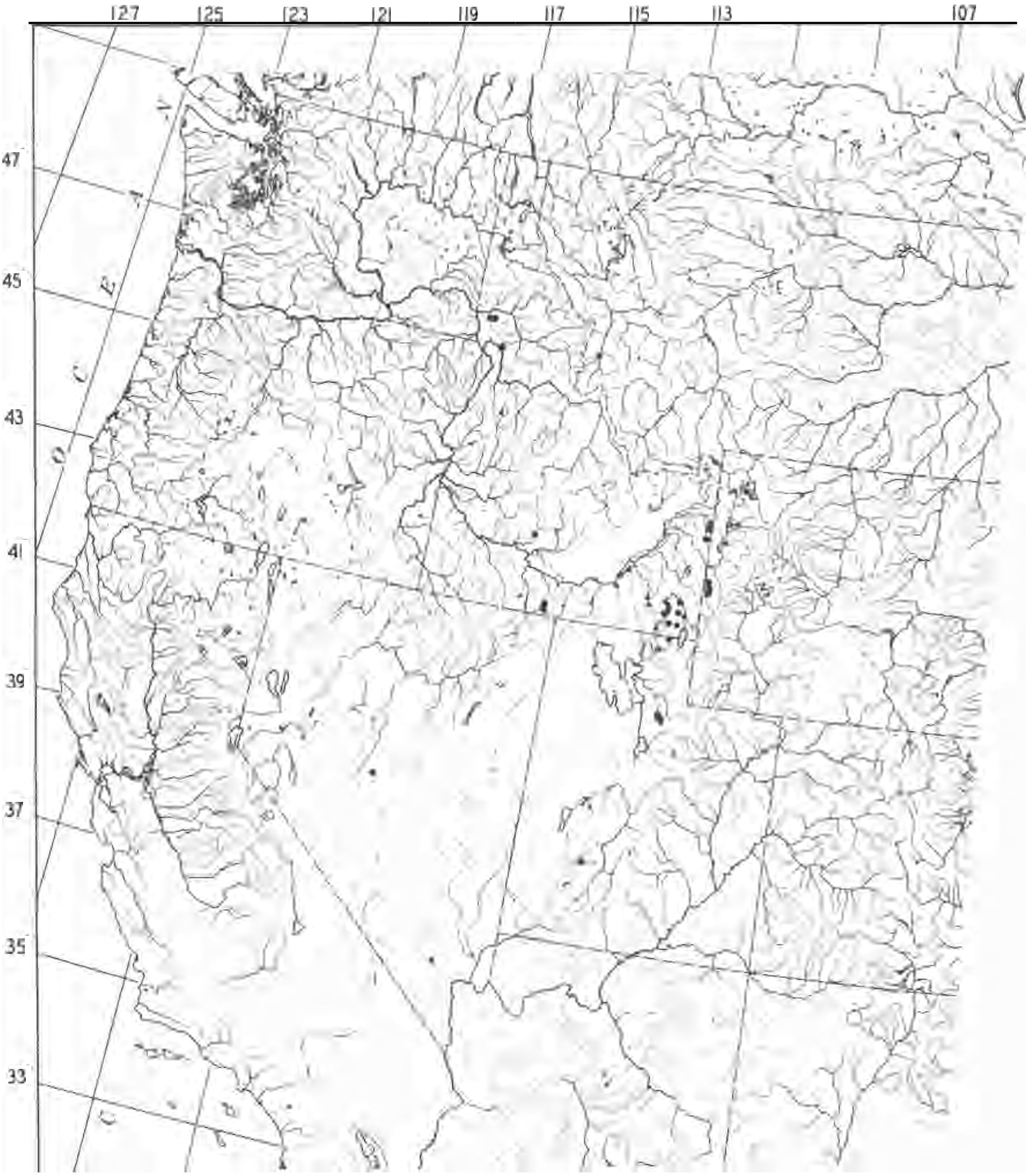


FIG. 17. Distribution of *Lymnaea (Hinkleyia) montanensis* (Baker), family Lymnaeidae, a snail of springs and clear-water streams. Precise data for most of the localities were given by Taylor et al. (1963); the map includes a few additional localities. Living occurrences, dots; fossil, triangles. The easternmost triangle represents the only known Blancan occurrence, in the upper Teewinot Formation, Jackson Hole, Wayoming. Other fossil occurrences are late Pleistocene.

(Fig. 1, locality 7). Figure 14 shows the distribution of the species; it is common in the Star Valley region.

Bulimnea

Young shells, fragments of spires and of later whorls indicate *Bulimnea* clearly at locality 4. It can be recognized by the relatively large nuclear whorl, as well as the wide, low ribs on the surface of mature shells. The occurrence is significant because the genus is otherwise restricted to pre-Blancan horizons in western North America.

Lymnaea (Hinkleyia) montanensis (Baker)

Lymnaea aff. *caperata* Say: Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123 (loc. 1), Fig. 3. Love, 1956, Wyo. Geol. Assoc. Guidebook: 92. Love, 1956, Bull. Am. Assoc. Petrol. Geol., 40: 1910.

Stagnicola (Hinkleyia) montanensis (Baker). Taylor, Walter, Burch, 1963, Malacologia, 1: 240, 260.

Figure 17 shows the known distribution of the species. The fossil occurrence in Jackson Hole is the easternmost known locality. The species is known only from west of the Missouri and Green River drainages.

Lymnaea (Stagnicola) cf *L. elodes* Say

Lymnaea palustris (Muller): Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123 (loc. 11, 15, 16).

The change in nomenclature reflects the opinion that shells in this group do not provide criteria for identification to species in the present state of knowledge. For discussion and references see Taylor (1965).

Ferrissia

Ferrissia: Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123 (loc. 11).

Omalodiscus patters oni (Baker)

Anisus pattersoni (Baker): Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123 (loc. 11), fig. 1. Taylor, 1958, J. Paleont., 32: 1150.

Figure 13 shows the distribution of this species in western North America. With the reinterpretation of the age of the Star Valley occurrence as late Pliocene rather than middle Pliocene, the known range of the species becomes late Pliocene to late Pleistocene.

Gyraulus parvus (Say)

Gyraulus parvus (Say): Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123 (loc. 11).

Planorbella (Pierosoma)

Helisoma cf *trivolvis* Say: Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123 (loc. 15, 16).

The fragmentary material cannot be identified to species. *Planorbella trivolvis* is not native west of the continental divide, hence the fossils are probably one of the western species or a close relative.

Planorbula cf *P. campestris* (Dawson)

The fossils cannot be identified specifically beyond doubt, but so far as the material goes may be *P. campestris.* That species is the only living *Planorbula* in the west (see distribution map, Fig. 18), hence reference of the fossils to this form is plausible.

Promenetus umbilicatellus (Cockerell)

Promenetus umbilicatellus (Cockerell): Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123 (loc. 1, 11). Love, 1956, Wyo. Geol. Assoc. Guidebook: 92. Love, 1956, Bull. Am. Assoc. Petrol. Geol., 40: 1910.

Menetus

Vorticifex: Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123 (loc. 1). Love, 1956, Wyo. Geol. Assoc. Guidebook: 92. Love, 1956, Bull. Am. Assoc. Petrol. Geol., 40: 1910.

Additional material collected since 1956 shows the characters of growth line, surface microsculpture and shape of spire-pit that indicate *Menetus.* The genus is now practically confined to the Pacific Coast region, from southern California to southern Alaska, but Blancan fossils document its occurrence far eastward in Idaho and Wyoming (Fig. 1, localities 34, 38, 39).

Physa

Physa: Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123 (loc. 11, 16).

Pupilla muscorum (Linnaeus)

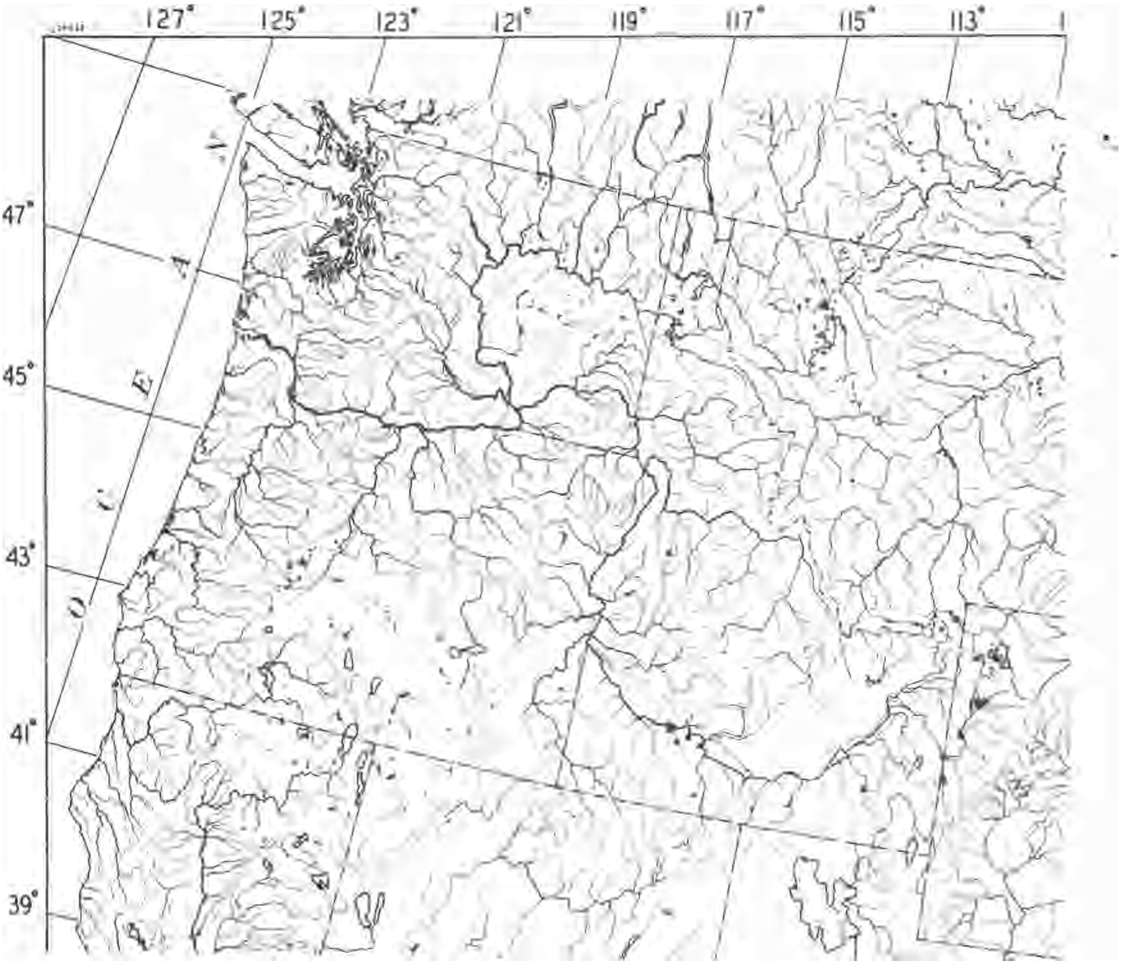


FIG. 18. Distribution of *Planorbula campestris* (G. M. Dawson, 1875), family Planorbidae, a snail of ponds and marshes. Dots, living oQcurrences west of the continental divide; most of the range of the species is in the plains of south-central Canada and north-central U.S.A. Triangles, fossil occurrences probably but not surely representing the species. From specimens in collections UMMZ , USGS, USNM. Blancan occurrences are indicated by the western group of triangles (Glenns Ferry Formation), and southeasternmost and northeasternmost triangles (unnamed formation). Middle triangle in eastern group indicates Hemphillian occurrence in Teewinot Formation; triangle between eastern and western groups marks late Pleistocene occurrence.

Pupilla muscorum (Linne): Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123 (loc. 1), Fig. 9. Love, 1956, Wyo. Geol. Assoc. Guidebook: 92. Love, 1956, Bull. Am. Assoc. Petrol. Geol., 40: 1910.

cf *Succinea* (2 species)

Succinea cf *avara* Say: Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123 (loc. 1), Fig. 6. Love, 1956, Wyo. Geol. Assoc. Guidebook: 92. Love, 1956, Bull. Am. Assoc. Petrol. Geol., 40: 1910.

Succinea cf *grosvenori* Lea: Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123 (loc. 1), Fig. 7. Love, 1956, Wyo. Geol. Assoc. Guidebook: 92. Love, 1956, Bull. Am. Assoc. Petrol. Geol., 40: 1910.

Discus cronkhitei (Newcomb)

Discus cronkhitei (Newcomb): Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123 (loc. 1). Love, 1956, Wyo. Geol. Assoc. Guidebook: 92. Love, 1956, Bull. Am. Assoc. Petrol. Geol., 40: 1910.

Hawaiia minus cula (Binney)

Hawaiia minuscula (Binney): Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123 (loc. 1), Fig. 5. Love, 1956, Wyo. Geol. Assoc. Guidebook: 92. Love, 1956, Bull. Am. Assoc. Petrol. Geol., 40: 1910.

Oreohelix peripherica (Ancey)

Oreohelix cf *subrudis* (Pfeiffer): Taylor, 1956, Wyo. Geol. Assoc. Guidebook: 123 (loc. 1). Love, 1956, Wyo. Geol. Assoc. Guidebook: 92. Love, 1956, Bull. Am. Assoc. Petrol. Geol., 40: 1910.

40. Colorado River area, California-Arizona
(NI 11-6 [Needles] A-1, A-2, A-5, B-5, B-6, NI 11-9 [Salton Sea] B-3, B-4, C-3, D-3, NI 12-7 [Phoenix] B-6)

Scattered localities in the Colorado River region, southeastern California-Arizona, have yielded marine, brackish and freshwater fossils that may be related to a former extension of the Gulf of California. The precise age of none of the localities is known, and the mutual correlation of only some of the geographically closer deposits has been established. The pertinent literature has not been brought together previously, although clearly all of the deposits might record a single geologic event. The Pliocene paleogeographic map by Durham and Allison (1960) shows a former northern extension of the Gulf of California on the basis of some of these fossils.

If these deposits represent a large marine and brackish embayment, its upper age limit can be defined as latest Blancan or earliest Irvingtonian. That is the age of the youngest marine fossils in the Colorado Desert that have been interpreted as recording such an embayment (Downs and Woodard, 1962). The lower age limit is unknown, except that it is probably Pliocene; perhaps it is as young as Blancan.

Localities

1. (NI 11-6 [Needles] B-6). San Bernardino County, California. Cadiz Lake quadrangle (1956) 1: 62500. Cadiz no. 1 drillhole, NE 1/4 sec. 4, T 2 N, R 15 E. (Bassett et al., 1959; P. B. Smith, 1960): ostracodes, *Chara,* andthe foraminifer *Streblus beccarii.*

2. (NI 11-6 [Needles] B-5). San Bernardino County, California. Milligan quadrangle (1956) 1: 62500. Danby no. 1 drillhole, NE 1/4 sec. 19, T 2N, R 18 E. (Bassett et al., 1959; P. B. Smith, 1960): gastropods, pelecypods, barnacles, ostracodes, Foraminifera, *Chara.*

3. (NI 11-6 [Needles] A-5). San Bernardino County, California. Iron Mountains quadrangle (1956) 1: 62500. Danby no. 2 drillhole, SE 1/4 sec. 34, T 2 N, R 18 E (Bassett et al., 1959; P. B. Smith, 1960): gastropods, pelecypods, barnacle, Foraminifera, *Chara.*

4. (NI 11-6 [Needles] A-2). Riverside County, California. Parker quadrangle (1949) 1: 62500. Road cut along west side of highway between Earp and Parker, NE 1/4 sec. 24, T 10 N, R 25 E (P. B. Smith, 1960): Foraminifera.

5. (NI 11-6 [Needles] A-1). Yuma County, Arizona. Black Peak quadrangle (1959) 1: 62500. Osborne Wash, in the vicinity of Osborne's Well (Ross, 1922: 189, 190; 1923: 23): *Melania* or *Gonio-*

basis and *Corbicula.* Osborne Wash (Blanchard, 1913: 39): *Bittium, Corbicula.*

6. (NI 11-9 [Salton Sea] C-3, D-3). Riverside County, California. Big Maria Mountains quadrangle (1951) 1: 62500; Blythe NE quadrangle (1951) 1: 24000. Southeastern Big Maria Mountains (Hamilton, 1960; P. B. Smith, 1960): pelecypods, barnacles, ostracodes, Foraminifera.

7. (NI 11-9 [Salton Sea] B-4). Imperial County, California. Pale Verde Mountains quadrangle (1953) 1: 62500. South end of pass through Palo Verde Mountains (Ross, 1922: 189-190; J. S. Brown, 1923: 46): *Melania* or *Goniobasis* and *Corbicula.* The published land net data are evidently wrong; the locality is in sec. 17 or 20, T 10 S, R 21 E.

8. (NI 11-9 [Salton Sea] B-3). Yuma County, Arizona. Cibola quadrangle (1951) 1: 62500. South and southeast of Cibola (Wilson, 1931; Metzger, 1963): cerithid, *Pisidium?, Corbicula?,* barnacles.

9. (NI 12-7 [Phoenix] B-6). Yuma County, Arizona. Eagletail Mountains quadrangle (1962) 1: 62500. East end of Clanton Hills (Ross, 1922: 190; 1923: 23-24): ostracodes. Judging by the map by Ross (1922, pl. 45) he used the name Clanton Hills for only the western part of that feature as now mapped; his locality is probably in sec. 12, T 2 S, R 12 W.

41. Verde Formation, Arizona
(Holbrook C-7, C-8, D-8,
Prescott D-1)

The fossil localities are scattered in the Verde Valley within a radius of about 10 miles. Mollusks have been mentioned by Jenkins (1923: 76-77), Anderson and Creasey (1958: 61), Lehner (1958: 561), Twenter (1962b), and listed by Mahard (1949). Twenter (1962a) and Twenter and Metzger (1963) specified numerous localities and illustrated some species, but did not describe or list the fauna. Distribution of the Verde Formation and its facies were mapped by Twenter and Metzger (1963, pl. 1). The fauna includes at least 10 species of clams, terrestrial and aquatic snails. Nonmolluscan fossils include ostracodes, charophytes, mammals and higher plants. The Pliocene (?) or Pleistocene age assigned to the Verde Formation by Twenter and Metzger (1963) is restricted to Blancan, and probably early Pleistocene, because of the similarity of the mollusks to those of the Benson local fauna (Fig. 1, locality 45). Most recent topographic maps: U. S. Geological Survey quadrangles, Camp Verde (1932) 1: 125000, Clarkdale (1944) 1: 62500.

42. Lake beds in Payson Basin,
Arizona
(NI 12-5 [Holbrook] A-6)

The one known fossil locality is in the drainage of Tonto Creek, on the east side of the Mazatzal Mountains about 6 miles southwest of Payson. Mollusks were mentioned by Feth and Hem (1963: 14). The areal distribution of the lake beds in the Payson Basin was shown roughly by Feth and Hem (1963: 5, Fig. 2). The only fossils known from these deposits are the 3 species of mollusks reported herein, interpreted as probably Blancan or post-Blancan in age. The fossils are in USGS collections. Most recent topographic map: U. S. Geological Survey Payson quadrangle (1936) 1: 62500.

Mollusks from lake beds in Payson Basin

USGS Cenozoic locality 20841. Gila County, Arizona. Lacustrine limestone at Table Mountain, about NE 1/4 sec. 34, T 10 N, R 9 E, unsurveyed; J. H. Feth, 1952. The fossils are preserved as molds in limestone.

Only 3 species of freshwater snails are represented:

Lymnaeidae
Lymnaea (Stagnicola) cf *L. elodes* Say
Planorbidae
Promenetus umbilicatellus (Cockerell)

Physidae

Physa, referable to *Physa virgata* Gould

All 3 species are extant, so far as the material permits identification. The absence of extinct species, the absence of genera that occur widely in Hemphillian faunas in western North America and the contrast with the White Cone local fauna (Fig. 1, locality 47) favor an age no greater than Blancan. Evidence from fossils favors an approximate correlation of the Verde Formation, and lake beds in the Payson and San Carlos Basins (Fig. 1, localities 41-43). These deposits were laid down in a series of basins aligned northwest-southeast from central Arizona to Chihuahua that may reflect the influence of a major structure bounding the Colorado Plateau (Feth and Hem, 1963: 14,21, Fig. 2; Feth, 1964: 16). Deposition in each basin was largely due to damming of the master stream, the Gila River, by "the extrusion and uplift of a great quantity of lava and ash" (Melton, 1965: 8). If the fossils known from each of the basins are nearly equivalent, they are more likely to be early Pleistocene than late Pliocene.

43. Lake beds in San Carlos Basin, Arizona
(NI 12-8 [Mesa] B-2)

The one known fossil locality is in the valley of the San Carlos River about 3 miles southeast of San Carlos, in the San Carlos Indian Reservation. Mollusks were listed by Feth and Hem (1963: 14). The areal distribution of the lake beds in the San Carlos Basin was shown roughly by Feth and Hem (1963: 5, Fig. 2). The fauna includes 1 species of freshwater snail; a large camel is the only other fossil known from the unit. Feth and Hem assigned a Pliocene or Pleistocene age to the lake beds, thus Blancan age is possible. The fossils are in USGS collections. Most recent topographic map: U. S. Geological Survey Mesa quadrangle (1960) 1: 250000.

Fossil mollusks from lake beds in San Carlos Basin

USGS Cenozoic locality 20237. Graham County, Arizona. Mesa quad. (1960) 1: 250000. NW 1/4 sec. 28, T 1 S, R 19 E. Silty limestone in stratigraphic section C of Feth and Hem (1963: 13). J. H. Feth, 1951.

The fossils were listed by Feth and Hem (1963) as *Physa* sp. and *Physa* cf *P. anatina* Lea. The material consists of internal and external molds in limestone that do not provide evidence for recognizing more than one species; it is referable to *Physa virgata* Gould, the widespread living species of southern California and Arizona.

44. Red Knolls, Arizona
(NI 12-11 [Tucson] D-1)

One locality is known, on the southwest side of the Gila River Valley about 15 miles northwest of Safford. Two species of mollusks were reported by Knechtel (1938), who included the locality in Gila Conglomerate as mapped, of Pliocene and Pleistocene age. Heindl et al. (1965: 64-65) assigned an early Pleistocene age and published a stratigraphic section. The fossils should be in USGS collections, but have not been found. Most recent topographic map: U. S. Geological Survey Jackson Mountain quadrangle (1944) 1: 62500.

45. Benson local fauna, Arizona
(NH 12-2 [Nogales] D-2)

Mollusks of the Benson local fauna have not been reported previously. Three localities are known, on the west side of the San Pedro Valley 2-10 miles south of Benson. The fossiliferous unit has been named St. David Formation by Gray (1965), but not yet described in detail. Seventeen species of land and freshwater mollusks are known. Associated vertebrates include fishes, amphibians, tortoises, lizards, birds and mammals (Brodkorb, 1964a; Bryant, 1945; Dawson, 1958; Etheridge, 1958; Frick, 1933,1937;

Gazin, 1942; Gidley, 1922a, b, 1926; Gilmore, 1923, 1928; Hay, 1927; Hibbard, 1941, 1954; Hoffmeister and Goodpaster, 1954; Lance, 1960; Osborn, 1936; Packard, 1960; Savage, 1955; Schultz, 1937; Tihen, 1962; Wetmore, 1924; Wilson, 1937; Wood, 1935). Composition of the fauna, and its contrast with the Irvingtonian Curtis Ranch local fauna higher in the formation, indicate a late Blancan, early Pleistocene, age. Fossil mollusks are in UMMZ collections. Most recent topographic map: U.S. Geological Survey Benson quadrangle (1958) 1: 62500.

Mollusks of Benson local fauna

During study of the stratigraphy and sedimentation of early Pleistocene sediments in the Benson area, R. S. Gray of the University of Arizona collected the mollusks listed here. An illustrated account of the stratigraphy and fauna is in preparation by Gray and Taylor. The molluscan fauna is significant because it is so similar to the early Pleistocene assemblages known from the High Plains in southwestern Kansas, in spite of the geographic distance. This similarity provides evidence for supposing that similar faunas can be found in Pleistocene deposits of much of the southwest. Another significance of the fauna is that it is in general accordance with the early Pleistocene age indicated by the mammals. No species previously restricted to the Pliocene is present, but the mollusks in themselves would not indicate an early rather than middle Pleistocene age.

Localities

1. 600 ft east, 1400 ft south, sec. 27, T 17 S, R 20 E. 3790 ft elev.
2. 1900 ft north, 600 ft west, sec. 35, T 18 S, R 20 E. About 3950 ft elev.
3. 1800 ft north, 900 ft west, sec. 23, T 18 S, R 20 E. About 3890 ft elev.

46. Tusker local fauna, Arizona (NI 12-2 [Silver City] C-6)

Two nearby localities are known, in the Safford Valley 15 miles southeast of Safford. Two species of mollusks were cited by Seff (1960). The fossiliferous unit was called the "111 Ranch beds" by Seff and by Heindl and Reed (1965: 67), who published stratigraphic sections. It was included in the Gila Conglomerate by Knechtel (1938), who mapped the area in a generalized way. Mammals have been recorded by Gazin (1936), Knechtel (1938), Lance (1958), P. A. Wood (1960) and Downey (1962). Diatoms from the area reported by Knechtel may be either Irvingtonian or Blancan, and are not surely part of the Tusker biota. The fauna is dated as early Irvingtonian on the basis of its composition, and the contrast with a Blancan assemblage (Lance, 1958, 1960; P. A. Wood, 1960) lower in the same depositional sequence. Most recent topographic map: U. S. Geological Survey Silver City quadrangle (1962) 1: 250000.

Several names have been used for this

TABLE 5. Locality occurrence of mollusks of Benson local fauna

Species	1	2	3
Pisidium casertanum (Poli)			X
Fossaria dalli (Baker)		X	
Lymnaea caperata Say		X	X
Lymnaea cf *L. elodes* Say	X	X	
Bakerilymnaea bulimoides techella (Haldeman)	X		X
Gyraulus parvus (Say)		X	X
Promenetus exacuous kansasensis (Baker)			X
Promenetus umbilicatellus (Cockerell)	X		
Physa virgata Gould	X	X	X
Gastrocopta cristata (Pilsbry and Vanatta)	X	X	X
Gastrocopta tappaniana (Adams)			X
Pupoides albilabris (Adams)	X	X	X
Vertigo milium (Gould)			X
Vertigo ovata Say		X	X
cf *Succinea*	X	X	X
Deroceras aenigma Leonard	X	X	X
Hawaiia minuscula (Binney)			X

assemblage. Lance (1958) and P. A. Wood (1960) termed it the "111 Ranch fauna"; Lance (1960) called it "Tusker Claim"; and Downey (1960) the Tusker local fauna.

47. White Cone local fauna, Arizona (NI 12-2 [Flagstaff] C-1)

The fossils come from the upper member of the Bidahochi Formation at White Cone Peak, in the Hopi Indian Reservation 50 miles northeast of Winslow. Mollusks have been listed or described by Gregory (1917: 82), Reagan (1932), Williams (1936: 130), Hunt (1956: 29) and Taylor (1957). Sabels (1962: 102) mentioned mollusks from another locality (not specified) in the lower part of the formation. The general distribution of the formation has been shown on small-scale maps by Hack (1942, pl. 1), Repenning and Irwin (1954, Fig. 1) and Hunt (1956, Fig. 20), who summarized the stratigraphy and discussed regional environments of deposition. Nine species of freshwater mollusks, only 2 surely extinct, are known. Associated fossils at White Cone include mammals (Stirton, 1936b; Lance, 1954) and fishes (Uyeno and Miller, 1965). An early to middle Hemphillian age is assigned here. The fossil mollusks listed by Gregory (1917) and Taylor (1957) are in USGS collections; others in UMMZ. Most recent topographic map: U. S. Geological Survey Flagstaff quadrangle (1960) 1: 250000.

Age of White Cone local fauna

The White Cone local fauna is probably of early to middle Hemphillian age. The aplodontid rodent (Lance, 1954) favors an age greater than late Hemphillian. The family is unknown after the Hemphillian and is rare in late Hemphillian faunas (Shotwell, 1958: 475). This evidence is interpreted as weightier than the possible late Hemphillian-early Blancan age of the beaver *Dipoides* suggested by Shotwell (1955: 141).

Basalt between the upper and lower members of the Bidahochi Formation yielded a potassium-argon radiogenic date of 4.1 million years (Evernden et al., 1964: 190). Within the known framework of faunal succession and reliable potassium-argon dates 4.1 million years is too young for a Hemphillian fauna, confirming the suspicions of Evernden et al.: "Fine-grain size of plagioclase worrisome. Figure obtained should be considered as a minimum."

The molluscan fauna from White Cone Peak is made up primarily of living species. Only 2 are extinct, and of these *Pseudosuccinea dineana* is known only from White Cone. *Lymnaea albiconica* is found elsewhere in the Teewinot Formation, Wyoming (Taylor, 1957), stratigraphically close to Hemphillian mammals and an obsidian sample that was dated 9.2 million years (Evernden et al., 1964: 185); in the lower to middle Pliocene Starlight and Neeley Formations in southeastern Idaho (Carr and Trimble, 1963); and in the Clarendonian part of the Laverne Formation, Oklahoma (Taylor, 1957). This evidence favors pre-Blancan age.

The molluscan data that might substantiate the possible early Blancan age considered by Shotwell (1955) and Evernden et al. (1964) is mostly negative. The White Cone local fauna does not include the common Hemphillian snails *Bulimnea* or *Coretus,* nor any of the extinct forms found in the Ogallala Formation in Kansas (Frye et al., 1956). Blancan assemblages in Arizona from the Verde Formation and Benson local fauna (Fig. 1, localities 39 and 43) are closely similar to Blancan faunas in the southern High Plains. The White Cone mollusks might therefore be expected to show greater similarities with these faunas if they were of early Blancan age.

48. Sand Draw local fauna, Nebraska (NK 14-5 [O'Neill] C-8)

The localities are in tributaries to Niobrara River, in northern Brown County north of Ainsworth. Forty-two species of mollusks have been reported

(Taylor, 1960b, and references therein). The fossiliferous unit has been described roughly, but not named; no geologic maps have been published. Associated fossils include fishes, reptiles and mammals, summarized by Taylor (1960b). Previous Nebraskan and Aftonian age assignments (Taylor, 1960b; Hibbard, 1960) are probably wrong; the fauna more likely comes from a time of alpine or minor continental glaciation that preceded the first major continental glaciation. Fossils are in the collections of the Chicago Natural History Museum; Illinois State Geological Survey and UMMZ. Most recent topographic maps: U. S. Geological Survey quadrangles, 1: 24000: Ainsworth (1954), Ainsworth NW (1954), Ainsworth SW (1954), Dutch Creek (1950).

49. Iowa Point, Kansas
(NJ 15-1 [Kansas City] D-5)

The locality is on the southwest side of the Missouri River, 5 miles north of Highland. Mollusks have been reported by Frye and Leonard (1952: 55, 151). The fossiliferous unit was first included in the David City Formation, but Reed et al. (1965) considered that it may be proglacial gravel related to the Iowa Point till, of late Nebraskan age, and not David City Formation of early Nebraskan age. Eight species of mollusks are the only fossils reported from the locality. Fossils are in the collections of the University of Kansas. Most recent topographic map: U. S. Geological Survey Oregon quadrangle (1959) 1:24000.

50. Saw Rock Canyon local fauna,
Kansas (NJ 14-7 [Dodge City] A-3)

The one known fossil locality is on the south side of the Cimarron River, 15 miles east of Liberal, Seward County, Kansas. Twenty-nine species of mollusks were recorded by Taylor (1960b). The fossils occur in the XI Member of the Rexroad Formation, distribution of which was mapped by Byrne and McLaughlin (1948). The associated fauna of fishes, amphibians, reptiles, birds and mammals has been summarized most recently by Hibbard (1964), who emphasized its transitional Hemphillian-Blancan character. Fossils are in the collections of the University of Kansas and University of Michigan. Most recent topographic map: U. S. Geological Survey Dodge City quadrangle (1959) 1:250000.

51a. Rexroad local fauna, Kansas
(NJ 14-7 [Dodge City] A-2, A-3, B-2)

The fossil localities are in central and southwestern Meade County, from about 2 to 25 miles southwest of Meade. Mollusks were reported by several authors prior to the summary by Taylor (1960b) and by Miller (1964). The fossils are from the upper part of the Rexroad Formation, the distribution of which in the vicinity of the fossil localities has been mapped by Miller (this volume), Stevens (in press) and Woodburne (1961). The fauna includes 48 species of mollusks in a total of about 170 species of ostracodes, crayfish, mollusks, fishes, amphibians, reptiles, birds and mammals. The late Pliocene age assigned by Taylor (1960a) is maintained here. Fossil mollusks are in the collections of the University of Kansas and UMMZ. Most recent topographic maps: U.S. Geological Survey quadrangles: Dodge City (1959) 1: 250000, Kismet SE (1963) 1: 24000, Lake Larrabee (1963) 1: 24000, Missler (1963) 1: 24000.

Rexroad Local Fauna

So many papers contributing to knowledge of the Rexroad local fauna have been published since the last faunal summary (Taylor, 1960b) that a revised faunal list has been compiled. The following references supplement those cited in that earlier summary: Auffenberg (1962), Brodkorb (1964a), Collins (1964), Dawson (1958), Etheridge (1958, 1960, 1961), Ford (in press), Gutentag and Benson (1962), Hazard (1961), Hibbard (1963a, b, 1964), Klingener

(1963), B. B. Miller (1964), Packard (1960), Patton (1965), Repenning (1962), Smith (1962), Stephens (1959), Stevens (1965), Tihen (1960, 1962), Tordoff (1959), Uyeno and Miller (1963), Webb (1965), Woodburne (1961).

Class Pelecypoda
- Order Schizodonta
  - Unionidae
    - *?Ligumia subrostrata* (Say)
- Order Heterodonta
  - Sphaeriidae
    - *Sphaerium* cf *S. partumeium (Say)*
    - *Sphaerium sulcatum* (Lamarck)
    - *Pisidium casertanum* (Poli)

Class Gastropoda
- Order Mesogastropoda
  - Hydrobiidae
    - *Marstonia crybetes* (Leonard)
- Order Basommatophora
  - Carychiidae
    - *Carychium exiguum* (Say)
  - Lymnaeidae
    - *Bakerilymnaea bulimoides techella* (Haldeman)
    - *Fossaria dalli* (Baker)
    - *Fossaria obrussa* (Say)
    - *Lymnaea caperata* Say
    - *Lymnaea exilis* Lea
    - *Lymnaea reflexa* Say
  - Ancylidae
    - *Ferrissia meekiana* (Stimpson)
    - *Ferrissia parallela* (Haldeman)
    - *Ferrissia rivularis* (Say)
  - Planorbidae
    - *Omalodiscus pattersoni* (Baker)
    - *Gyraulus parvus* (Say)
    - *Helisoma anceps* (Menke)
    - *Promenetus exacuous kansasensis* (Baker)
    - *Promenetus umbilicatellus* (Cockerell)
  - Physidae
    - *Physa virgata* Gould
    - *Physa* cf *P. skinneri* Taylor
- Order Stylommatophora
  - Cionellidae
    - *Cionella lubrica* (Muller)
  - Vertiginidae
    - *Vertigo hibbardi* Baker
    - *Vertigo milium* (Gould)
  - Chondrinidae
    - *Gastrocopta armifera* (Say)
    - *Gastrocopta* cf *G. cristata* (Pilsbry and Vanatta)
    - *Gastrocopta franzenae* Taylor
    - *Gastrocopta holzingeri* (Sterki)
    - *Gastrocopta paracristata* Franzen and Leonard
    - *Gastrocopta pellucida hordeacella* (Pilsbry)
    - *Gastrocopta rexroadensis* Franzen and Leonard
    - *Gastrocopta tappaniana* (Adams)
  - Pupillidae
    - *Pupoides albilabris* (Adams)
    - *Pupoides inornatus* Vanatta
  - Strobilopsidae
    - *Strobilops sparsicostata* Baker
  - Valloniidae
    - *Vallonia gracilicosta* Reinhardt
    - *Vallonia perspectiva* Sterki
  - Succineidae
    - cf *Succinea*
  - Endodontidae
    - *Helicodiscus parallelus* (Say)
    - *Helicodiscus singleyanus* (Pilsbry)
  - Zonitidae
    - *Hawaiia minuscula* (Binney)
    - *Nesovitrea electrina* (Gould)
    - *Retinella rhoadsi* (Pilsbry)
    - *Retinella wheatleyi* (Bland)
    - *Zonitoides arboreus* (Say)
  - Limacidae
    - *Deroceras aenigma* Leonard
  - Polygyridae
    - *Polygyra rexroadensis* Taylor

Class Crustacea
- Order Decapoda
  - Astacidae, indeterminate
- Order Podocopida
  - Cytherideidae
    - *Cyprideis littoralis* Brady

Class Osteichthyes
- Cyprinidae spp.
- Ictaluridae
  - *Ictalurus benderensis* Smith
- Cyprinodontidae
  - *Fundulus*
- Centrarchidae
  - cf *Ambloplites rupestris* (Rafinesque)
  - *Lepomis cyanellus* Rafinesque
  - Indeterminate species

Class Amphibia
Order Caudata
Ambystomatidae
Ambystoma hibbardi Tihen
Order Salientia
Pelobatidae
Scaphiopus diversus Taylor
Bufonidae
Bufo suspectus Tihen
Bufo cf *B. compactilis speciosus* Girard
Bufo rexroadensis Tihen
Ranidae
Anchylorana moorei Taylor
Anchylorana dubita Taylor
Anchylorana robustocondyla Taylor
Rana fayeae Taylor
Rana meadensis Taylor
Rana ephippium Taylor
Rana rexroadensis Taylor
Rana valida Taylor
Rana parvissima Taylor
Class Reptilia
Order Chelonia
Chelydridae
Chelydra serpentina (Linnaeus)
Macroclemys temminckii (Troost)
Testuthnidae
Geochelone rexroadensis (Oelrich)
Geochelone riggsi (Hibbard)
Order Squamata
Iguanidae
Sceloporus robustus Twente
Phrynosoma cornutum (Harlan)
Anguidae
Ophisaurus attenuatus Baird
Teidae
Cnemidophorus bilobatus Taylor
Cnemidophorus sexlineatus (Linnaeus)
Scincidae
Eumeces striatulatus Taylor
Colubridae
Natrix
Thamnophis
Heterodon plionasicus Peters
Class Ayes
Order Podicipediformes
Podicipedidae
Podiceps
Order Ardeiformes
Plataleidae
Eudocimus
Mesembrinibis cayennensis (Gmelin)
Phimosus infuscatus (Lichtenstein)
Plegadis gracilis Miller and Bowman
Plegadis
Order Anseriformes
Anatidae
Nettion bunkeri Wetmore
Bucephala albeola (Linnaeus)
Order Accipitriformes
Vulturidae
Pliogyps fisheri Tordoff
Accipitridae
Buteo
Order Galliformes
Phasianidae
Colinus hibbardi Wetmore
Agriocharis progenes Brodkorb
Order Gruiformes
Rallidae
Rallus prenticei Wetmore
Fulica americana Gmelin
Order Charadriiformes
Scolopacidae, indeterminate
Laridae
Sterna
Order Columbiformes
Columbidae
Zenaidura macroura (Linnaeus)
Order Strigiformes
Strigidae
Otus
Speotyto
Asio
Order Psittaciformes
Psittacidae, indeterminate
Order Passeriformes
Indeterminate
Class Mammalia
Order Insectivora
Soricidae
Sorex rexroadensis Hibbard
Sorex taylori Hibbard
Blarina adamsi Hibbard
Cryptotis? meadensis Hibbard
Paracryptotis rex Hibbard
Notiosorex jacksoni Hibbard
Order Chiroptera
Vespertilionidae
Lasiurus fossilis Hibbard
Order Edentata
Megalonychidae

Megalonyx cf *M. leptostomus* Cope
Order Rodentia
Sciuridae
Paenemarmota barbouri Hibbard and Schultz
Citellus howelli Hibbard
Citellus rexroadensis Hibbard
Geomyidae
Geomys quinni McGrew
Nerterogeomys minor (Gidley)
Heteromyidae
Perognathus rexroadensis Hibbard
Perognathus gidleyi Hibbard
Perognathus pearlettensis Hibbard
Prodipodomys rexroadensis Hibbard
Liomys centralis Hibbard
Castoridae
Dipoides rexroadensis Hibbard and Riggs
Procastoroides sweeti Barbour and Schultz
Cricetidae
Reithrodontomys rexroadensis Hibbard
Reithrodontomys wetmorei Hibbard
Peromyscus baumgartneri Hibbard
Peromyscus kansasensis Hibbard
Parahodomys quadriplicatus Hibbard
Bensonomys eliasi (Hibbard)
Baiomys kolbi Hibbard
Baiomys rexroadi Hibbard
Onychomys gidleyi Hibbard
Sigmodon intermedius Hibbard
Symmetrodontomys simplicidens Hibbard
Ogmodontomys poaphagus Hibbard
Pliophenacomys primaevus Hibbard
Nebraskomys?
Zapodidae
Zapus rinkeri Hibbard
Zapus sandersi rexroadensis Klingener
Order Carnivora
Canidae
Urocyon progressus Stevens
Canis lepophagus Johnston
Canis
Borophagus divers idens Cope
Procyonidae
Bassariscus casei Hibbard
Bassariscus rexroadensis Hibbard
Procyon rexroadensis Hibbard
Mustelidae
Buisnictis breviramus (Hibbard)
Trigonictis kansasensis Hibbard
Martes foxi Hibbard and Riggs
Mustela rexroadensis Hibbard
Mustela
Taxidea taxus (Schreber)
Spilogale rexroadi Hibbard
Mephitis? rexroadensis Hibbard
Brachyopsigale dubius Hibbard
Lutra cf *L. piscinaria* Leidy
Felidae
Felis lacustris Gazin
Felis rexroadensis Stephens
Machairodontidae
Machairodus?
Order Proboscidea
Gomphotheriidae
Stegomastodon rexroadensis Woodburne
Mammutidae
Mammut adamsi (Hibbard)
Order Lagomorpha
Leporidae
Pratilepus kansasensis Hibbard
Notolagus lepusculus (Hibbard)
Hypolagus regalis Hibbard
Nekrolagus progressus (Hibbard)
Order Artiodactyla
Tayassuidae
Platygonus bicalcaratus Cope
Camelidae
Megatylopus cochrani (Hibbard and Riggs)
Titanotylopus spatulus (Cope)
Tanupolama blancoensis Meade
Cervidae
Odocoileus brachyodontus Oelrich
Antilocapridae, indeterminate
Order Perissodactyla
Equidae
Nannippus phlegon (Hay)
Plesippus simplicidens (Cope)

Localities

Topographic maps of most of Meade County have become available only recently. They now permit precise locality descriptions, given below not only for mollusk localities but for all fossil localities of the Rexroad local fauna shown on these maps.

TABLE 6. Locality occurrence of mollusks of Rexroad local fauna

Species	1	2	6	7	11	14	15	16	17
? Ligumia subrostrata					X				
Sphaerium cf *S. partumeium*				X					
Sphaerium sulcatum				X					
Pisidium casertanum		X		X	X				X
Marstonia crybetes	X				X		X		
Carychium exiguum		X		X	X			X	
Bakerilymnaea bulimoides techella	X	X						X	X
Fossaria dalli	X	X	X	X	X		X		X
Fossaria obrussa				X					
Lymnaea caperata			X	X					
Lymnaea exilis	X			X	X		X		
Lymnaea reflexa				X					
Ferrissia meekiana				X					
Ferrissia parallela					X			X	
Ferrissia rivularis				X	X			X	
Omalodiscus pattersoni				X					
Gyraulus parvus		X		X					
Helisoma anceps				X	X			X	
Promenetus exacuous kansasensis	X			X	X				
Promenetus umbilicatellus	X		X	X				X	X
Physa virgata	X	X	X	X	X		X		X
Physa cf *P. skinneri*				X					
Cionella lubrica		X			X				
Vertigo hibbardi		X		X	X			X	
Vertigo milium		X		X	X		X		X
Gastrocopta armifera				X					
Gastrocopta cf *G. cristata*				X					
Gastrocopta franzenae		X		X	X		X		X
Gastrocopta holzingeri	X	X		X	X				
Gastrocopta paracristata	X	X		X	X		X		X
Gastrocopta pellucida hordeacella				X	X				
Gastrocopta rexroadensis		X			X			X	
Gastrocopta tappaniana		X		X	X		X		X
Pupoides albilabris	X	X		X	X	X	X		X
Pupoides inornatus		X			X				
Strobilops sparsicostata	X			X	X		X		
Vallonia gracilicosta					X				
Vallonia perspectiva		X			X				
cf *Succinea*	X	X	X	X	X		X		X
Helicodiscus parallelus				X					
Helicodiscus singleyanus		X		X	X		X		
Hawaiia minuscula	X	X		X	X		X		X
Nesovitrea electrina					X			X	
Retinella rhoadsi					X				
Retinella wheatleyi					X				
Zonitoides arboreus				?	?				
Deroceras aenigma	X	X		X	X	X	X		
Polygyra rexroadensis		X			X		X		

1. Missler quadrangle (1963) 1: 24000, 2200 ft west, 8'75 ft south, sec. 18, T 32 S, R 28 W. Exposure on the south side of Hart Draw, where the Rexroad Formation is overlain with erosional unconformity by Ballard Formation. Sanders local fauna locality 1 is in superposition about 500 ft to the southwest. Locality 1 of Taylor (1960a: 29); shown as R loc. 1 on the map by Miller (this volume); University of Kansas Meade County locality 25. For measured stratigraphic section see Hibbard (1956: 150).

2. Missler quadrangle (1963) 1: 24000, 1950 ft west, 100 ft south, sec. 24, T 32 S, R 29 W. Exposure on the south side of Spring Creek, east of the mouth of an unnamed tributary. Sanders local fauna localities 2 and 3, in the Ballard Formation, are in superposition about 3/4 mile to the southwest. Locality 2 of Taylor (1960a: 29); shown as R loc. 2 on the map by Miller (this volume).

3. Lake Larrabee quadrangle (1963) 1: 24000, 1300 ft east, 400 ft north, sec. 4, T 33 S, R 29 W. Exposure in cut bank on the northeast side of an unnamed tributary to Stump Arroyo (not Stumpie Arroyo proper, as shown on map) where the Rexroad Formation is overlain with erosional unconformity by the Ballard Formation.

4. Lake Larrabee quadrangle (1963) 1: 24000, 2500 ft east, 1400 ft north, sec. 9, T 33 S, R 29 W. Exposure in tributary of Stump Arroyo, high in Rexroad Formation close beneath unconformably overlying Ballard Formation.

5. Lake Larrabee quadrangle (1963) 1: 24000, 1750 ft west, 1150 ft north, sec. 10, T 33 S, R 29 W. Exposure on south side of mouth of tributary to Stump Arroyo (not Stumpie Arroyo proper, as shown on map). *Paenemarmota,* University of Michigan Museum of Paleontology 47886.

6. Lake Larrabee quadrangle (1963) 1: 24000, 1900 ft west, 50 ft north, sec. 10, T 33 S, R 29 W. Exposure in minor gulch northwest of artesian spring-fed pond in Meade County State Park. Mollusks were collected by a University of Michigan Museum of Paleontology field party in 1962, and are reported for the first time herein.

'7. Lake Larrabee quadrangle (1963) 1: 24000, 2100 ft west, 1500 ft north, sec. 16, T 33 S, R 29 W. Exposure in tributary of Stump Arroyo downstream from farm road, where Rexroad Formation is overlain with erosional unconformity by Ballard Formation. Mollusks were reported from this locality by Miller (1964), who assigned them to the Bender local fauna. Whether one places them in the Bender or Rexroad, there are several downward extensions in known stratigraphic range. Fewer species are added to the Rexroad than to the Bender local fauna, and the only stratigraphically restricted species, *Vertigo hibbardi,* is known from several Rexroad localities but not from the Bender local fauna. These faunal data slightly favor a Rexroad rather than Bender correlation.

8. Lake Larrabee quadrangle (1963) 1: 24000, 1700 ft east, 1050 ft south, sec. 22, T 33 S, R 29 W. University of Kansas Meade County locality 2. Shown as locality 2 on the map by Woodburne (1961).

9. Lake Larrabee quadrangle (1963) 1: 24000, 1650 ft east, 1350 ft south, sec. 22, T 33 S, R 29 W. University of Kansas Meade County locality 2a. Shown as locality 2a on the map by Woodburne (1961).

10. Lake Larrabee quadrangle (1963) 1: 24000, 1000 ft east, 1600-2000 ft north sec. 22, T 33 S, R 29 W. Exposure in cut bank on east side of tributary to Stump Arroyo, where the Rexroad Formation is deeply channeled by the overlying Ballard Formation. This is the deposit of an ancient artesian spring, from which the vertebrates of "Rexroad locality 3" have come. Locality 3 of Taylor (1960a: 29) in part; University of Kansas Meade County locality 3, in part; shown as locality 3 on the map by Woodburne (1961). For measured stratigraphic section see Woodburne (1961:

66).

11. Lake Larrabee quadrangle (1963) 1: 24000, 900 ft east, 1300 ft north, sec. 22, T 33 S, R 29 W. Fossils from a shelly lens in the Rexroad Formation, now covered by the east side of the sandy bed of a tributary of Stump Arroyo. Locality 3 of Taylor (1960a: 29) in part; University of Kansas Meade County locality 3, in part; USGS Cenozoic locality 21171. All mollusks recorded from "Rexroad locality 3" are from this site.

12. Lake Larrabee quadrangle (1963) 1: 24000, 900 ft east, 200 ft north, sec. 33, T 33 S, R 29 W. Exposure on Shorts Creek. University of Michigan Museum of Paleontology locality UM-K3-53; shown as locality K3 on the map by Woodburne (1961). For measured section see Woodburne (1961: 64).

13. Kismet SE quadrangle (1963) 1: 24000, 200 ft east, 900 ft north, sec. 34, T 34 S, R 30 W. Exposure in bottom of Keefe Canyon, illustrated by Hibbard (1950, pl. 4). University of Kansas Meade County locality 22.

14. Kismet SE quadrangle (1963) 1: 24000, 2000 ft west, 2550 ft south, sec. 35, T 34 S, R 30 W. Exposure in bluff on south side of tributary to Fox Canyon, illustrated by Hibbard (1950, pl. 5). Locality 4a of Taylor (1960a: 29); University of Michigan Museum of Paleontology locality UM-K1-47.

15. Kismet SE quadrangle (1963) 1: 24000, 1500 ft west, 2500 ft south, sec. 35, T 34 S, R 30 W. Exposure in cut bank on east side of Fox Canyon. Locality 4b of Taylor (1960a: 29).

16. Kismet SE quadrangle (1963) 1: 24000, 1500 ft west, 1900 ft north, sec. 35, T 34 S, R 30 W. Exposure in cut bank on east side of Fox Canyon. Some of the mollusks reported by Franzen and Leonard (1947), Frye and Leonard (1952) and Leonard (1952) came from a lenticular body of clay formerly exposed 300 ft downstream from the preceding locality, according to C. W. Hibbard. The species listed from locality 4b (Taylor, 1960b: 29, Table 11) on the basis of literature records rather than specimens were not found in University of Michigan collections from locality 15, and hence probably came from locality 16.

17. Kismet SE quadrangle (1963) 1: 24000, 1750 ft west, 2250 ft north, sec. 7, T 35 S, R 30 W. Exposure in cut bank of minor tributary to canyon between Wolf Canyon and Gas Well Canyon.

51b. Bender local fauna, Kansas (NJ 14-7 [Dodge City] A-2, 3, B-2)

The two known localities are in Meade County, 11 miles southwest of Meade; and in Seward County on the south side of the Cimarron River, 15 miles east of Liberal. Twenty-one species of mollusks were listed by Taylor (1960b and herein). They are from the uppermost Rexroad Formation, above a massive caliche bed. The formation in the vicinity of the fossil localities has been mapped by Byrne and McLaughlin (1948), Miller (this volume), Stevens (in press) and Woodburne (1961). No other associated fossils are known. The late Pliocene age assigned by Taylor (1960) is maintained here. Fossils are in UMMZ collections. Most recent topographic maps: U. S. Geological Survey Dodge City quadrangle (1959) 1: 250000; and Lake Larrabee and Missler quadrangles (1963) 1: 24000.

Localities

Revised locality descriptions for Bender locality 1 follow. All are in sec. 22, T 33 S, R 29 W, Lake Larrabee quadrangle (1963) 1: 24000.

la. 2150 ft east, 950 ft north. Dark bed on south side of wash.

lb. 2600 ft east, 1000 ft north. East side of wash, immediately below Angell Gravel Member of Ballard Formation.

lc. 2650 ft west, 200 ft north. Southwest side of wash.

Additional mollusks from Bender local fauna

Bender locality 3. Meade County, Kansas. Missler quadrangle (1963)1: 24000. 2400 ft west, 900 ft south, sec. 18, T 32

S, R 28 W. Fossils from southeast side of the mouth of a gully tributary to Hart Draw, in the Rexroad Formation above thick caliche. Rexroad local fauna locality 1 is 200 ft east; Sanders local fauna locality 1 is about 300 ft to the southwest. C. W. Hibbard et al., 1957.

The following list of species includes only 1 form (*Gyraulus parvus*) that is surely an addition to the faunal list published by Taylor (1960b). The fauna is not characteristic enough to indicate whether it is closely correlative with Bender locality 1, or whether it might be somewhat younger.

Lymnaeidae
- *Bakerilymnaea bulimoides techella* (Haldeman)
- *Fossaria dalli* (Baker)
- *Lymnaea reflexa* Say?

Planorbidae
- *Gyraulus parvus* (Say)
- *Promenetus umbilicatellus* (Cockerell)

Physidae
- *Physa virgata* Gould

Vertiginidae
- *Vertigo milium* (Gould)

Chondrinidae
- *Gastrocopta cristata* (Pilsbry and Vanatta)
- *Gas trocopta tappaniana* (Adams)

Pupillidae
- *Pupoides albilabris* (Adams)

Succineidae
- cf *Succinea*

Zonitidae
- *Hawaiia minus cula* (Binney)

Limacidae
- *Deroceras aenigma* Leonard

51c. Spring Creek local fauna, Kansas (NJ 14-7 [Dodge City] B-2)

The one known locality is on the Big Springs Ranch, about 6 miles west of Meade, Meade County, Kansas. Berry and Miller (this volume, p 263) record 16 species of mollusks. The fossils occur in the Missler Silt Member of the Ballard Formation, the local distribution of which was mapped by Miller (this volume, p 200). Only one associated mammal is known. The fauna is from the interval prior to the first major continental glaciation but later than an alpine or limited continental glaciation. Fossils are in UMMZ collections. Most recent topographic map: U.S. Geological Survey Missler quadrangle (1963) 1: 24000.

51d. Deer Park local fauna, Kansas (NJ 14-7 [Dodge City] A-2)

The one known locality is in Meade County State Park, 10 miles southwest of Meade. A slug is the single mollusk known; associated fossils include reptiles, birds and mammals (Taylor, 1960b). The fossils are from the Missler Silt Member of the Ballard Formation, in deposits of a former artesian spring. The Aftonian age previously assigned is probably wrong. The fauna seems to be older than the first major continental glaciation of North America, during which the Nebraskan till was deposited, but younger than an episode of climatic cooling associated with alpine or limited continental glaciation. Fossil mollusks are in UMMZ collections; fossil vertebrates in the University of Kansas and University of Michigan.

The fossil locality is shown on the U. S. Geological Survey Lake Larrabee quadrangle (1963) 1: 24000, 2500 ft west, 800-900 ft north, sec. 15, T 33 S, R 29 W. (University of Kansas Meade County locality 1).

51e. Sanders local fauna, Kansas (NJ 14-7 [Dodge City] A-2)

The 3 known fossil localities are on the Big Springs Ranch, Meade County, about 4-6 miles southwest of Meade. Twenty-three species of mollusks were recorded by Taylor (1960b). The fossils are from the Missler Silt Member of the Ballard Formation, the local distribution of which has been mapped by Miller (this volume, p 200). Associated fossils included amphibians, birds and mammals. References subsequent to those cited by Taylor (1960b) include Harrell (1960) and Klingener (1963). The late Aftonian age assigned previously is probably wrong. The fauna seems to be older than the first major continental glaciation of North America, during which the Nebraskan till was deposited, but younger than an episode of climatic cooling associated with alpine or limited continental glaciation. Fossils are in the collections of the Universtiy of Michigan. Most recent topographic maps: U. S. Geological Survey Lake Larrabee and Missler quadrangles (1963) 1: 24000.

Localities

Revised locality descriptions are as follows:

1. Missler quadrangle (1963) 1: 24000, 2650 ft east, 1150 ft south, and 2550 ft east, 1250 ft south, sec. 18, T 32 S, R 29 W. Exposure on southeast side of tributary to Hart Draw, where Ballard Formation overlies Rexroad Formation with erosional unconformity. Locality 1 of Taylor (1960b: 40); University of Michigan Museum of Paleontology locality UM-K1-53, shown on map by Miller (this volume, p 195). For measured section see Hibbard (1956: 150).

2. Lake Larrabee quadrangle (1963) 1: 24000, 650 ft west, 1500 ft north, sec. 23, T 32 S, R 29 W. Gray silt exposed on southeast side of tributary to Spring Creek. Locality 2 of.Taylor (1960b: 40); University of Michigan Museum of Paleontology locality UM-K2-53, in part.

3. Lake Larrabee quadrangle (1963) 1:24000, 1400 ft west, 1250 ft north, sec. 23, T 32 S, R 29 W. Gray silt exposed on southeast side of tributary to Spring Creek. Locality 3 of Taylor (1960b: 40); University of Michigan Museum of Paleontology locality UM-K2-53, in part. For measured section see Hibbard (1956: 151).

52a. Dixon local fauna, Kansas
(NJ 14-8 [Pratt] C-1, NJ 14-9 [Wichita] B-8)

The 2 known localities are in Kingman County, Kansas, south and southeast of Kingman. Forty-eight species of mollusks have been reported (Taylor, 1960b, and references therein). The fossiliferous unit has been described and mapped by Lane (1960) as Holdredge and Fullerton Formations, undifferentiated. Associated fossils include amphibians, birds and mammals (Harrell, 1960; Taylor, 1960b and references therein). The previous age assignment of latest Nebraskan or earliest Aftonian is probably wrong; the fauna more likely comes from shortly after a time of alpine or minor continental glaciation that preceded the first major continental glaciation. Fossils are in the collections of the University of Kansas and University of Michigan. Most recent topographic maps: U. S. Geological Survey quadrangles, 1: 250000: Pratt (1959), Wichita (1959).

52b. Swingle locality, Kansas
(NJ 14-8 [Pratt] B-2)

The one known locality is in the southwestern part of Kingman County 18 miles southwest of Kingman. Twenty-two species of mollusks were reported by Lane (1960), who mapped the fossiliferous unit as Holdredge and Fullerton Formations, undifferentiated. Associated fossils (Hibbard, 1958a) include 3 species of rodents and 1 shrew. The Aftonian age assigned previously is probably wrong; the fauna more likely comes from an interval after alpine or minor continental glaciation but before the first major continental glaciation. Fossils are in the collections of the University of Michigan. Most recent topographic map: U. S. Geological Survey Pratt quadrangle (1959) 1: 250000.

53. Buis Ranch local fauna, Oklahoma
(NJ 14-10 [Perryton] D-2)

The 2 known localities are on the south side of the Cimarron River, 15 miles northeast of Beaver City, Beaver County, Oklahoma. Taylor (1960b) recorded 5 species of mollusks. The fossils are from the Ogallala Formation. Associated vertebrates include amphibians, reptiles and mammals; references subsequent to those cited by Taylor (1960b) include Hazard (1961) and Hibbard (1963c). The late Hemphillian age assigned by Taylor (1960b) is maintained here. Fossils are in the collections of the University of Michigan. Most recent topographic map: U. S. Geological Survey Perryton quadrangle (1958) 1: 250000.

54. Red Corral local fauna, Texas
(NI 13-3 [Tucumcari] C-2)

The 1 published fossil locality is in northern Oldham County, 10 miles southwest of Channing. Eighteen species of mollusks have been reported (Taylor, 1960b). The fossiliferous unit is unnamed, and no stratigraphic data or geologic maps have been published. Most of the rich vertebrate fauna is undescribed; 2 genera of mammals were cited by Taylor (1960b). The late Pliocene age assigned previously is maintained here. Fossil mollusks are in UMMZ collections; mammals in the UCMP and Frick Laboratory, American Museum of Natural History. Most recent topographic map: Army Map Service Tucumcari quadrangle (1958) 1: 250000.

55. Whitefish Creek, Texas
(NI 14-1 [Amarillo] A-3)

Fossil mollusks collected by M. F. Skinner in the drainage of Whitefish Creek, Donley County, Texas, are thought by him to be of probably Pliocene age on the basis of local stratigraphy; a Blancan age is assigned on the basis of the mollusks. Fossils are in UMMZ collections. Most recent topographic map: U. S. Geological Survey Spencer Lake quadrangle (1949) 1: 24000.

Mollusks from Whitefish Creek

USGS Cenozoic locality 22112. Donley County, Texas. Spencer Lake quadrangle (1959) 1: 24000. West side of Whitefish Creek, on divide with drainage to west, at elevation of about 2480 ft near top of hill VABM 2499; M. F. Skinner, 1959.

Lymnaeidae
Lymnaea (Stagnicola)
Planorbidae
Gyraulus parvus (Say)
Planorbella (Pierosoma)
Promenetus exacuous kansasensis (Baker)
Physidae
Physa (s.s.) cf *P. skinneri* Taylor
Physa (Physella)
Succineidae
Oxyloma

This small assemblage is probably Blancan or post-Blancan; hence if Pliocene, it is late Pliocene.

56. Blanco local fauna, Texas
(NI 14-7 [Lubbock] D-6)

The mollusks and most of the vertebrates come from a group of localities north of Crawfish Draw, about 2 miles west of its mouth. Mollusks have not been recorded previously; the vertebrate fauna and its extensive literature have been summarized by Meade (1945), Hibbard (1950: 136-137), Johnston and Savage (1955) and Oelrich (1957: 228-229). The fossiliferous unit is Blanco Formation, of which no detailed map has been published. The fauna includes 11 mollusks, 1 tortoise, a bird and 18 species of mammals. The age is approximately that of an interval of alpine or continental glaciation older than the first major continental glaciation of the central United States. Fossil mollusks are in UMMZ collections. Most recent topographic map: U. S. Geological Survey Lubbock quadrangle (1954) 1: 25000.

Fossil mollusks of Blanco local fauna

Crosby County, Texas. On the map published by Meade (1945, Fig. 1) 1400 ft SW of Mt. Blanco, halfway between localities 4 and 10. W. W. Dalquest, 1964-1965.

Lymnaeidae
Bakerilymnaea bulimoides techella (Haldeman)
Lymnaea caperata Say
Lymnaea reflexa Say
Ancylidae

Ferrissia
Planorbidae
Gyraulus parvus (Say)
Planorbella trivolvis (Say)
Physidae
Physa (Physella)
Chondrinidae
Gas trocopta procera (Gould)
Succineidae
cf *Succinea*
Zonitidae
Hawaiia minus cula (Binney)
Zonitoides arboreus (Say)

Only 2 of these species, the Lymnaeas, are south of their present range and hence suggest that summer extremes of heat and drought were formerly less. The *Ferrissia* is characteristic of a perennial water body, but the other aquatic species might have lived in a stream or lake that dried up substantially in summer.

All the species are still extant, and hence without associated mammals no precise age could be assigned. *Planorbella trivolvis* and *Gas trocopta procera* are unknown from Pliocene faunas. Their occurrence lends slight support to the early Pleistocene age assigned on the basis of the mammals, particularly if the inferred phylogeny of *G. procera* (Taylor, 1960b) be correct. Correlative faunas in southwestern Kansas are the Sanders, Dixon and Deer Park, but no more precise correlation of the known Blanco fauna is possible.

In spite of their meager contribution to understanding the local environment, these fossil mollusks are scientifically significant in showing that they can provide some valid basis for correlation over a wide region. Even with no associated mammals the assemblage would surely be called Pleistocene, for it has no extinct species and 2 forms unknown before the Pleistocene. Thus the molluscan evidence accords with that of the mammals, and both emphasize how misguided was application of the term "Blanco Formation" in Kansas by Frye and Leonard (1952).

57. "Unit A", Florida
(NG 17-2 [Fort Pierce] A-3, B-2, B-3, NG 17-5 [West Palm Beach] B-4, C-3, C-6, D-3, D-6)

Several localities in southern Florida have deposits representing a major marine transgression younger than the Caloosahatachee Formation. This younger formation has not been described or named previously, but Olsson (in Olsson and Petit, 1964) briefly mentioned its significance in regional geologic history and listed some of the marine fossils. He considered it probably of late Pliocene age, but possibly early Pleistocene. Nonmarine mollusks occur either mixed with marine species, or as strictly nonmarine associations. Druid Wilson, U. S. G. S., is preparing a summary of the stratigraphy and paleontology; fossils are in USGS collections. Most recent topographic maps: U. S. Geological Survey quadrangles, 1: 24000, Fort Pierce SW (1953), Goodno (1958), Okeechobee 1 NE (1953), Okeechobee 4 NE (1953), Sears (1958); and West Palm Beach quadrangle (1963) 1: 250000.

Fossil nonmarine mollusks from "unit A"

The available collections were mostly made by Druid Wilson, on whose field experience and laboratory study of the marine fossils the stratigraphic data rest. Collections were made in place at only a few sites, but these have served to confirm the horizon of other collections made from the spoil heaps of artificial excavations. The joint occurrence of absolutely and locally extinct species, and of some unknown from older or younger horizons, indicate a distinctive fauna valuable for future stratigraphic studies.

Only the larger or more significant species have been studied in detail. The Hydrobiidae and some land snails have been omitted in the notes and faunal list. The following notes indicate the stratigraphic significance of some of the species, and provide varying amounts of taxonomic information.

The nonmarine molluscan fauna of "unit A" taken collectively is distinguished by first appearances, last appearances and both locally and absolutely extinct forms. These are as follows:

Extinct; restricted to "unit A":
Planorbella wilsoni Taylor, sp. n.
Extinct; appearing last in "unit A":
Stenophysa meigsii (Dall)
Planorbella conanti (Dall)
Extinct; appearing first in "unit A":
Planorbella aff *P. disstoni* (Dall)
Locally extinct; living only outside of Florida:
Pomacea flagellata innexa (Crosse and Fischer)
Bulimulus dealbatus (Say)
Living Floridian species appearing first in "unit A":
Pomacea paludosa (Say)

Systematic discussion

Family Viviparidae
Subfamily Viviparinae
Viviparus Montfort, 1810

Viviparus georgianus (Lea), 1837
Plate 7, Fig. 3

This species is accepted here in the sense of Goodrich (1942). Its nomenclature has been discussed by Morrison (1953) and Pilsbry (1953b). Clench (1962) gave more precise data on the type locality of the species, but his distribution map is based on a broader definition of the species. In the narrower sense V. *georgianus* is found only from southern Georgia to central Florida. Both in *Viviparus* and the related genus *Tulotoma,* a relatively narrow conchological definition of species is favored by different chromosome numbers (Patterson, 1965). *Viviparus georgianus* differs in this way from *V. contectoides,* both considered a single species by Clench (1962).

Dall (1890-1903) recorded the species from the Caloosahatchee Formation.

Family Pilidae (=Ampullariidae)
Pomacea Perry, 1810

Pain (1956) discussed the priority of *Pomacea* over the name *Ampullarius,* used by some authors such as Wenz (1938-1944).

Pomacea flagellata innexa (Crosse and Fischer), 1890
Plate 7, Figs. 6, 9, 10

1890 *Ampullaria innexa:* Crosse and Fischer, J. Conchyl. , 38: 111.
1890 *Ampullaria innexa,* Crosse et Fischer: Fischer and Crosse, Miss. Sci. Mex. , Rech. zool. , 7(2): 242, pl. 44, fig. 7-7c.
1932 *"Ampullaria hopetonensis Lea":* Tucker and Wilson, Proc. Indiana Acad. Sci. , 41: 356 (list).

Specimens from USGS locality 22038 were recorded by Tucker and Wilson as *Ampullaria hopetonensis* (a synonym of *Pomacea paludosa,* the common living species of Georgia and Florida). A later collection is now reidentified with a Central American form. The shells differ obviously from those of the Floridian species by their relatively smaller aperture, higher spire and smaller size.

Comparison was made with collections in the USNM identified by J. C. Bequaert. Specimens of this form came from 11 localities, distributed from southeastern Mexico (states Oaxaca, Tabasco and Vera Cruz) to northern Guatemala (Alta Vera Paz).

Pomacea paludosa (Say), 1829
Plate 7, Fig. 8

1932 *Ampullaria depressa* Say: Tucker and Wilson, Proc. Indiana Acad. Sci. , 41: 356 (list).

This common living species of Florida and southern Georgia is represented at many localities in "unit A". Collections made in recent years from the Caloosahatchee Formation have not

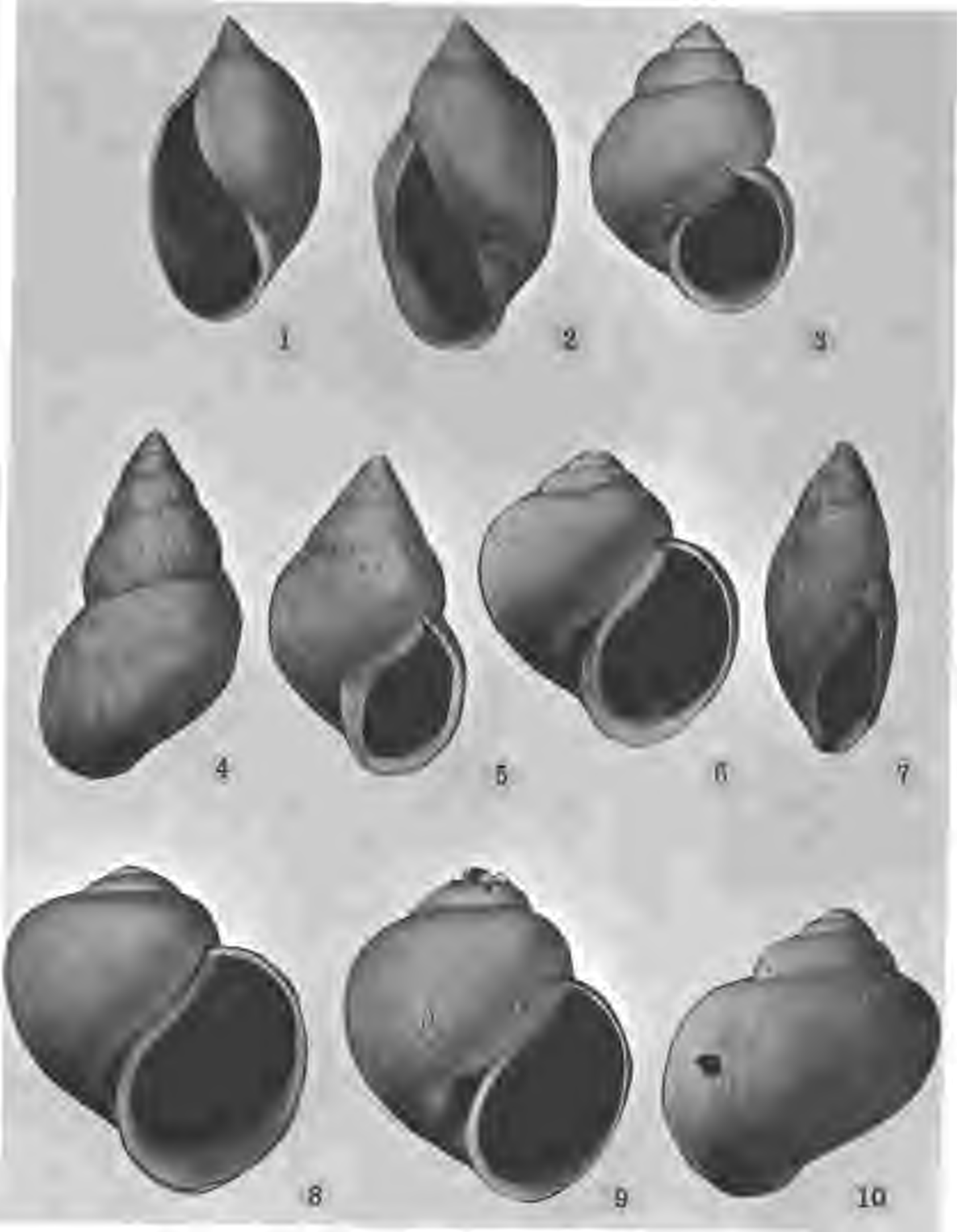

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PLATE 7

FIG. 1. *Stenophysa nicaraguana* (Morelet), X 1.5. Figured specimen, USNM 510900. Swamp near Moyogalpa, Ometepe Island, Nicaragua; B. Shimek, 1893.

FIG. 2. *Stenophysa meigsii* (Dall), X 1. 5. Figured specimen, USNM 644826. USGS locality 23698, "unit A", Ortona Lock, Florida.

FIG. 3. *Viviparus georgianus* (Lea), X 1.5. Figured specimens, USNM 644827. USGS locality 21861, "unit A", Belle Glade, Palm Beach Co., Florida.

FIGS. 4-5. *Bulimulus dealbatus* (Say), X 2. Figured specimens, USNM 644828 and 644832. USGS locality 21861, "unit A", Belle Glade, Palm Beach Co. , Florida.

FIGS. 6,10. *Pomacea flagellata innexa* (Crosse and Fischer), X 2. Figured specimens, USNM 644829. USGS locality 22040, "unit A", St. Lucie Canal, Martin Co., Florida.

FIG. 7. *Euglandina rosea* (Férussac), X 1. Figured specimen, USNM 644830. USGS locality 22704, "unit A", Belle Glade, Palm Beach Co., Florida.

FIG. 8. *Pomacea paludosa* (Say), X 1.5. Figured specimen, USNM 644831. USGS locality 22805, "unit A", Canal C-24, St. Lucie Co. , Florida.

FIG. 9. *Pomacea flagellata innexa* (Crosse and Fischer), X 2. Figured specimen, USNM 60460. Near San Juan Guichiconi, Isthmus of Tehuantepec. J. Sumichrast, 1869.

yielded any specimens of this genus or species, despite the large size of the shells and the thorough collecting in the formation. The report of *Ampullaria hopetonensis (=Pomacea paludosa)* inthe C aloosahatchee Formation by Dall (1890-1903) is probably based on shells that came from a higher stratigraphic position. Possibly *Pomacea paludosa* has extended its range into central Florida only in relatively late geologic time.

Family Pleuroceridae
Elimia H. and A. Adams, 1854

Usage of this name for most of the genus *Goniobasis* in the broader, traditional sense follows H. B. Baker (1963c).

Elimia catenaria effosa (Smith), 1938

1938 *Goniobasis effosa* n. sp.: Smith, Nautilus, 51: 91 (Belle Glade, Florida).
1953 *Goniobasis cat enaria effosa* M. Smith: Pilsbry, Mon. Acad. Nat. Sci. Phila. , 8: 445, pl. 65, fig. 3.

Druid Wilson (personal communication, 1964) considered that this form might possibly be from strata equivalent to "unit A". His own collections have not revealed it, and its precise stratigraphic range remains uncertain.

Family Physidae
Stenophysa von Martens, 1898

The group *Stenophysa*, of tropical America, has previously been ranked as a subgenus of *Aplexa* but is here treated as a separate genus. Shells of *Stenophysa* differ from those of *Aplexa hypnorum* (Linnaeus), the genotype, by having an aperture more than half the total shell length, and by a simple, acute apex. The parietal callus is often wider, in species with a mantle broadly reflected over the shell. *Aplexa hypnorum* has an aperture less than half of the total shell length, a narrow parietal callus correlated with an unreflected mantle, and a frequently bulbous, spirally sculptured apex. The bulbous apex is commonly but not uniformly obvious at low magnifications in the many series of North American specimens seen. It is due to the deviation of the axis of coiling of the protoconch from the axis of the mature shell, so that the first whorl may bulge over the second. This character has not been seen in any group of *Physa* or *Stenophysa*. It is probably a vestige of heterostrophy, a character of all marine Euthyneura and one that probably occurred in the ancestors of all freshwater Basommatophora.

This division of *Aplexa* into the two genera *Aplexa* and *Stenophysa* leaves the circumboreal genus *Aplexa* with only one species as generally classified, *A. hypnorum* (Linnaeus). The tropical genus *Stenophysa* ranges northward in North America to Mexico, with the outlying localized *Stenophysa microstriata* (Chamberlin and Berry, 1930) in southern Utah. *Aplexa* approaches the range of *Stenophysa* most nearly in Colorado and Utah.

As emphasized by Harry and Hubendick (1964), little anatomical information is available on Physidae. Possibly *Stenophysa* is composite, and will need to be subdivided later. The characters of the apex are similar in *Stenophysa* and *Physa (Physella)*, and both groups overlap in geographic distribution and shell form. They are likely to prove more closely related to each other than either is to *Physa (s.* s.) or to *Aplexa.*

Stenophysa meigsii (Dall), 1890
Plate 7, Fig. 2

1890 *Physa meigsii* n. s.: Dall, Trans. Wagner Free Inst. Sci. , 3(1): 22, pl. 10, fig. 12.

Dall explicitly compared *Stenophysa meigsii* with the large tropical species of Mexico and Guatemala, concluding "that they have little in common". Nevertheless the additional material now available indicates close similarities, and *S. meigsii* is interpreted as an extinct tropical element, significant both stratigraphically and ecologically.

Compared with living large species of

Stenophysa, *S. meigsii* shares the common features of large size; acute apex; a parietal callus more extensive than in *Physa (Physella)*; and sculpture that frequently includes low, axial white riblets spaced almost regularly with interspaces 3-5 times as wide. An especially significant character is the wide parietal callus that extends directly ventrad from the suture a short distance before turning anteriorly. This callus is thin and frequently broken away in fossil specimens. A lot of recent *Stenophysa nicaraguana* (Morelet) (USNM 510900, Pl. 7, Fig. 1) from a swamp near Moyogalpa, Ometepe Island, Nicaragua, collected by Bohumil Shimek in 1893 provides the closest approach to *S. meigsii* in USNM collections. *S. meigsii* differs by its usually more elongate and flatter-sided spire, with consequently more fusiform shape, and by the usually more pronounced sculpture. Most of the recent specimens are glossy, some without spiral sculpture, but the *S. meigsii* type of sculpture occurs.

Large species of *Stenophysa*, of the type of *S. aurantia* (Carpenter), *S. nicaraguana* (Morelet) and *S. princeps* (Philippi), are represented in USNM and UMMZ collections from Nicaragua and Guatemala north to Mazatlan on the west coast of Mexico and to Tampico on the east coast of Mexico. It is to this group of living species that *S. meigsii* belongs.

The holotype of *Stenophysa meigsii* (Dall), USNM 112561, is from USGS locality 2094, a collection from both sides of the Caloosahatchee River at Four Mile Hammock between Fort Thompson and Deneaud, W. H. Dall coll., 1887. The locality is in strata assigned to the Caloosahatchee Formation. The occurrence in "unit A" is the last known record of the species; it is represented in Florida in both the Caloosahatchee Formation and in Miocene deposits for which Olsson (in Olsson and Petit, 1964) suggested the name "Pincrest beds".

Family Planorbidae
Subfamily Helisomatinae
Planorbella Haldeman, 1842
Subgenus *Seminolina* Pilsbry, 1934

As established by Pilsbry this subgenus is endemic to Florida, and includes 2 species-groups: the group of *Planorbella scalaris* (Jay), including only that species; and the group of *Planorbella duryi* (Wetherby), including that species with several races as well as the extinct *P. conanti* (Dall, 1890) and *P. disstoni* (Dall, 1890). Undescribed USGS collections show that this latter species-group was in Florida as long ago as the late Miocene. Harry and Hubendick (1964) suggested that *P. fovealis* (Menke) and other Caribbean species that are nomenclatorially older may prove to be based upon artificial introductions of *P. duryi*.

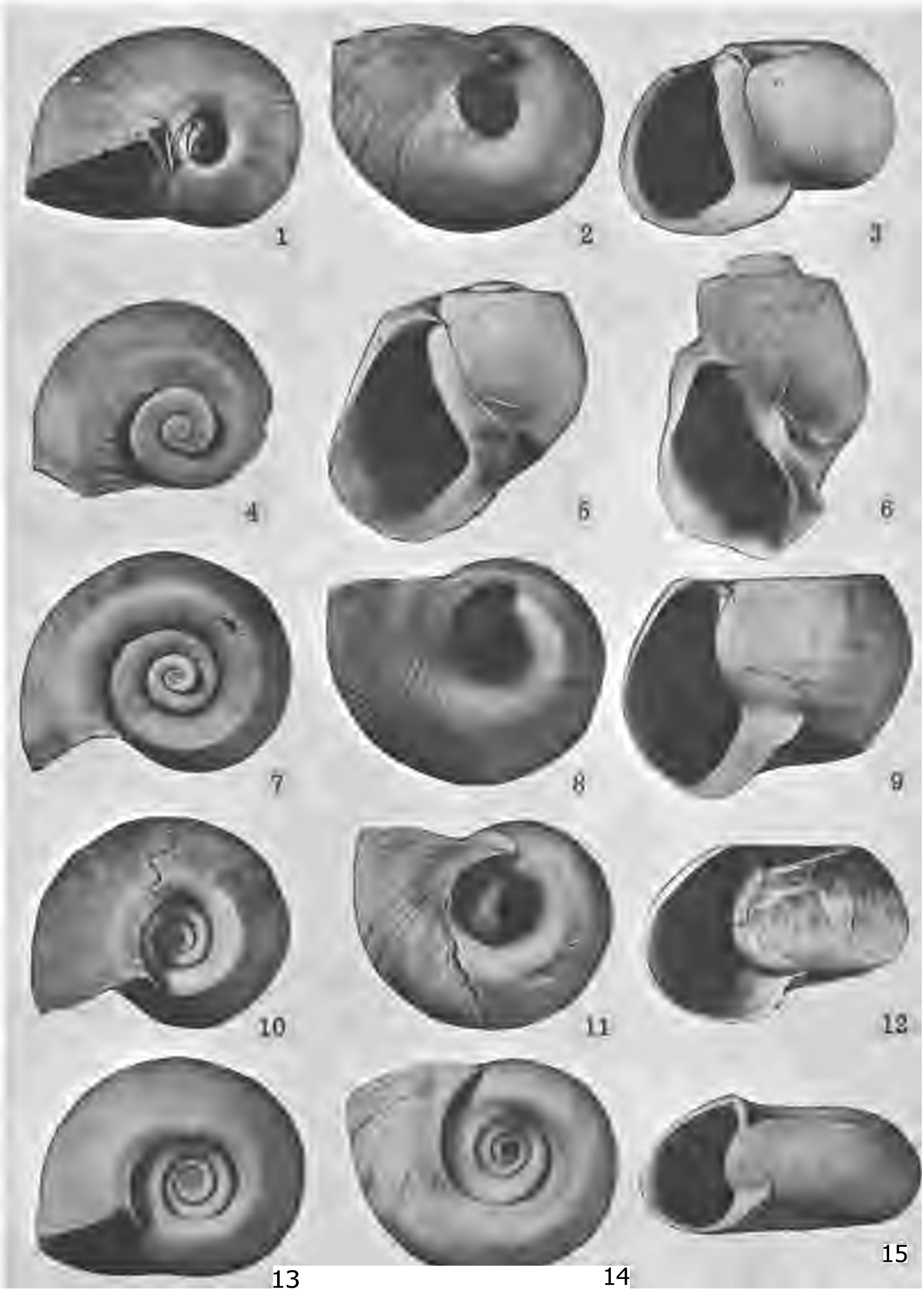
Planorbella (Seminolina) aff
P. disstoni (Dall)
Plate 8, Figs. 10-15

The most common planorbid in "unit A" is obviously related to *Planorbella disstoni* (Dall) of the Caloosahatchee Formation. Extensive series from both units show that the younger form is generally larger, and often proportionally wider in the axis of coiling. The sunken spire is like that of *P. disstoni*, and unlike that of living forms of the *P. duryi* group. Probably these collections represent a new species, descended from *P. disstoni*, belonging to an extinct lineage of *Seminolina*. Formal description would be unwise without more thorough study of the group than is practicable now.

Planorbella (Seminolina) wilsoni[3]
Taylor, n. sp.
Plate 8, Figs. 7-9

Diagnosis. A *Seminolina* of the *duryi*-group, distinguished by large size and

3 Named for Druid Wilson, U. S. Geological Survey, Washington, D. C.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relatively great axial width (about 25 x 25 mm), flat left side, funicular right side, and moderately rapidly enlarging whorls.

Type. USNM 644835. USGS Cenozoic locality 22704, "unit A", Belle Glade, Palm Beach County, Florida. Float from road metal pit on south side of state highway 80 west of town, collected by Druid Wilson, January, 1962, when the pit was being dug to a depth of 40 ft from the former depth of about 30 ft.

Discussion and comparisons. Only 3 specimens of this new species are known, but the abundant material of the associated species shows considerable variation without overlapping *P. wilsoni.* As shown by the illustrations (Pl. 8) of related species, *P. wilsoni* combines characters of otherwise distinct forms. In height of spire and shape of the left side it is intermediate between the higher-spired *P. duryi seminole* (Pl. 8, Figs. 5-6) and the lower-spired *P.* aff *P. disstoni* (Pl. 8, Figs. 12, 15) which has a concave left side. In rate of enlargement of whorls it is closer to *P. duryi seminole* (Pl. 8, Fig. 4) than to *P.* aff *P. disstoni* (Pl. 8, Figs. 10,13). In the funicular right side it is closer to the more loosely coiled specimens of *P.* aff *P. disstoni* (Pl. 8, Fig. 11) than to the narrowly phaneromphalous *P. duryi seminole* (Pl. 8. Figs. 5-6). The larger specimens of *P. wilsoni* have about twice the bulk of large *P. duryi seminole,* and are thus similar to *P.* aff *P. disstoni.*

Measurements. The type is the only well-preserved one of the 3 known specimens. In the following table, measurements that are estimated from broken specimens are in parentheses.

Locality	22704(Type)	22704	21861
No. whorls	5	4 3/4	5
Length	24.6	(25)	(31)
Width	19.1	(19)	27.8
Length aperture	14.4		
Width aperture	19.1	(19)	(24)

Subgenus *Pierosoma* Dall, 1905

The widespread American subgenus *Pierosoma* is represented in Florida today by *P. trivolvis intertexta* (Pilsbry, 1934a). No collections surely from the Caloosahatchee Formation or "unit A" contain it. As is the case with *Pomacea paludosa,* the Recent distribution in much of Florida of the *Planorbella trivolvis* group is geologically young, judging by the available fossil record.

Planorbella (Pierosoma) clewistonensis (Baker)
Plate 8, Figs. 1-3

1940 *Helisoma clewistonense* sp. nov.: Baker, Nautilus, 54: 17, pl. 1, fig. 8.

Baker described this species from

PLATE 8

FIGS. 1-3. *Planorbella (Pierosoma) clewistonensis* (F. C. Baker), X 3. Type, USNM 515222. Clewiston, Florida; "unit A"?

FIGS. 4-6. *Planorbella (Seminolina) duryi seminole* (Pilsbry), X 3. Figured specimens, USNM 644833 and 644834. USGS locality 21861, "unit A", Belle Glade, Palm Beach County, Florida.

FIGS. 7-9. *Planorbella (Seminolina) wilsoni* Taylor, n. sp. , X 2. Type, USNM 644835. USGS locality 22704, "unit A", Belle Glade, Palm Beach County, Florida.

FIGS. 10-15. *Planorbella (Seminolina)* aff *P. disstoni* (Dall). Figured specimens, USGS locality 21861, "unit A", Belle Glade, Palm Beach County, Florida. Figs. 10-12, USNM 644836, X 2. Figs. 13-15, USNM 644837, X 1.5.

the vague locality "Clewiston, Florida, in Pliocene strata". It has not been collected subsequently, but is discussed here since it may be of Blancan age.

The opinion of Baker that *P. clewistonensis* is close to *P. tenuis chapalensis* (Pilsbry) from Mexico is reaffirmed. A more recently described form is even more similar, however: *P. valens* (Leonard and Franzen, 1944) from the lower Pliocene Laverne Formation, Oklahoma. The significant similarities between *P. valens* (represented by large series in the UMMZ) and *P. clewistonensis* (known only by the type specimen) are in the relatively rapid enlargement of whorls, narrowly funicular right side, narrow, concave left side and oblique aperture. In both of these species the left side is plane for only the first whorl; during subsequent growth the axial height of the whorls increases rapidly so that the left side of the shell is narrowly, deeply concave. In *P. tenuis chapalensis* as represented in UMMZ and USNM collections the first 2-2 1/4 whorls are plane on the left side; that side of the shell is broadly and shallowly concave, and may have raised spiral lines absent in *P. clewistonensis*.

Family Bulimulidae
Bulimulus Leach, 1815
Subgenus *Rabdotus* Albers, 1850
Bulimulus (Rabdotus) dealbatus (Say)
Plate 7, Figs. 4-5

1946 *Bulimulus dealbatus* (Say): Pilsbry, Mon. Acad. nat. Sci. Phila. , 3(2): 7, fig. 4a-d.

This land snail now lives from Texas eastward to southern Illinois and Alabama. It is relatively conspicuous, so that the apparent absence from Florida is probably real. The fossils from "unit A" are larger than Recent specimens in USNM collections from east of the Mississippi River, but agree in size and shape with those from Oklahoma and Texas. One of the fossils retains the color pattern in the shell typical of *dealbatus.*

Family Helminthoglyptidae
Cepolis Montfort, 1810
Cepolis (s. s.) *caroli* McGinty

1940 *Cepolis caroli,* new species: McGinty, Nautilus, 53: 81, pl. 10, fig. 6, 6a.

Druid Wilson (personal communication, 1964) considered that this species might possibly be from strata equivalent to "unit A". It has not been collected since the original description. According to McGinty (*fide* Wilson)there were no other mollusks associated with the unique type of the species. The genus is otherwise known only from Hispaniola.

Mollusks described by Clench (1925) and Marshall (1926)

Nonmarine mollusks collected by M. D. Barber from spoil of canal excavations at West Palm Beach, Florida, were described as Pliocene or Pleistocene fossils by Clench (1925) and Marshall (1926). Druid Wilson suspected that these "fossils" were actually shells of the snails living in the canal at the time it was dredged, from the relatively fresh appearance of the specimens. This interpretation is also more consistent with the known fossils record in Florida. The species and their present classification are as follows:

Planorbella (Seminolina) duryi preglabrata (Marshall). Ranked as a valid form of *P. duryi* by Pilsbry (1934a).

Physa (Physella) barberi Clench

Oxyloma barberi (Marshall). This species was originally described in the lymnaeid group *Pseudosuccinea.* After examining the type lot, H. A. Rehder (personal communication, 1964) concurred that the name is a senior synonym of *Oxyloma sanibelensis* (Rehder, 1933). One of the localities cited by Pilsbry (1948: 793) for the latter is "in marl dredged from channel to Lake Worth, through Boynton, Palm Beach County," Florida. This geographically nearby site might also represent a similar occur-

TABLE 7. Occurrence by locality of mollusks in "unit A"

Localities	21861	22038	22039	22040	22704	22801	22803	22804	22805	22806	22810	22843	22844	22845	22846	22850	23135	23670	23675	23683
Rangia cuneata (Gray)					X															X
Viviparus georgianus (Lea)	X				X	X	X		X		X							X		
Pomacea paludosa (Say)	X				X	X			X					X		X				
P. flagellata innexa (Fischer and Crosse)		X		X													X			
Physa	X				X				X											
Stenophysa meigsii (Dall)																				X
Planorbella aff P. disstoni (Dall)	X	X	X	X			X	X	X		X		X	X	X	X	?	X		X
P. conanti (Dall)	X	X													X			X		
P. duryi seminole (Pilsbry)	X				X				X					X	X			X	X	
P. wilsoni Taylor, n. sp.	X				X															
Gyraulus parvus (Say)					X															
Laevapex					X															
Gastrocopta pentodon (Say)									X											
G. rupicola (Say)					X															
Vertigo									X											
Strobilops texasiana floridana Pilsbry									X											
cf *Succinea*					X															
Euglandina rosea (Férussac)	X				X	X	X		X	X			X					X		
Bulimulus dealbatus (Say)	X				X															
Polygyra					X	X			X	X				X		X				

rence. *Lymnaea aperta* Marshall (1926) is based upon a shorter-spired, broader specimen of this same *Oxyloma.* It is strikingly similar to the holotype of *O. sanibelensis* as figured by Rehder (1933) and republished by Pilsbry (1948).

Localities

Locality numbers in the following list are those of the USGS Cenozoic series.

21861. Palm Beach County, Florida. Float from road metal pit on south side of state highway 80 west of Belle Glade. Freshwater mollusk bed said by drag-line operator to be beneath "hardpan" at top of section. Druid Wilson, 1958.

22038. Martin County, Florida. Float from spoil banks on both sides of St. Lucie Canal in vicinity of Port Mayaca. Druid Wilson, 1938, 1940.

22039. Martin County, Florida. Float from spoil banks on south side of St. Lucie Canal at eastern boundary of Port Mayaca. Druid Wilson, 1938.

22040. Martin County, Florida. Float from spoil bank on south side of St. Lucie Canal, about 2.5 miles east of Port Mayaca on state highway 76 opposite cemetery. Druid Wilson, 1953.

22704. Same locality as 21861, but pit being deepened from former depth of about 30 ft to about 40 ft. Druid Wilson, 1962.

22801. St. Lucie County, Florida. Fort Pierce SW quadrangle (1953) 1: 24000. N 1/2 sec. 24, T36 S, R 38 E. Float from spoil bank on south side of canal C-24 (Rim Ditch), about 6.2 miles down canal from state highway 70. Druid Wilson, 1962.

22803. St. Lucie County, Florida. About 7.6-7.8 miles down canal C-24 (Rim Ditch) from state highway 70. Druid Wilson, 1962.

22804. St. Lucie County, Florida. Fort Pierce SW quadrangle (1953) 1: 24000. NE 1/4 sec. 19, T 36 S, R 39 E. Northeast side of canal C-24 (Rim Ditch) about 1.3 miles northwest of Florida East Coast Railroad. Druid Wilson, 1962.

22805. St. Lucie County, Florida. Fort Pierce SW quadrangle (1953) 1: 24000. NE 1/4 sec. 29, T 36 S, R 39 E. Southwest side of canal C-24 (Rim Ditch) about 0.1 mile northwest of Florida East Coast Railroad. Druid Wilson, 1962.

22806. St. Lucie County, Florida. Fort Pierce SW quadrangle (1953) 1: 24000. Northeast side of canal C-24 (Rim Ditch) just southeast of Florida East Coast Railroad. Druid Wilson, 1962.

22810. St. Lucie County, Florida. Okeechobee 1 NE quadrangle (1953) 1: 24000. E 1/2 sec. 5, T 36 S, R 38 E. West side of canal C-24 (Rim Ditch) about 0.7-0.8 mile north of state highway 70. Druid Wilson, 1962.

22843. St. Lucie County, Florida. Okeechobee 4 NE quadrangle (1953) 1: 24000. Sec. 36, T 37 S, R 37 E. Float from spoil bank on west side of canal C-23 about 0.5 mile north of Florida East Coast Railroad. Druid Wilson, 1962.

22844. St. Lucie County, Florida. Canal C-23 about 0.7 mile north of Florida East Coast Railroad. Druid Wilson, 1962.

22845. St. Lucie County, Florida. Canal C-23 about 1.8 miles north of Florida East Coast Railroad at secondary side canal. Druid Wilson, 1962.

22846. St. Lucie County, Florida. Canal C-23 about 2.4 miles north of Florida East Coast Railroad. Druid Wilson, 1962.

22850. St. Lucie County, Florida. Canal C-23 about 6.1 miles north of Florida East Coast Railroad just south of fence apparently on line between T 36 S and T 37 S. Druid Wilson, 1962.

23135. Palm Beach County, Florida. Float from spoil bank on west side of Miami Canal about 9.2-9.3 miles north of Pump No. 8 at Palm Beach-Broward County line. Druid Wilson, 1962.

23670. Hendry County, Florida. Sears quadrangle (1958) 1: 24000. SE 1/4 NW 1/4 sec. 18, T 43 S, R 29 E. Float from road-metal pits about 100 yards south of state highway 80. The float consists primarily of marine shells but a bed of Planorbidae is visible locally at water-level. Druid Wilson, 1964, 1965.

23675. Glades County, Florida. Ortona Lock. South bank of Caloosahatchee Canal about 0.2 mile west of Atlantic Coast Line Railroad bridge in vicinity of turn in canal; thin marl bed with abundant Planorbidae. Druid Wilson, 1964.

23698. Glades County, Florida. Ortona Lock. North bank of Caloosahatchee Canal west of Atlantic Coast Line Railroad bridge some distance east of west end of "cutoff" of old partially filled river channel; locally unindurated freshwater limestone. Druid Wilson, 1964.

MOLLUSKS DESCRIBED FROM BLANCAN TYPES

The following catalogue includes all nominal species whose types come from localities shown on Fig. 1 and summarized in the preceding text. Geographic and stratigraphic locality data have been revised as far as possible. Quotation marks around a generic name indicated that the species is known or suspected not to belong to that genus. The classification is mainly that by Modell (1964), Taylor and Sohl (1962), Wenz (1938-1944) and Zilch (1959-1960).

Data given for the type and type locality of each nominal species are as follows:

Reference to original description
15-minute quadrangle, according to the system of designation shown in Fig. 12.
County and state
Geographic locality
Formation and/or faunal horizon, and reference to map(Fig. 1)
Location of type
Synonymy

Types in CAS, SU, UMMZ USNM and University of Utah collections have been examined personally. Others are cited from the original publications, or the catalogues by H. B. Baker (1964) and Leonard (1957).

PELECYPODA
MARGARITIFERIDAE
Pseudodontinae
Gonidea

Gonidea coalingensis Arnold (1910). NI 10-3 [San Luis Obispo] D-1. Kings County, California. USGS locality 4739, SE 1/4 sec. 10, T 23 S, R 17 E. Basal part of Tulare Formation, Kreyenhagen Hills (Fig. 1, locality 17). Type USNM 165521.

Gonidea coalingensis var. *cooperi* Arnold (1910). Arnold stated this variety was associated with the typical form at some localities, but designated no type or type locality. =*G. coalingensis* Arnold.

Margaritana subangulata Cooper (1894a). About NJ 10-12 [Santa Cruz] A-1. Fresno or Kings County, California. Basal part of Tulare Formation, Kettleman Hills, probably North Dome (Fig. 1, locality 18). Type formerly in CAS, now destroyed. Preoccupied in *Gonidea* by *Anodonta angulata* var. *subangulata* Hemphill (1891). =*G. coalingensis* Arnold.

UNIONIDAE
Anodontinae
Anodonta

Anodonta kettlemanensis Arnold (1910). NJ 10-12 [Santa Cruz] A-1. Kings County, California. USGS locality 4731, NW 1/4 NE 1/4 sec. 35, T 21 S, R. 17 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type USNM 165522.

SPHAERIIDAE
Sphaeriinae
Sphaerium

Sphaerium cooperi Arnold (1910). NJ 10-12 [Santa Cruz] A-1. Fresno County, California. USGS locality 4732, SW 1/4 NE 1/4 sec. 30, T 21 S, R 17 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type USNM 165528. =*S. striatinum* (Lamarck).

Sphaerium cynodon Hanna (1923). NJ 10-5 [Santa Rosa] B-3. Sonoma County, California. CAS locality 417, Willow Brook 1 mile southeast of Penngrove, sec. 9, T 5 N, R 7 W, unsurveyed. Petaluma Formation (Fig. 1, locality 10). Type CAS 514.

Sphaerium idahoense Meek (1870). About NK 11-5 [Jordan Valley] D-2. Owyhee County, Idaho. Castle Creek. Basal part of Glenns Ferry Formation (Fig. 1, locality 34). Type USNM 12520.

Sphaerium kettlemanense Arnold (1910). NJ 10-12 [Santa Cruz] A-1. Kings County, California. USGS locality 4731, NW 1/4 NE 1/4 sec. 35, T 21 S, R 17 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type USNM 165519.

Sphaerium meeki Dall (1924b). About NK 11-5 [Jordan Valley] D-2. Owyhee County, Idaho. Castle Creek. Basal part of Glenns Ferry Formation (Fig. 1, locality 34). Type USNM 333521. =*S. idahoense* Meek.

Cytherea parvula Hall (1845). NK 11-6 [Twin Falls] D-5. Elmore County, Idaho. NW 1/4 sec. 28, T 6 S, R 11 E. Glenns Ferry Formation (Fig. 1, locality 34). Type lost. Species unrecognizable.

Pisidiinae
Pisidium (Rivulina) (note 1, p 127)

Pisidium curvatum Hanna (1923). NJ 10-5 [Santa Rosa] B-3. Sonoma County, California. CAS locality 417, Willow Brook 1 mile southeast of Penngrove, sec. 9, T 5 N, R 7 W, unsurveyed. Petaluma Formation (Fig. 1, locality 10). Type CAS 515. Preoccupied by *Pisidium compres sum curvatum* Sterki (1916). =*Pisidium compressum* Prime.

Pisidium exiguum Yen (1944). NK 11-6 [Twin Falls] D-6. Elmore or Owyhee County, Idaho. Near Hammett. Glenns Ferry Formation (Fig. 1, locality 34). Type CAS 8275. Preoccupied by

Pisidium abortivum exiguum Sterki (1916). =*Pisidium woodringi* Yen (1945).

Pisidium compressum praecompressum Pilsbry (1935). NJ 10-12 [Santa Cruz] A-1. Fresno County, California. 2000 ft west, 600 ft south, sec. 30, T 21 S, R 17 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type ANSP 12942. =*P. supinum* Schmidt.

Pisidium woodringi Yen (1945). New name for *P. exiguum* Yen (1944), not Sterki (1916).

MACTRIDAE

Rangia

Rangia lecontei (Conrad, 1853). NI 11-9 [Salton Sea] A-7 or A-8. Imperial County, California. Brawley Formation, in northwestern part of T 13 S, R 12 E, or northern edge of Superstition Hills, T 13 S, R 11 E (Fig. 1, locality 26). Type in ANSP?; not in USNM.

GASTROPODA

PROSOBRANCHIA

PAYETTIIDAE (note 2, p 127)

Payettia

Payettia dallii (C. A. White, 1882). NK 11-6 [Twin Falls] D-6. Owyhee County, Idaho. S 1/2 sec. 1, T 6 S, R 8 E. Glenns Ferry Formation (Fig. 1, locality 34). Type USNM 11547.

"Payettia" micra Yen (1947). NK 12-7 [Brigham City] D-1. Box Elder County, Utah. USGS locality 20093, SE 1/4 sec. 16, T 13 N, R 2 W. Cache Valley Formation (Fig. 1, locality 37). Type USNM 560002.

VALVATIDAE

Valvata

Valvata calli Hannibal (1910). NK 10-6 [Klamath Falls] D-3 or D-4. Lake County, Oregon. Summer Lake basin (Fig. 1, locality 4). Type SU 472.

Valvata humeralis densestriata Pilsbry (1934b). NJ 10-12 [Santa Cruz] B-1. Fresno County, California. Boston Land Company well "C", sec. 27, T 19 S, R 18 E, depth 772-792 ft. Upper part of Tulare Formation, within or immediately above Corcoran Clay Member (Fig. 1, locality 16). Type ANSP 12955a.

Valvata incerta Yen (1947). NK 12-7 [Brigham City] D-1. Box Elder County, Utah. USGS locality 20093, SE 1/4 sec. 16, T 13 N, R 2 W. Cache Valley Formation (Fig. 1, locality 37). Type USNM 559994.

Valvata oregonensis Hanna (1922). NK 11-4 [Adel] C-7 or C-8. Lake County, Oregon. Warner Lake basin (Fig. 1, locality 6). Type University of Oregon 19. =*V. whitei* Hannibal.

Valvata virens platyceps Pilsbry (1935). NI 11-1 [Bakersfield] D-8. Kings County, California. USGS locality 12843, 1700 ft north, 410 ft west, sec. 28, T 23 S, R 19 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type USNM 495197.

Valvata whitei Hannibal (1910). NK 10-6 [Klamath Falls] D-3 or D-4. Lake County, Oregon. Summer Lake. basin (Fig. 1, locality 4). Type SU 473.

Aphanotylus

"Aphanotylus" whitei Dall (1924b). About NK 11-5 [Jordan Valley] D-2. Owyhee County, Idaho. Castle Creek. Basal part of Glenns Ferry Formation (Fig. 1, locality 34). Type USNM 333528.

ORYGOC ERATIDAE

Orygoceras

Orygoceras arcuatum Dall (1924b). About NK 11-5 [Jordan Valley] D-2. Owyhee County, Idaho. Castle Creek. Basal part of Glenns Ferry Formation (Fig. 1, locality 34). Type not found in USNM.

Orygoceras crenulatum Dall (1924b). About NK 11-5 [Jordan Valley] D-2. Owyhee County, Idaho. Castle Creek. Basal part of Glenns Ferry Formation (Fig. 1, locality 34). Type not found in USNM.

Orygoceras idahoense Dall (1924b). About NK 11-5 [Jordan Valley] D-2. Owyhee County, Idaho. Castle Creek. Basal part of Glenns Ferry Formation (Fig. 1, locality 34). Type not found in USNM.

Orygoceras tricarinatum Yen (1944). NK 11-6 [Twin Falls] D-6. Elmore or Owhyee County, Idaho. Near Hammett. Glenns Ferry Formation (Fig. 1, locality 34). Type CAS 8265. =*O. arcuatum* Dall (1924b).

Orygoceras tuba Dall (1924b). About NK 11-5 [Jordan Valley] D-2. Owyhee County, Idaho. Castle Creek. Basal part of Glenns Ferry Formation (Fig. 1, locality 34). Type not found in USNM.

PLIOPHOLYGIDAE (note 3, p 128)
Pliopholyx

Pliopholyx campbelli (Dall, 1924b). NK 11-6 [Twin Falls] D-5. Elmore County, Idaho. USGS locality 3486, 50-100 ft south, 1350-1700 ft east, sec. 14, T 5 S, R 10 E. Glenns Ferry Formation (Fig. 1, locality 34). Type USNM 333527.

Pliopholyx idahoensis Yen (1944). NK 11-6 [Twin Falls] D-6. Elmore or Owyhee County, Idaho. Near Hammett. Glenns Ferry Formation (Fig. 1, locality 34). Type CAS 8271.

Pliopholyx reesidei Yen (1947). NK 12-7 [Brigham City] D-1. Box Elder County, Utah. USGS locality 20093, SE 1/4 sec. 16, T 13 N, R 2 W. Cache Valley Formation (Fig. 1, locality 37). Type USNM 560008.

DELAVAYIDAE (note 4, p 128)
Anculopsis

Anculopsis bicarinata Yen (1947). NK 12-7 [Brigham City] D-1. Box Elder County, Utah. USGS locality 20093, SE 1/4 sec. 16, T 13 N, R 2 W. Cache Valley Formation (Fig. 1, locality 37). Type USNM 560000.

Anculopsis houghterlingi Yen (1947). NK 12-7 [Brigham City] D-1. Box Elder County, Utah. USGS locality 20093, SE 1/4 sec. 16, T 13 N, R 2 W. Cache Valley Formation (Fig. 1, locality 37). Type USNM 560001.

Anculopsis utahensis (Yen, 1947). NK 12-7 [Brigham City] D-1. Box Elder County, Utah. USGS locality 20093, SE 1/4 sec. 16, T 13 N, R 2 W. Cache Valley Formation (Fig. 1, locality 37). Type USNM 559999.

PLEUROCERIDAE
Elimia

Elimia catenaria effosa (M. Smith, 1938). NG 17-5 [West Palm Beach] C-3. Palm Beach County, Florida. Belle Glade. "Unit A"? (Fig. 1, locality 57). Location of type unknown.

Juga

Juga arnoldiana (Pilsbry, 1934b). NJ 10-12 [Santa Cruz] A-1. Fresno County, California. 2000 ft west, 600 ft south, sec. 30, T 21 S, R 17 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type ANSP 12949a.

Juga chrysopylica Taylor, new name. NJ 10-5 [Santa Rosa] B-3. Sonoma County, California. CAS locality 417, Willow Brook 1 mile southeast of Penngrove, sec. 9, T 5 N, R7 W, unsurveyed. Petaluma Formation (Fig. 1, locality 10). Type CAS 513. New name for *Goniobasis rodeoensis* (Clark) in the sense of Hanna (1923); Clark's type being referred to the Potamididae.

Juga kettlemanensis (Arnold, 1910). NI 11-1 [Bakersfield] D-8. Kern County, California. USGS locality 4715, sec. 10, T 25 S, R 19 E. Upper part of San Joaquin Formation, Kettleman Hills (Fig. 1, locality 18). Type USNM 165501.

Juga kettlemanensis woodringi (Pilsbry, 1934b). NI 11-1 [Bakersfield] D-8. Kings County, California. USGS locality 12683, 1980 ft south, 1960 ft east, sec. 17, T 23 S, R 19 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type USNM 4 95244.

"*Melania*" (note 5, p 130)

"*Melania*" *taylori* Gabb (1866). NK 11-2 [Boise] B-3. Canyon or Owyhee County, Idaho. Near Walters Ferry, N 1/2 sec. 17, T 1 S, R 2 W. Glenns Ferry Formation (Fig. 1, locality 34). Type lost?

"*Melania*" *taylori* var. *calkinsi* (Dall, 1924b). NK 11-6 [Twin Falls] D-6. Elmore County, Idaho. One mile west of Slick Bridge, SE 1/4 sec. 26, T 5 S, R 9 E. Glenns Ferry Formation (Fig. 1, locality 34). ="M." *taylori* (Gabb). Type USNM 333526.

Melania decursa Conrad (1871). About NK 11-5 [Jordan Valley] D-2. Owyhee County, Idaho. Probably Castle Creek. Basal part of Glenns Ferry Formation (Fig. 1, locality 34). Type lost?; not in USNM. =*"Melania" taylori* (Gabb, 1866).

Turritella bilineata Hall (1845). NK 11-6 [Twin Falls] D-5. Elmore County, Idaho. NW 1/4 sec. 28, T 6 S, R 11 E. Glenns Ferry Formation (Fig. 1, locality 34). Type lost. Preoccupied by *Turritella bilineata* von Dechen, in De La Beche (1832). =*"Melania" taylori* Gabb (1866).

HYDROBIIDAE

Hydrobiinae

"Amnicola"

"Amnicola" bithynoides Yen (1944). NK 11-6 [Twin Falls] D-6. Elmore or Owyhee County, Idaho. Near Hammett. Glenns Ferry Formation (Fig. 1, locality 34). Type CAS 8253.

Calipyrgula

Calipyrgula carinifera Pilsbry (1934b). NJ 10-12 [Santa Cruz] A-1. Kings County, California. USGS locality 12479, 370 ft south, 2080 ft west, sec. 35, T 21 S, R 17 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 17). Type USNM 495214.

Calipyrgula ellipsostoma Pilsbry (1934b). About NJ 10-12 [Santa Cruz] A-1. Fresno or Kings County, California. Geographic locality unknown. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type ANSP 12946a.

Calipyrgula stewartiana Pilsbry (1935). NI 11-1 [Bakersfield] D-8. Kings County, California. USGS locality 13254, 1690 ft south, 1870 ft east, sec. 17, T 23 S, R 19 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type USNM 495218.

"Hydrobia"

"Hydrobia" anclersoni (Arnold, 1910). NJ 10-12 [Santa Cruz] A-1. Fresno County, California. USGS locality 4732, SW 1/4 NE 1/4 sec. 30, T 21 S, R 17 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type USNM 165505.

"Hydrobia" birkhauseri Pilsbry (1935). NJ 10-12 [Santa Cruz] A-1. Kings County, California. 2500 ft east, 1000 ft south, sec. 6, T 22 S, R 18 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type ANSP 12920a.

Paludestrina curta Arnold (1903). NI 11-7 [Long Beach] C-2. Los Angeles County, California. Bluffs along waterfront (now destroyed), central San Pedro. San Pedro Sand (Fig. 1, locality 24). Type USNM 162542. =*"Hydrobia" imitator* (Pilsbry, 1899).

Amnicola hannai Pilsbry (1934b). NJ 10-12 [Santa Cruz] A-1. Kings County, California. 2500 ft east, 1000 ft south, sec. 6, T 22 S, R 18 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type ANSP 12922a. =*"Hydrobia" andersoni* (Arnold, 1910) according to Pilsbry (1935).

"Hydrobia" margaretana Hanna and Gester (1963). NK 10-9 [Alturas] D-8. Siskiyou County, California. CAS locality 34807, SW 1/4 sec. 4, T 47 N, R 1 E. Butte Valley (Fig. 1, locality 2). Type CAS 12472.

"Hydrobia" andersoni var. *sterea* Pilsbry (1935). NJ 10-12 [Santa Cruz] A-1. Kings County, California. 2500 ft east, 1000 ft south, sec. 6, T 22 S, R 18 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type ANSP 12929a.

Mars tonia

Marstonia crybetes (Leonard, 1952). NJ 14-7 [Dodge City] A-3. Seward County, Kansas. Near center of west line sec. 36, T 34 S, R 31 W. Saw Rock Canyon local fauna, Rexroad Formation (Fig. 1, locality 50). Type University of Kansas Museum of Natural History 3805.

Nematurella

Nematurella euzona Hanna (1923). NJ

10-5 [Santa Rosa] B-3. Sonoma County, California. CAS locality 415, sec. 14, T 5 N, R 7 W, unsurveyed. Petaluma Formation (Fig. 1, locality 10). Type CAS 511.

Pyrgulopsis

Pyrgulopsis? polynematica Pilsbry (1934b). NI 11-1 [Bakersfield] B-6. Kern County, California. Milham Exploration Co. well Wisnome no. 1, sec. 27, T 28 S, R 23 E, depth 2649-2660 ft. Basal part of Tulare Formation, Buttonwillow gas field (Fig. 1, locality 21). Type ANSP 12936a.

Pyrgulopsis tropidogyra Pilsbry (1935). NJ 10-9 [San Jose] A-8. Santa Clara County, California. Near Los Gatos. Santa Clara Formation (Fig. 1, locality 11). Type ANSP 76162.

Pyrgulopsis vincta Pilsbry (1934b). NJ 10-12 [Santa Cruz] A-1. Fresno County, California. 2000 ft west, 600 ft south, sec. 30, T 21 S, R 17 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type ANSP 12935a.

"*Pyrgulopsis*" *carinata* Yen (1944). NK 11-6 [Twin Falls] D-6. Elmore or Owyhee County, Idaho. Near Hammett. Glenns Ferry Formation (Fig. 1, locality 34). Type CAS 8252.

Savaginius (note 6, p 130)

Savaginius nannus (Chamberlin and Berry, 1933). NK 12-7 [Brigham City] D-1. Box Elder County, Utah. USGS locality 20094. SE 1/4 sec. 19, T 12 N, R 2 W. Cache Valley Formation (Fig. 1, locality 37). Type not found; paratypes in University of Utah.

Savaginius percarinatus (Pilsbry, 1934b). NI 11-1 [Bakersfield] C-7. Kern County, California. Universal Consolidated well 44, sec. 32, T 26 S, R 21 E, depth 445-520 ft. Upper part of San Joaquin Formation, Lost Hills oil field (Fig. 1, locality 20). Type ANSP 12969a.

Savaginius perditicollis (Pilsbry, 1934b). NI 11-1 [Bakersfield] C-7. Kern County, California. Universal Consolidated well 44, sec. 32, T 26 S, R 21 E, depth 455-650 ft. Upper part of San Joaquin Formation, Lost Hills oil field (Fig. 1, locality 20). Type ANSP 12968a.

Savaginius pilula (Pilsbry, 1934b). NI 11-1 [Bakersfield] C-7. Kern County, California. Universal Consolidated well 44, sec. 32, T 26 S, R 21 E, depth 435-445 ft. Upper part of San Joaquin Formation, Lost Hills oil field (Fig. 1, locality 20). Type ANSP 12976a.

Savaginius puteanus (Pilsbry, 1935). NI 11-1 [Bakersfield] C-7. Kern County, California. Kern no. 2 well, sec. 8, T 28 S, R 23 E, depth 2410-2428 ft. Basal part of Tulare Formation, Buttonwillow gas field (Fig. 1, locality 21). Type ANSP 12930a.

Savaginius siegfusi (Pilsbry, 1934b). NI 11-1 [Bakersfield] C-7. Kern County, California. Universal Consolidated well 44, sec. 32, T 26 S, R 21 E, depth 365-720 ft. Upper part of San Joaquin Formation, Lost Hills oil field (Fig. 1, locality 20). Type ANSP 12977a.

Savaginius spiralis (Pilsbry, 1934b). NJ 10-12 [Santa Cruz] B-1. Fresno County, California. Boston Land Company well "C", sec. 27, T 19 S, R 18 E, depth 772-792 ft. Upper part of Tulare Formation, within or immediately above Corcoran Clay Member (Fig. 1, locality 16). Type ANSP 12972.

Fluminicola yatesiana utahensis Yen (1947). NK 12-7 [Brigham City] D-1. Box Elder County, Utah. USGS locality 20093, SE 1/4 sec. 16, T 13 N, R 2 W. Cache Valley Formation (Fig. 1, locality 37). Type USNM 559996. =*Savaginius nannus* (Chamberlin and Berry, 1933).

Savaginius williamsi (Hannibal, 1912b). NI 11-1 [Bakersfield] C-7. Kern County, California. Martin and Dudley's well, SE 1/4 sec. 32, T 26 S, R 21 E. Upper part of San Joaquin Formation, Lost Hills oil field (Fig. 1, locality 20). Type SU 461.

Savaginius yatesianus (Cooper, 1894b). NJ 10-9 [San Jose] C-8. Alameda County, California. Ridge of gravel and alluvium at Mission San Jose, probably in secs. 1, 2, 11, 12, T 5 S, R 1 W. Irvington local fauna, Santa Clara Formation (Fig. 1, locality 11). Type lost.

Zetekina (note 7, p 130)

Zetekina woodringi (Pilsbry, 1934b).

NI 11-1 [Bakersfield] D-8. Kings County, California. USGS locality 12843, 1700 ft north, 410 ft west, sec. 28, T 23 S, R 19 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type USNM 495221.

Lithoglyphinae
Lithoglyphus (note 8, p 131)

Lithasia antiqua Gabb (1866). NK 11-2 [Boise] B-3. Canyon or Owyhee County, Idaho. Near Walters Ferry, N 1/2 sec. 17, T 1 S, R 2 W. Glenns Ferry Formation (Fig. 1, locality 34). Type lost. =*Lithoglyphus occidentalis* (Hall, 1845).

Lithoglyphus kettlemanensis (Pilsbry, 1934b). NI 11-1 [Bakersfield] D-8. Kings County, California. Near center of sec. 26, T 22 S, R 18 E. Lower part of San Joaquin Formation, immediately below *Pecten* zone, Kettleman Hills (Fig. 1, locality 18). Type ANSP 12979.

Lithoglyphus occidentalis (Hall, 1845). NK 11-6 [Twin Falls] D-5. Elmore County, Idaho. NW 1/4 sec. 28, T 6 S, R 11 E. Glenns Ferry Formation (Fig. 1, locality 34). Type lost.

Lithoglyphus sanmateoensis (Glen, 1960). NJ 10-8 [San Francisco] C-2. San Mateo County, California. CAS locality 36724, T 5 S, R 5 W, 300 yards north 45° west of entrance on Skyline Boulevard to Skyline Materials Plant No. 1. Santa Clara Formation (Fig. 1, locality 11). Type CAS 10449.

Lithoglyphus superbus (Yen, 1944). NK 11-6 [Twin Falls] D-6. Elmore or Owyhee County, Idaho. Near Hammett. Glenns Ferry Formation (Fig. 1, locality 34). Type CAS 8259.

Lithoglyphus utahensis (Yen, 1947). NK 12-7 [Brigham City] D-1. Box Elder County, Utah. *USGS* locality 20093, SE 1/4 sec. 16, T 13 N, R 2 W. Cache Valley Formation (Fig. 1, locality 37). Type USNM 559997.

Lithoglyphus weaveri (Yen, 1944). NK 11-6 [Twin Falls] D-6. Elmore or Owyhee County, Idaho. Near Hammett. Glenns Ferry Formation (Fig. 1, locality 34). Type CAS 8255.

Littoridininae
Tryonia

Alabina io Bartsch (1911). NI 11-7 [Long Beach] C-2. Los Angeles County, California. San Pedro; horizon uncertain. Type USNM 148669. =*Tryonia stokesi* (Arnold).

Tryonia stokesi (Arnold, 1903). NI 11-7 [Long Beach] C-2. Los Angeles County, California. Bluffs along waterfront (now destroyed), central San Pedro. San Pedro Sand (Fig. 1, locality 24). Type USNM 162541.

EUTHYNEURA
ELLOBIIDAE
Carychium

Carychium perexiguum F. C. Baker (1938). NJ 14-7 [Dodge City] A-2. Meade County, Kansas. 900 ft east, 1300 ft north, sec. 22, T 33 S, R 29 W. Rexroad local fauna, Rexroad Formation (Fig. 1, locality 51). Type Illinois State Geological Survey P6776. =*C. exiguum* (Say) according to Taylor (1960b).

LANCIDAE
Lanx

Lanx kirbyi Hanna and Gester (1963). NK 10-9 [Alturas] D-8. Siskiyou County, California. CAS locality 34807, SW 1/4 sec. 4, T 47 N, R 1 E. Butte Valley (Fig. 1, locality 2). Type CAS 12453.

Lanx moribundus Hanna (1922). NK 11-4 [Adel] C-7 or C-8. Lake County, Oregon. Warner Lake basin (Fig. 1, locality 6). Type University of Oregon 18.

LYMNAEIDAE
Bakerilymnaea (note 9, p 131)

Lymnaea diminuta Leonard (1952). NJ 14-7 [Dodge City] A-2. Meade County, Kansas. 900 ft east, 1300 ft north, sec. 22, T 33 S, R 29 W. Rexroad local fauna, Rexroad Formation (Fig. 1, locality 51). Type University of Kansas Museum of Natural History 8801. =*Bakerilymnaea bulimoides techella* (Haldeman) according to Taylor (1960b).

Bulimnea

Bulimnea petaluma (Hanna, 1923). NJ 10-5 [Santa Rosa] B-3. Sonoma County, California. CAS locality 417, Willow Brook 1 mile southeast of Penngrove, sec. 9, T 5 N, R 7 W, unsurveyed. Petaluma Formation (Fig. 1, locality 10). Type CAS 516.

Fossaria

Lymnaea turritella Leonard (1952). NJ 14-7 [Dodge City] A-3. Seward County, Kansas. Near center of west line sec. 36, T 34 S, R 31 W. Saw Rock Canyon local fauna, Rexroad Formation (Fig. 1, locality 50). Type University of Kansas Museum of Natural History 3807. =*Fossaria dalli* (Baker) according to Taylor (1960b).

Lymnaea (Stagnicola)

Lymnaea alamosensis Arnold (1907). NI 10-6 [Santa Maria] C-2. Santa Barbara County, California. Progressive grid coordinates about 459500 ft north, 1299200 ft east. Paso Robles Formation (Fig. 1, locality 19). Type USNM 165426. Species inquirenda, *Lymnaea "palustris"* group.

Lymnaea albiconica Taylor (1957). NI 12-2 [Flagstaff] C-1. Navajo County, Arizona. Sec. 12, T 25 N, R 21 E. White Cone local fauna, Bidahochi Formation (Fig. 1, locality 47). Type USNM 562081.

Lymnaea filocosta Hanna (1923). NJ 10-5 [Santa Rosa] B-3. Sonoma County, California. CAS locality 417, Willow Brook 1 mile southeast of Penngrove, sec. 9, T 5 N, R 7W, unsurveyed. Petaluma Formation (Fig. 1, locality 10). Type CAS 518.

Lymnaea kerri Hanna (1923). NJ 10-5 [Santa Rosa] B-3. Sonoma County, California. CAS locality 417, Willow Brook 1 mile southeast of Penngrove, sec. 9, T 5 N, R 7W, unsurveyed. Petaluma Formation (Fig. 1, locality 10). Type CAS 519. =*L. limatula* Hanna.

Lymnaea kingii Meek (1877). NK 12-7 [Brigham City] C-1. Cache County, Utah. About sec. 1, T 11 N, R 2 W. Cache Valley Formation (Fig. 1, locality 37). Type USNM 8097.

Lymnaea limatula Hanna (1923). NJ 10-5 [Santa Rosa] B-3. Sonoma County, California. CAS locality 417, Willow Brook 1 mile southeast of Penngrove, sec. 9, T 5 N, R 7W, unsurveyed. Petaluma Formation (Fig. 1, locality 10). Type CAS 520. Species inquirenda, *Lymnaea "palustris"* group.

Lymnaea macella Leonard (1952). NJ 14-7 [Dodge City] A-2. Meade County, Kansas. 900 ft east, 1300 ft north, sec. 22, T 33 S, R 29 W. Rexroad local fauna, Rexroad Formation (Fig. 1, locality 51). Type University of Kansas Museum Of Natural History 8804. =*Lymnaea exilis* Lea according to Taylor (1960b).

Lymnaea parexilis Leonard (1952). NJ 14-7 [Dodge City] A-2. Meade County, Kansas. 900 ft east, 1300 ft north, sec. 22, T 33 S, R 29 W. Rexroad local fauna, Rexroad Formation (Fig. 1, locality 51). Type University of Kansas Museum of Natural History 8805. =*Lymnaea exilis* Lea according to Taylor (1960b).

Pseudosuc cinea

Pseudosuccinea dineana (Taylor, 1957). NI 12-2 [Flagstaff] C-1. Navajo County, Arizona. Sec. 12, T 25 N, R 21 E. White Cone local fauna, Bidahochi Formation (Fig. 1, locality 47). Type USNM 562084.

PLANORBIDAE

Planorbinae

Brannerillus (note 10, p 131)

Brannerillus involutus Pilsbry (1934b). NJ 10-12 [Santa Cruz] A-1. Fresno County, California. SW 1/4 NE 1/4 sec. 30, T 21 S, R 17 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type ANSP 12958a. =*B. physispiraHannibal* (1912b)?

Brannerillus physispira Hannibal (1912b). About NJ 10-12 [Santa Cruz] A-1. Fresno or Kings County, California. Mouth of gulch south of Medallion One Canyon (locality not found). Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type SU 460.

Brannerillus involutus praeposterus Pilsbry (1935). NJ 10-12 [Santa Cruz] A-1. Kings County, California. 2500 ft east, 1000 ft south, sec. 6, T 22 S, R 18 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type ANSP 12961a. =*B. physispira* Hannibal (1912)?

Brannerillus involutus thremma Pilsbry (1935). NJ 10-12 [Santa Cruz] A-1. Kings County, California. 2500 ft east, 1000 ft south, sec. 6, T 22 S, R 18 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type ANSP 12964. =*B. physispira* Hannibal (1912b)?

Gyraulus (Gyraulus)

Gyraulus pleiopleurus (Hanna, 1923). NJ 10-5 [Santa Rosa] B-3. Sonoma County, California. CAS locality 417, Willow Brook 1 mile southeast of Penngrove, sec. 9, T 5 N, R 7W, unsurveyed. Petaluma Formation (Fig. 1, locality 10). Type CAS 521.

Gyraulus (Idahoella)

Gyraulus annectans Chamberlin and Berry (1933). NK 12-7 [Brigham City] D-1. Box Elder County, Utah. USGS locality 200094, SE 1/4 sec. 19, T 12 N, R 2 W. Cache Valley Formation (Fig. 1, locality 37). Type University of Utah. =*G. monocarinatus* Chamberlin and Berry (1933).

Gyraulus monocarinatus Chamberlin and Berry (1933). NK 12-7 [Brigham City] D-1. Box Elder County, Utah. USGS locality 20094, SE 1/4 sec. 19, T 12 N, R 2 W. Cache Valley Formation (Fig. 1, locality 37). Type University of Utah.

Gyraulus multicarinatus (Yen, 1944). NK 11-6 [Twin Falls] D-6. Elmore or Owyhee County, Idaho. Near Hammett. Glenns Ferry Formation (Fig. 1, locality 34). Type CAS 8268.

Gyraulus (Torquis)

Gyraulus enaulus Leonard (1952). NJ 14-7 [Dodge City] A-3. Seward County, Kansas. Near center of west line sec. 36, T 34 S, R 31 W. Saw Rock Canyon local fauna, Rexroad Formation (Fig. 1, locality 50). Type University of Kansas Museum of Natural History 8803. =*Gyraulus parvus* (Say) according to Taylor (1960b).

Omalodiscus (note 11, p 131)

Omalodiscus pattersoni (F. C. Baker, 1938). NK 14-5 [O'Neill] C-8. Brown County, Nebraska. Center of north side NW 1/4 sec. 34 and southeast corner of SW 1/4 sec. 27, T 31 N, R 22 W. Sand Draw local fauna (Fig. 1, locality 48). Type Chicago Natural History Museum 26128.

"Platytaphius"

"Platytaphius" chestermani Hanna and Gester (1963). NK 10-9 [Alturas] D-8. Siskiyou County, California. CAS locality 34807, SW 1/4 sec. 4, T 47 N, R 1 E. Butte Valley (Fig. 1, locality 2). Type CAS 12469.

Biomphalariinae

Biomphalaria (note 12, p 131)

Biomphalaria kansasensis Berry, in Berry and Miller, this volume. NJ 14-7 [Dodge City] B-2. Meade County, Kansas. 1000 ft east, 1925 ft south, sec. 14, T 32 S, R 29 W. Spring Creek local fauna, Missler Silt Member of Ballard Formation (Fig. 1, locality 51). Type UMMZ 220142.

Helisomatinae

Helisoma (s.s.) (note 13, p 131)

Helisoma (s. s.)? kettlemanense Pilsbry (1934b). NJ 10-12 [Santa Cruz] A-1. Fresno County, California. 2000 ft west, 600 ft south, sec. 30, T 21 S, R 17 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 17). Type ANSP 13053.

Helisoma (Carinifex) (note 13, p 131)

Helisoma marshalli (Arnold, 1910). NJ 10-12 [Santa Cruz] A-1. Fresno County, California. USGS locality 4732, SW 1/4 NE 1/4 sec. 30, T 21 S, R 17 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type USNM 165507.

He sanctaeclarae (Hannibal, 1909). NJ 10-9 [San Jose] A-8. Santa Clara County, California. "Near Los Gatos Limestone Quarry", probably sec. 27 or 28, T 8S, R 1W. Santa Clara Formation (Fig. 1, locality 11). Type SU 451.

Planorbella (Pierosoma)
(note 13, p 131)

Planorbella (Pierosoma) clewistonensis (F. C. Baker, 1940). NG 17-5 [West Palm Beach] C-4. Hendry County, Florida. Clewiston. The stratigraphic position of the type is uncertain, but it may be from "unit A" (Fig. 1, locality 57). Type USNM 515222.

Planorbella (Seminolina)
(note 13, p 131)

Planorbella (Seminolina) wilsoni Taylor, n.sp. NG 17-5 [West Palm Beach] C-3. Palm Beach County, Florida. USGS Cenozoic locality 22704, road metal pit on south side of state highway 80 west of Belle Glade. "Unit A". Type USNM 644835.

Vorticifex (note 14, p 131)

Vorticifex condoni Hanna (1922). NK 11-4 [Adel] C-7 or C-8. Lake County, Oregon. Warner Lake basin (Fig. 1, locality 6). Type University of Oregon 17.

Parapholyx packardi corrugata F. C. Baker (1942). NK 10-6 [Klamath Falls] D-3 or D-4. Lake County, Oregon. Well at north end of Summer Lake, depth 1080 ft (Fig. 1, locality 4). Type Illinois State Geological Survey P7451. =*Vorticifex packardi* (Hanna, 1922)?

Vorticifex durhami (Glen, 1960). NJ 10-8 [San Francisco] C-2. San Mateo County, California. CAS locality 36724, T 5 S, R 5 W, 300 yards north 45° west of entrance on Skyline Boulevard to Skyline Materials Plant No. 1. Santa Clara Formation (Fig. 1, locality 11). Type CAS 10451.

Vorticifex gesteri (Hanna, 1963). NJ 11-4 [Walker Lake] A-4. Mono County, California. CAS locality 36730, NW corner SW 1/4 sec. 3, T 2 N, R 29 E. Lake beds in Mono Basin (Fig. 1, locality 29). Type CAS 12521.

Vorticifex laxus Chamberlin and Berry (1933). NK 12-7 [Brigham City] D-1. Box Elder County, Utah. USGS locality 20094, SE 1/4 sec. 19, T 12 N, R 2 W. Cache Valley Formation (Fig. 1, locality 37). Type University of Utah. Species unrecognizable; probably one of the Hydrobiidae described by Yen (1947).

Vorticifex minimus (Yen, 1947). NK 12-7 [Brigham City] D-1. Box Elder County, Utah. USGS locality 20093, SE 1/4 sec. 16, T 13 N, R 2 W. Cache Valley Formation (Fig. 1, locality 37). Type USNM 560007.

Vorticifex packardi (Hanna, 1922). NK 11-4 [Adel] C-7 or C-8. Lake County, Oregon. Warner Lake basin (Fig. 1, locality 6). Type University of Oregon 16.

Pompholopsis planospiralis Yen (1947). NK 12-7 [Brigham City] D-1. Box Elder County, Utah. USGS locality 20093. SE 1/4 sec. 16, T 13 N, R 2 W. Cache Valley Formation (Fig. 1, locality 37). Type USNM 560006. =*Vorticifex utahensis* (Yen, 1947).

Vorticifex utahensis (Yen, 1947). NK 12-7 [Brigham City] D-1. Box Elder County, Utah. USGS locality 20093, SE 1/4 sec. 16, T 13 N, R 2 W. Cache Valley Formation (Fig. 1, locality 37). Type USNM 560005.

Vorticifex whitei (Call, 1888). NJ 10-9 [San Jose] C-7 or C-8. Alameda County, California. North of Livermore. Probably Livermore Gravels (Fig. 1, locality 13). Type formerly in University of California, now lost.

Coretus (note 15, p 131)

Coretus plenus (Hanna, 1923). NJ 10-5 [Santa Rosa] B-3. Sonoma County, California. CAS locality 417, Willow Brook 1 mile southeast of Penngrove, sec. 9, T 5 N, R 7W, unsurveyed. Petaluma Formation (Fig. 1, locality 10). Type CAS 522.

Planorbulinae
Menetus (Planorbifex)

Menetus vanlecki (Arnold, 1910). NJ 10-12 [Santa Cruz] A-1. Kings County, California. USGS locality 4731, NW 1/4 NE 1/4 sec. 35, T 21 S, R 17 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type USNM 165506.

Paraplanorbis

Paraplanorbis condoni (Hanna, 1922). NK 11-4 [Adel] C-7 or C-8. Lake County, Oregon. Warner Lake basin (Fig. 1, locality 6). Type University of Oregon 14.

Promenetus (s. s.)

Promenetus exacuous kansasensis (F. C. Baker, 1938). NJ 14-7 [Dodge City] A-2. Meade County, Kansas. 900 ft east, 1300 ft north, sec. 22, T 33 S, R 29 W. Rexroad local fauna, Rexroad Formation (Fig. 1, locality 51). Type Illinois State Geological Survey P6778.

Promenetus (Phreatomenetus)

Promenetus blancoensis Leonard (1952). NJ 14-7 [Dodge City] A-3. Meade County, Kansas. 1500 ft west, 1900 ft north, sec. 35, T 34 S, R 30 W. Rexroad local fauna, Rexroad Formation (Fig. 1, locality 51). Type University of Kansas Museum of Natural History 8802. =*Promenetus umbilicatellus* (Cockerell, 1887) according to Taylor (1960b).

Planorbis scabiosus Hanna (1922). NK 11-4 [Adel] C-7 or C-8. Lake County, Oregon. Warner Lake basin (Fig. 1, locality 6). Type University of Oregon 15. =*Promenetus umbilicatellus* (Cockerell)?

PHYSIDAE
Hannibalina

Hannibalina dorrisensis Hanna and Gester (1963). NK 10-9 [Alturas] D-8. Siskiyou County, California. CAS locality 34807, SW 1/4 sec. 4, T 47 N, R 1 E. Butte Valley (Fig. 1, locality 2). Type CAS 12462.

Physa (Costatella)

Physa wattsi Arnold (1910). NJ 10-12 [Santa Cruz] A-1. Fresno County, California. USGS locality 4732, SW 1/4 NE 1/4 sec. 30, T 21 S, R 17 E. Basal part of Tulare Formation, Kettleman Hills (Fig. 1, locality 18). Type USNM 165503.

VERTIGINIDAE
Vertigo

Vertigo hibbardi F. C. Baker (1938). NJ 14-7 [Dodge City] A-2. Meade County, Kansas. 900 ft east, 1300 ft north, sec. 22, T 33 S, R 29W. Rexroad local fauna, Rexroad Formation (Fig. 1, locality 51). Type Illinois State Geological Survey P6773.

CHONDRINIDAE
Gastrocoptinae
Gastrocopta (s .s.)

Gastrocopta chauliodonta Taylor (1954). NK 14-5 [O'Neill] C-8. Brown County, Nebraska. North side of SW 1/4 and south side of NW 1/4 sec. 25, T. 31 N, R 22 W. Sand Draw local fauna (Fig. 1, locality 48). Type UMMZ 181120.

Gastrocopta franzenae Taylor (1960b). NJ 14-7 [Dodge City] A-2. Meade County, Kansas. 900 ft east, 1300 ft north, sec. 22, T 33 S, R 29W. Rexroad local fauna, Rexroad Formation (Fig 1, locality 51). Type UMMZ 183033a.

Gastrocopta paracristata Franzen and Leonard (1947). NJ 14-7 [Dodge City] A-3. Meade County, Kansas. 1500 ft west, 1900 ft north, sec. 35, T 34 S, R 30 W. Rexroad local fauna, Rexroad Formation (Fig. 1, locality 51). Type University of Kansas Museum of Natural History 3929.

Gastrocopta scaevoscala Taylor (1960). NJ 14-7 [Dodge City] A-2. Meade County, Kansas. SE 1/4 SW 1/4 and SW 1/4 SE 1/4 sec. 22, T 33 S, R 29 W. Bender local fauna, Rexroad Formation (Fig. 1, locality 51). Type UMMZ 184320.

Gastrocopta (Immersidens)

Gastrocopta rexroadensis Franzen and Leonard (1947). NJ 14-7 [Dodge City] A-2. Meade County, Kansas. 900ft east, 1300 ft north, sec. 22, T 33 S, R 29 W. Rexroad local fauna, Rexroad Formation (Fig. 1, locality 51). Type University of Kansas Museum of Natural History 3781.

STROBILOPSIDAE
Strobilops (s.s.)

Strobilops sparsicostata Baker (1938). NJ 14-7 [Dodge City] A-2. Meade County, Kansas. 900 ft east, 1300 ft north, sec. 22, T 33 S, R 29 W. Rexroad local fauna, Rexroad Formation (Fig. 1, locality 51). Type Illinois State Geological Survey P6774.

LIMACIDAE
Deroceras

Deroceras aenigma Leonard (1950). NJ 14-7 [Dodge City] A-2. Meade County, Kansas. 900 ft east, 1300 ft north, sec. 22, T 33 S, R 29 W. Rexroad local fauna, Rexroad Formation (Fig. 1, locality 51). Type University of Kansas Museum of Natural History 5127.

POLYGRIDAE
Polygyra (Erymodon)

Polygyra rexroadensis Taylor (1960b). NJ 14-7 [Dodge City] A-3. Meade County, Kansas. 1500 ft west, 2550 ft south, sec. 35, T 34 S, R 30W. Rexroad local fauna, Rexroad Formation (Fig. 1, locality 51). Type UMMZ 177610a.

HELMINTHOGLYPTIDAE
Cepolis

Cepolis caroli McGinty (1940). NG 17-5 [West Palm Beach] C-1. Palm Beach County, Florida. Range line canal west of Boynton. Perhaps from "unit A" (Fig. 1, locality 57). Type in T. L. McGinty collection.

TAXONOMIC NOTES

The following notes document only the more striking innovations in taxonomy or nomenclature of the preceding list of "mollusks described from Blancan types".

1. The living North American species of *Pisidium* have been reviewed by Herrington (1962), who recognized no subdivisions within the genus. Boettger (1961, 1962, 1964) and Kuiper (1962a, b, 1964) have discussed subgeneric groups of *Pisidium;* Heard (1965) has applied their data to a classification of the North American species. The subgenera are defined mainly by anatomical criteria, but partly by shell characters; and the known fossil *Pisidium* can thus be assigned to a subgenus, *Rivulina* includes nearly all of the known North American species. Both Boettger and Kuiper recognized this same taxonomic subgenus, but under different names. Boettger (1961, 1962, 1964) advocated use of *Galileja* Costa, but I follow Kuiper (1964) in believing that this name is based on some marine clam that is not even one of the Sphaeriidae. Kuiper (1962a) used the name *Cycladina* Clessin for the subgenus, but this name is doubly preoccupied as Boettger (1961) had already indicated. *Rivulina* Clessin, 1873, is the earliest available name for the group so designated by Heard (1965).

2. The Payettiidae were included in the Basommatophora by Taylor and Sohl (1962). Study of this group has revealed that in *Payettia* and in other, undescribed genera the internal muscle scar is roughly horseshoe-shaped though slightly asymmetrical. Exceptionally well-preserved shells of several undescribed species retain a color pattern of crudely divaricating series of chevrons, reminiscent of that in the genus *Septaria* (Neritidae). Evidently the family is *Neritacean,* and probably represents an ancient derivative of the Ne-

ritidae. The narrow columellar septum, few rapidly expanding whorls, and color pattern suggest relationship to *Septaria* of southeastern Asia, but the asymmetrical shell and small size are distinctive. No opercula have been found.

3. The new family Pliopholygidae is proposed for the sole genus *Pliopholyx* Yen, 1944, including 3 named species and others undescribed. Exceptionally well preserved specimens from the Glenns Ferry Formation, Idaho (Fig. 1, locality 34) reveal several spiral color bands in the shell, much as in *Viviparus*. Another striking feature is the characteristic doubly effuse aperture; this is interpreted as correlated with an inhalant and exhalant siphon, and a ciliary mode of feeding. The large size of some species, the thick shell of *P. reesidei* Yen, and the elongate spire of other species, are additional features that accord ill with the Planorbidae, in which Yen classified the genus. One might suggest that the group is hydrobiid, related perhaps to *Lithoglyphus*. Yet review of the UMMZ collections of Hydrobiidae, Bithyniidae, Viviparidae, Pilidae, Pleuroceridae and Thiaridae shows a general consistency of color pattern at generic or even family level. No Hydrobiidae or Bithyniidae have color pattern in the calcareous part of the shell, but spiral bands are common in the Viviparidae and Pilidae. In addition, some species of *Pliopholyx* are far larger than any known Hydrobiidae. The correlation of color banding with probable inhalant and exhalant siphons seems clearly to indicate relationship with the Pilidae and Viviparidae, although not closer to one than another. The family may be diagnosed as follows:

Order Mesogastropoda
Superfamily Viviparacea
Family Pliopholygidae Taylor, new family

Shell elongate-conic to globose, 10-40 mm long in adults, with about 5 whorls, and 4 equidistant spiral color bands in at least 1 species. Aperture 40-100% of total shell length, either effuse at both anterior and posterior ends, or rounded broadly anteriorly with a siphonal notch in the callus of the posterior angle. Base anomphalous or narrowly phaneromphalous; inductura thick and heavy or thin. Sculpture usually consists only of prosocline growth lines becoming more steeply inclined with growth; a spiral carina present in 1 species.

So far the family is known only by about 10 species (3 described) of *Pliopholyx,* all late Pliocene, in the Glenns Ferry and Cache Valley Formations, southern Idaho and northern Utah (Fig. 1, localities 34-37).

The genus *Reesidella* Yen (discussed by Tozer, 1956) of Mesozoic and lower Tertiary rocks in the northern Rocky Mountains exhibits similarities to some species of *Pliopholyx.* The shells of some species in both genera are of similar size and shape. When preserved, the color-banding too is similar, although Yen (1952: 6) described the shell of a *Reesidella* as showing only 2 bands. But no *Reesidella* shells I have seen show a siphonal notch or effuse aperture, and if *Pliopholyx* had a thick calcareous operculum like *Reesidella* it seems strange that none have been found. Seemingly *Reesidella* shares characters of the related families Viviparidae, Pilidae, Bithyniidae and Pliopholygidae, but in the present state of knowledge cannot be allocated to one of them plausibly. In any case, the similarities of *Pliopholyx* to *Reesidella* strengthen the evidence for classifying the former in the Viviparacea.

4. The family Delavayidae was established by Annandale (1924), but since Thiele (1928) merged it with the Lithoglyphine Hydrobiidae the name has not even been mentioned. Annandale (1924) diagnosed the family particularly by characters of the radula, but other morphological data include numerous distinctive features. Only the radula is known in most genera, but in *Jullienia* (*Fenouilia*) from Yunnan Province,

China, as described by Annandale and Prashad (1919) there are characters that show relationships to. the Pleuroceridae, and others that are unique. The lack of a penis, and the probable occurrence of an oviducal groove, are features common to the Cerithiacea. All known Hydrobiidae have a penis. Unique aspects are the spindle-shaped head; location of the eyes behind the bases of the tentacles; and the large size and integumentary cover of the eyes. The basal denticles of the central tooth are a character unknown in Pleuroceridae. The spindle-shaped fecal pellets indicate Cerithiacean rather than Rissoacean affinities; in all known Hydrobiidae the fecal pellets are ovoid, but in Pleuroceridae and Thiaridae spindle-shaped. In the light of present knowledge, Thiele (1928) seems to have considerably exaggerated the systematic value of the radula, and underrated the significance of other characters.

The scope of the Delavayidae remains uncertain since the radula is the only non-conchological structure known widely in the group. About 7 genera are known living in southeastern Asia, mainly in Yunnan Province, China, and in the Mekong River. The anatomically better-known group *Jullienia (Fenouilia)* of Yunnan shows the greatest conchological resemblance to the American fossil *Anculopsis,* and on this basis they are grouped together.

Specimens of *Jullienia* compared with *Anculopsis* are UMMZ 91602, 3 topotypes of *J. kreitneri* (Neumayr) from Lake Tali (Erh-Hai), Yunnan Province; and UMMZ 117334, 6 paratypes of *J. carinata* Fulton from Lake Yunnan (K'un-Yang Hai), Yunnan Province. These show that the spiral keels do not begin at the first or second whorl, but develop in later growth. This is a similarity to *Anculopsis bicarinata* Yen, but contrasts with the ontogenetically early spiral sculpture in the pleurocerid *Leptoxis (=Anculosa).* Strong spiral keels in *Leptoxis* do not persist into adult growth if they are ever present, and in many species are probably absent. Despite the gross similarity in size and form of *Leptoxis* and *Anculopsis* they differ fundamentally in development of sculpture.

In *Jullienia* of Yunnan Province the 2 spiral keels are situated precisely as in *Anculopsis bicarinata.* The posterior keel is strong in *Anculopsis,* weak or absent in *Jullienia,* but is 1/3-1/4 of the distance from the suture to the peripheral keel in both. In both genera the peripheral keel is strong, and just overlapped by the succeeding whorl. The base of the shell is anomphalous in both genera, but the umbilical area is concave. In *Jullienia* a sharp, narrow ridge runs from the anterior end of the inductura posteriorly along the outer edge of the concavity and disappears beneath the inductura; this narrow ridge marks successive positions of the inductura. In *Anculopsis* there is no such sharp ridge; the concave umbilical area is deeper, but bordered by only an indistinct swelling. None of these spiral structures have corresponding spirals in *Leptoxis,* although the concavity in the umbilical area can be duplicated.

Collabral sculpture in *Anculopsis bicarinata* consists of growth lines and variably developed indistinct low swellings. These form irregular undulations on the shell and may form weak nodes on the posterior keel in *Anculopsis bicarinata.* These undulations are present and strikingly similar in *Jullienia kreitneri* (Neumayr), but are not evident in the series of *J. carinata.*

Although *Anculopsis* is of about the same size and shape as *Lithoglyphus,* there are several characters that weigh against classifying both together in the Lithoglyphinae. The concave umbilical area, strong spiral keels, and the anterior spout of the aperture that occur in one or another *Anculopsis* are all absent in *Lithoglyphus.* Some details of sculpture, shape of aperture and umbilical area in the various *Anculopsis* species are so similar as to suggest that they form a coherent group. On the basis of morphological features Anculopsis seems closest to the Asiatic group *Jullienia (Fenouilia),* in the Delavayidae, but there are some gross characters in common with the families Pleuroceridae and Hydrobiidae.

The classification of *Anculopsis* in the Delavayidae introduces another family into the known fauna of North America. Inasmuch as the only morphological characters available are those of the shell, it is worth pointing out that other groups are common to the lakes of Yunnan Province and of Idaho and Utah. *"Melania" dulcis* Fulton (1904), from Lake Yunnan, seems to be the most similar living species to *"Melania" taylori* Gabb, from the Glenns Ferry Formation, Idaho (Fig. 1, locality 34). *Lithoglyphus taliensis* Annandale (1924), from Lake Tali, is the Asiatic species of the genus most similar to those of northwestern America.

5. The systematic position of *"Melania" dulcis* Fulton (1904) of Lake Yunnan, Yunnan Province, China is uncertain. Annandale (1924) ascribed it confidently to the pleurocerid *Semisulcospira,* but noted differences in the operculum. *"Melania" taylori* Gabb from the Glenns Ferry Formation, Idaho, is rather similar in sculpture, and I suspect the two are congeneric. The fossil species has a narrow spire and acute apex, distinct from the blunt apex of *Semisulcospira.* Neither published illustrations, nor specimens in the University of Michigan collections, show the early whorls of *"M." dulcis* that might prove diagnostic.

6. Most hydrobiids lack characteristic shell features, hence study of fossils in this group is difficult. The features of size and shape of protoconch have proved taxonomically useful in the western American species, being generally correlated with anatomical differences of generic or higher rank. Some of the fossil species previously referred to *Fluminicola (=Lithoglyphus)* by Pilsbry (1934b, 1935) have relatively large protoconchs similar to those of living *Lithoglyphus,* but most of them do not. These other species have a small protoconch as in the small species of *Fontelicella,* but attain a larger size and often have conspicuous spiral sculpture. For this group, with no known living representatives, a new genus is established.

Order Mesogastropoda
Superfamily Rissoacea
Family Hydrobiidae
Subfamily Hydrobiinae
Savaginius[4] Taylor, new genus

Diagnosis. Shell 2.5-7.5 mm long in adults, anomphalous, elongate-conic to globose, with 3-6 whorls, the aperture 20-80 percent ot total shell length. Collabral sculpture consists only of minute growth striae. Spiral sculpture usually present, consisting of a shoulder or peripheral keel and/or fine spiral striae. Protoconch similar in size to that of *Fontelicella,* but more acute, so that the apical angle is about the same as the spire angle instead of substantially greater. Inductura sometimes thick.

Type. *Savaginius nannus* (Chamberlin and Berry, 1933) (Pl. 6, Figs. 1-6).

Distribution. Pliocene and Pleistocene, California, Idaho and Utah.

The species included in this group can be assigned to 2 geographic subdivisions: the smaller species in southern Idaho and Utah; and the larger Californian species found in the Great Valley and Coast Ranges. Most of the species described by Pilsbry (1934b, 1935) are assigned on the basis of his descriptions and illustrations only, and some may belong elsewhere.

7. The conchological similarities of *Littoridina woodringi* Pilsbry (1934b) are evidently with tropical species rather than any geographically nearby form, as Pilsbry recognized. The Central American species similar to *L. woodringi* differ anatomically from *Littoridina,* and

[4] Named in honor of Dr. D. E. Savage, Dept. of Paleontology, University of California, Berkeley.

Morrison (1946, 1947) has proposed for them the genus *Zetekina.*

8. Fluminicola is included here in *Lithoglyphus.* As Pilsbry (1935) noted, the 2 groups cannot be distinguished consistently by shell; and from studies in progress (including examination of the verge in living animals of most of the American species) I do not believe there is any anatomical warrant for the separation of 2 genera.

9. Weyrauch (1964) proposed the name *Bakerilymnaea* as a substitute for *Nasonia F.* C. Baker, preoccupied. In this group the apex of the shell is like that of *Lymnaea (Stagnicola),* whereas features of pigmentation and behavior are like those of *Fossaria.* In at least one species the egg masses are remarkably distinctive, forming ovoid masses 6-10 mm long, 4-6 mm wide, laid free rather than appressed to the substratum, with a thick, sticky outer husk. Whether all of the nominal forms referred to this group are congeneric is uncertain, for shell characters are poorly marked.

10. Brannerillus has previously been classified as a hydrobiid, but is interpreted here as a planorbid. Sinistral coiling is virtually unknown in Hydrobiidae, but several examples are known in *Brannerillus.* It seems more likely that the usual dextral shell of *Brannerillus* is hyperstrophic as in some other planorbids, and that the sinistral shells represent occasional orthostrophic individuals.

11. Usage of *Omalodiscus* in place of *Anisus* follows H. B. Baker (1963a).

12. Opinion 735 of the International Commission on Zoological Nomenclature (Bull. zool. Nomen., 22: 94-99, 1965) ruled that the name *Biomphalaria* Preston has precedence over *Planorbina* Haldeman, 1842, *Taphius* H. and A. Adams, 1855, and *Armigerus* Clessin, 1884. From the comments by various authors that led to this opinion (Bull. zool. Nomen., 20: 92-99, 1963), one can see that there is general agreement that the nominal American genera *Tropicorbis* and *Australorbis* are subjective synonyms of *Biomphalaria,* but *Taphius* may or may not belong to this taxonomic genus. Hence the Neotropical Planorbidae listed by Harry (1962) as *Taphius* should all be relegated to *Biomphalaria* with the possible exception of *Taphius* s. s., the "Group of *Taphius andecolus* d'Orbigny" in that list. According to the classification by F. C. Baker (1945), *Biomphalaria kansasensis* would be a species of *Tropicorbis.*

13. The Planorbidae classified by F. C. Baker (1945) in the genera *Helisoma* and *Carinifex* are rearranged here on the basis of shell characters that have not been used previously. Among these snails the most conspicuous differences seem to be direction of coiling, and the shell form. In *Helisoma (s.* s.) (i.e., *Helisoma anceps)* and in *Carinifex,* the left side has a broadly conical concavity bordered by a conspicuous keel. In *Helisoma* the shell is biconcave, whereas the right side is convex in *Carinifex*, but in both of these groups the shell is dextral and hyperstrophic.

In the groups *Planorbella, Pierosoma* and *Seminolina* the shell is sinistral and orthostrophic. The left side is plane in early stages of growth, with a carina around the edge, and becomes slightly concave only as successive whorls enlarge. There is no funicular concavity on the left side. The right side has a narrow umbilicus.

Expression of these similarities and differences by grouping them into 2 genera, while preserving all of the subgeneric groups, yields a genus *Helisoma* (including *Carinifex*), and a genus *Planorbella* (including *Pierosoma* and *Seminolina).*

14. The usage of *Vorticifex* (based on a fossil species) for fossils and also the living species often separated as *Parapholyx* follows the treatment by Zilch (1959-1960). The variability of the species, and the intergradations of form, are so great that no subordinate groupings within the genus seem practicable at this time.

15. Usage of *Coretus* instead of

Planorbarius follows H. B. Baker (1963b).

TAXONOMIC CHANGES

New names proposed

Pliopholygidae, new family of Viviparacea, for *Pliopholyx* Yen, described originally in Planorbidae.

Pleuroceridae
Calibasis, new subgenus of *Juga*
Oreobasis, new subgenus of *Juga*
Idabasis, new subgenus of *Juga*
Juga chrysopylica Taylor, new name for *"Goniobasis rodeoensis"* of Hanna

Hydrobiidae
Savaginius, new genus of Hydrobiinae

Lymnaeidae
Radix intermontana Taylor, new name for *Lymnaea idahoensis* Yen, non Henderson

Planorbidae
Planorbella wilsoni Taylor, sp. n.

Changes in classification

Margaritiferidae
Gonidea malheurensis (Henderson and Rodeck) transferred from *Anodonta*

Sphaeriidae
Sphaerium cooperi Arnold = *S. striatinum* (Lamarck)
Sphaerium meeki Dall = *S. idahoense* Meek
Pisidium curvatum Hanna = *P. compressum* Prime
Pisidium compressum praecompressum Pilsbry = *P. supinum* Schmidt

Payettiidae
The family is referred to the Neritacea from the Ancylacea.

Valvatidae
Valvata utahensis horatii Baily and Baily = V. *utahensis* Call
Valvata oregonensis Hanna = *V. whitei* Hannibal

Orygoceratidae
Orygoceras tricarinatum Yen = *O. arcuatum* Dall

Pliopholygidae
Lithoglyphus campbelli Dall assigned to *Pliopholyx*.

Delavayidae
The family is restored to its originally proposed status in the Cerithiacea, from the current classification as part of the Hydrobiidae (Rissoacea).
Anculopsis Yen transferred from the Pleuroceridae
Lioplax utahensis Yen is transferred to *Anculopsis* from the Viviparidae.

Pleuroceridae
Juga H. and A. Adams is recognized as a valid genus, including all Recent and Tertiary Pleuroceridae of western North America that have shells like those of *Elimia*. *Namrutua* Abbott may be a synonym.
"Melania" taylori Gabb and *"M." dulcis* Fulton are classified as Pleuroceridae not surely referable to a known genus.

Hydrobiidae
Fluminicola Stimpson = *Lithoglyphus* Hartmann
Pilsbryus Yen =*Lithoglyphus* Hartmann
Anculotus nuttalii Reeve = *Lithoglyphus hindsii* (Baird)
Fluminicola coloradoense Morrison = *Lithoglyphus hindsii* (Baird)
Fluminicola fusca of authors, not Haldeman, = *Lithoglyphus hindsii* (Baird)
Fluminicola modoci Hannibal = *Lithoglyphus turbiniformis* (Tryon)
Amnicola dalli Call = *Lithoglyphus turbiniformis* (Tyron)
Paludestrina curta Arnold = *"Hydrobia" imitator* (Pilsbry)
Paludestrina nanna Chamberlin and Berry assigned to *Savaginius*
Fluminicola percarinata Pilsbry as to *Savaginius*
Fluminicola perditicollis Pilsbry as to *Savaginius*
Fluminicola pilula Pilsbry assigned to *Savaginius*
Fluminicola puteana Pilsbry assigned to *Savaginius*
Fluminicola siegfusi Pilsbry assigned to *Savaginius*
Fluminicola spiralis Pilsbry assigned to *Savaginius*
Fluminicola yatesiana utahensis Yen = *Savaginius nannus* (Chamberlin and

Berry)

Pyrgulopsis williamsi Hannibal assigned to *Savaginius*

Amnicola yatesiana Cooper assigned to *Savaginius*

Littoridina woodringi Pilsbry assigned to *Zetekina*

Tryonia stokesi (Arnold) is not surely a synonym of the poorly understood species *T. protea* (Gould)

Lymnaeidae

Bakerilymnaea Weyrauch raised to generic rank.

Lymnaea alamosensis Arnold = species inquirenda, *Lymnaea "palustris"* group.

Lymnaea kerri Hanna = *L. limatula* Hanna

Payettia (?) malheurensis Henderson and Rodeck transferred to *Radix*

Pseudosuccinea venusta Russell transferred to *Radix*

Planorbidae

Brannerillus Hannibal transferred from Hydrobiidae

Idahoella Yen ranked as a subgenus of *Gyraulus*

Carinifex Binney ranked as a subgenus of *Helisoma*

Planorbella Haldeman raised to generic rank, with 2 subgenera *Pierosoma* Dall and *Seminolina* Pilsbry

Paraplanorbis Hanna assigned to Planorbulinae

Vorticifex laxus Chamberlin and Berry is an unrecognizable species, probably of Hydrobiidae

Planorbis scabiosus Hanna assigned to *Promenetus (Phreatomenetus)*, probably = *P. umbilicatellus* (Cockerell)

Physidae

Hannibalina Hanna and Gester transferred from Ancylidae

Stenophysa Martens raised to generic rank

Physa meigsii Dall transferred to *Stenophysa*

Aplexa microstriata Chamberlin and Berry transferred to *Stenophysa*

Succineidae

Lymnaea barberi Marshall transferred to *Oxyloma*

Lymnaea aperta Marshall = *Oxyloma barberi* (Marshall)

Succinea sanibelensis Rehder = *Oxyloma barberi* (Marshall)

ACKNOWLEDGEMENTS

The specimens in the collections cited throughout the text were essential to the preparation of this paper. The distributional data summarized herein could not have been brought together without the cooperation of the private individuals and institutional curators responsible, to whom I express thanks.

Many persons have contributed importantly to the quality of the paper by the gift of specimens, discussions of stratigraphy and aid in collating voluminous literature. For such aid I stand in debt to R. C. Bright, G. H. Curtis, W. W. Dalquest, T. Downs, J. W. Durham, R. S. Gray, M. J. Grolier, J. F. Lance, J. D. Love, H. Masursky, C. A. Repenning, M. F. Skinner, J. A. Vedder, C. Wahrhaftig, J. A. White and D. Wilson.

Most of this paper was written in the Mollusk Division, Museum of Zoology, University of Michigan. Henry van der Schalie and J. B. Burch of this division generously provided many facilities that helped substantially in both research and publication.

C. W. Hibbard and D. E. Savage are largely responsible for the scope and synthetic viewpoint of this work, through the examples of their own work and the direct influence of their teaching. They have reviewed the paper as well as discussed many details of stratigraphy and correlation, but do not necessarily endorse all statements I have made.

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INDEX TO SCIENTIFIC NAMES

RESUMEN

SUMARIO DE LOS MOLUSCOS NORTEAMERICANOS CONTINENTALES DE EDAD BLANCAN

D. W. Taylor

Todos los moluscos continentales conocidos en Norte America de edad Blancan (Plioceno superior y Pleistoceno inferior) se ubican aquí dentro del sistema hasta ahora disponible de fósiles asociados, estratigrafia física, y edades del potasio-argon radiogénico. Muchos de los conjuntos independientes de estos moluscos son tan similares a otras faunas, que la mayoría de los fósiles se pueden asignar confiadamente a la edad Blancan. Esta asignación permite compilar listas de las últimas apariciones de géneros y familias, desconocidos durante o después del Blancan. Se conocen alrededor de 50-55 conjuntos del Blancan. y junto con otras 10-15 faunas más antiquas o más modernas incluidas por conveniencia en nuestra discusiOn, se sumarizan bajo 57 denominaciones geográficas locales (mapa, Fig. 1).

Para cada conjunto los siguientes datos se suministran, en lo posible: posiciOn, previas referencias a moluscos, unidades estratigráficas y mapas geológicos más recientes, número de especies, mención de otros fOsiles de la misma localidad o formación, edad, institución donde los fOsiles se conservan, y más recientes mapas topográficos. El tratamiento en detalle varía ampliamente, de acuerdo a la informaciOn disponible, progreso de los conocimientos desde la literatura antecedente, y el grado de utilidad de las nuevas informaciones. Listas de especies son incluidas sólo si la fauna es revisada o registrada por primera vez, pero las referencias a trabajos previous intentan ser completas.

Las faunas Blancan de la region de los Grandes Llanos (Nebraska, Kansas, Oklahoma, Texas), y de Arizona, generalmente son similares e incluyen muchas especies de amplia distribuciOn. Cambios Blancan y post-Blancan en moluscos se debieron a la progresiva extinción de relativamente pocas especies, y a cambios de distribución en especies existentes causados por otros en el habitat local y clima regional.

Las faunas Blancan del oeste (California, Oregon, Idaho, Nevada, Wyoming) son substancialmente diferentes unas de otras y también de las vivientes. Incluyen muchas especies y géneros extinguidos y algunas familias regionalmente extintas en N. America pero que sobreviven en otras partes, asi como algunas familias completamente extinguidas. Los cambios de los moluscos Blancan en el oeste de los Estados Unidos se debieron a alguna evoluciOn local, y a la terminación de sus linajes. Cambios en el post-Blancan fueron causados por extinciOn drástica, asociada con el vaciamiento o relleno de las cuencas palustres, vulcanismo, cambio en los sistemas de drenaje, climáticos, y amplios cambios topográficos. En contraste con los del tiempo Blancan, los moluscos actuales, salvo escasas excepciones, no se reducen a una cuenca antiguamente, el endemismo local era una caracteristica de la mayoría de las faunas occidentales.

La malacofauna fluvial viviente al este y oeste de la divisoria continental, muestran contrastes como los de la fauna Blancan. Hacia el este hay especies de más amplia distribuciOn, sin formas endémicas locales, pero al oeste hay amplitud de formas endémicas. El límite del endemismo local Reciente en Utah y oeste de Wyoming (mapa, Fig. 2) corresponde, aproximadamente, al limite oriental en la region de los depósitos Blancan (Fig. 1). Esta correlación junto con datos de las faunas Blancan soporta dos proposiciones que se aplican a los moluscos fluviales de Norte America en general y quizá a los de todas partes: (a) especies de amplios habitats tienen relativamente amplia distribución geográfica; (b) actividad tectónica provoca diferenciación taxonOmica. En el oeste de Norte America, las diferencias entre las faunas Blancan de las cuencas locales son tan grandes, que en el presente estado de nuestros conocimientos un cuadro claro no es evidente. Lo más cercano a un cuadro regional es la presencia de especies comunes, o estrechamente relacionadas, al sur de Idaho y el Valle San Joaquín de California. Esta afinidad está mostrada por especies Blancan y post-Blancan y hasta por unas pocas formas vivientes. Es de presumir que existió una antiqua conexión fluvial entre las dos areas: si tal fué, esta era de edad medio-Pliocena, como que esa es la edad de los más antiguos fOsiles y las faunas Blancan eran substancialmente diferentes.

El tipo de distribución geográfica, a la cual la pluralidad de los moluscos fluviales que viven en el oeste está relacionada, tiene groseramente la forma de un anzuelo rodeando, y cercano, a los bordes norte y oeste de la Gran Cuenca (Great Basin) (Fig. 7). Mayor número de fósiles Blancan tienen afinidades con este "anzuelo" que con el cuadro de Idaho-California. Así parece que los acontecimientos Blancan o inmediatamente pre-Blancan, reformaron el drenaje, y la distribución de los moluscos para formar ese cuadro anzueloide, y que la fauna moderna retiene una marcada estampa de esos cambios.

Se incluye una lista de todas las especies nominales descriptas de las localidades discutidas en el texto, y todas las especies estinguidas descriptas sobre ejemplares de edad Blancan, y unas pocas de antigüedad mayor o menor. Los datos provistos para cada uno de los 140 nombres incluyen referencia a la descripción original, ubicación geográfica y geológica revisada, localidad tipica y sinonimia. Estas especies se catalogan en un esquema de clasificación que envuelve un número de cambios jerárquicos, asignación genérica y sinonimia que no está explicitamente discutida pero que figura en la sección "Cambios Taxonómicos". Sólo unos pocos taxa nuevos han sido propuestos, todos en gastrópodos. Ellos incluyen Pliopholygidae nueva familia (Viviparacea), Calibasis, Oreobasis, e *Idabasis*, tres géneros nuevos de Juga (Pleuroceridae); y Savaginius nuevo género (Hydrobiidae).

АБСТРАКТ

БЛАНКАНСКИЕ НЕМОРСКИЕ MOJIJIOCKI4 СЕВЕРНОЙ АМЕРИКИ

Z. B. Тэйлор

В этой работе рассматриваются Bce известные B настоящее время Северо-Американские не-морские моллюски Бланканского возраста (поздний Плиоцен--ранний Плейстоцен), a также привлекаются Bce доступные данные, касающиеся связанных с ними других ископаемых форм, данные no Физической стратиграфии M по определению возраста с помощью метода радиоактивных изотопов калия аргона.

Многие из моллюско вых комплексов, датированные независимо OT других, настолько близки К другим Фаунам, что В целом большая часть ископаемых форм может быть уверенно отнесена к Бланканскому возрасту. Это позволило составить списки последних по времени находок тех родов m семейств, которые уже неизвестны B Бланканских или B более поздних отложениях. B настоящее время известно около 50-55 комплексов Бланканского времени; вместе с 10-15 другими, более древними mzm более молодыми фаунами (привлеченными для удобства обсуждения), они составляют B сумме около 57 локальных географических пунктов (карта, pm. 1).

Для каждого локального комплекса приводятся, no возможности, все следующие данные: местоположение, npexcHme указания Ha моллюсков, стратиграфическая характеристика и наиболее современные геологические данные (KapTm); указывается количество BM4OB MOJIMOCKOB, приводятся упоминания o других ископаемых формах из этого xe места или фации, возраст; название учреждения, где хранятся образцы, a также приводятся наиболее современные топографические данные (карты).

Детали исследования значительно меняются B зависимости OT доступной информации, OT HOBMX HayqHMX достижений no сравнению с прежними данными и OT качества получаемых HOBMX данных. Списки видов обычно приводятся лишь в случае ревизии фауны или   н указывается в 6т впервые; ссылки н прежние работы можно считать достаточно полными.

Бланканская фауна а н Великих Равнин (Небраска, Канзас, Оклахома, т   ) и Аризоны в общем сходна и включает, главным образом широко-распространенные ныне-живущие виды. Изменения в составе   н моллюсков Бланканского и после-Бланканского времени произошли, главным образом благодаря прогрессирующему вымиранию относительно немногих видов, также благодаря изменению распространения современных видов, вызванному изменениями климата и местных условий.

Бланканские фауны из западных районов CIIA (Калифорния, Орегон, а   , Невада, Юта, Вайоминг) значительно отличаются одна от другой от ныне-живущей фауны. Они содержат мноро вымерших видов и родов, некоторые семейства, вымершие в отдельных районах Северной Америки, но сохранившиеся в других каких нибудь местах, также некоторые семейства, в настоящее время вымершие полностью. Изменения в Бланканской фауне моллюсков н з а США произошли, как вследствие местной эволюции фауны, т и вследствие вымирания поколений. Изменения этой фауны в после-Бланканское время произшли, главным образом вследствие резкого отмирания, связанного с высыханием или наполнением озерных бассейнов, с вулканизмом, переменами мест дренажа почвы, с широкими колебаниями климата и изменениями в топографии местности.

в противоположность Бланканскому времени, ныне-живущие моллюски слабо-приурочены к какому нибудь одному озерному бассейну; наблюдавшийся н локальный эндемизм был характерен для большинства западных фаун.

Современная фауна пресноводных моллюсков, обитающих к востоку и к западу от континентального водораздела,   отличается от фауны Бланканского времени. н востоке обитают более широко-распространенные виды, н имеющие локальных эндемичных форм, н з а * последние имеют широкое распространение. Восточная граница распространения современных локальных эндемиков в Юта и западном Вайоминге (карта, рис. 2), примерно соответствует восточной границе распространения Бланканских отложений (рис. 1). Такая корреляция, вместе с данными по Бланканским фаунам подтверждает два предположения, которые можно отн стм к пресноводным моллюскам Северной Америки вообще (может быть и к другим районам их обитания): (т виды, связанные с широко-распространенными биотопами имеют и относительно широкое географическое и геологическое распространение, б) что тектоническая активность способствует таксономической дифференциации форм.

в западной части Северной Америки различия между Бланканскими фаунами, обитающими в отдельных локальных бассейнах так велики, что   современном состоянии их изученности еще нельзя получить ясного представления об их особенностях.

Наиболее близкое представление о региональных особенностях заключается в данных о встречаемости общих или близко-родственных видов Южном а   и в долине Сан-Вакин, Калифорния. Такая близость намечается Бланканским до-Бланканским и даже по нескольким ныне-живущим видам. Можно думать, что 6 района прежде соединялись между собо системой; если это так, то это могло быть примерно в среднем Плиоцене, поскольку таков возраст самых древних, имеющих к этому отношение, ископаемых форм, от которых Бланканские фауны существенно отличаются.

Система географического распространения, к которой большая часть ныне-живущих западно-американских пресноводных моллюсков имеет тн н , представляет собой, 6 говоря, изогнутую полосу в форме рыболовного крючка располагающуюся как внутри, т к м близко к северной западной окраинам Великого Бассейна (рис. 7). вн т этой Бланканские ископаемые фауны имеют между собой больше сходства, чем внутри системы Айдахо-Калифорния.

Отсюда вмано, события, имевшие место в Бланканское или в близкое до-Бланканское время, перераспределили дренаж и т н н моллюсков, чего оно приобрело общую систему, ввиде рыболовного крючка и современная фауна еще н т н 6 ясные следы этих изменений.

в дополнительных материалах к т т имеется список всех поименованных видов, которые были н 143 местообитаний, использованных в работе; включены все вымершие виды, описанные экземплярам Бланканского возраста, т немного более древние молодые. Для к 143 140 видовых названий приводится ссылка н первое описание, нн географическое и геологическое положение типичного местонахождения, местонахождение типа вида смнонммn.

Список видов дается в систематическом порядке, с указанием многих перемен их н в системе, в родовой принадлежности синонимии; все это излагается в разделе "Таксономические изменения", без а 6н обсуждения.

Для брюхоногих было предложено несколько новмх таксонов: новое семейство P (V); 3 новых подрода J (Pleuroceridae); C, O I; новый род S (H).