THE STRATIGRAPHY OF MESOZOIC AND EARLY CENOZOIC NONMARINE MOLLUSKS OF COLORADO

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INTRODUCTION

The nonmarine fossil record of brackish, freshwater, and terrestrial snails and clams in Colorado is long ranging but variously known. Nonmarine mollusks occur in the Late Triassic, Late Jurassic, Early and Late Cretaceous, and in the epochs of the Tertiary. The most comprehensive illustrated work representing the nonmarine molluscan taxa of Colorado, and the Western Interior in general, was published by C.A. White (1883c) before the turn of the century and is generally only available in geological libraries. Subsequent studies, unfortunately, are also highly specialized and not easily obtainable. Probably the individual with the greatest breadth of knowledge on the nonmarine molluscan faunas of Colorado was T.W. Stanton of the U.S. Geological Survey (USGS). Although contributing to the published literature, much of Stanton's efforts lie hidden in service work, both in the field and through correspondence to geologists, where his identifications provided the basis for environmental and stratigraphic interpretations.

This paper is an overview of the stratigraphic occurrence of mollusks in Colorado and provides a general picture of the state of our knowledge of the various faunas, their distribution in time and space, and reference to the individuals contributing to our current state of understanding. The state maps illustrated as Figure 1 are intended to provide a relatively comprehensive yet general view of where published and unpublished localities are known in Colorado.

TRIASSIC STRATA

The earliest records of nonmarine mollusks in Colorado are from the Upper Triassic Chinle and Dolores Formations of southwestern Colorado. Localities from the Chinle Formation have been reported from Montrose, San Juan, San Miguel, and Dolores Counties (Good, 1993), while the two poorly known snail localities in the Dolores Formation may be from Dolores, Montezuma, or La Plata Counties (Cross and others, 1899). The only comprehensive treatment of Late Triassic faunas was conducted by S.C. Good (1993) in his review of the nonmarine mollusks of the Chinle Formation in Arizona and Utah. In Colorado, the Upper Triassic molluscan fauna is known from only indeterminate or unidentified freshwater heteroconch clams (Unionidae) and snails.

JURASSIC STRATA

Nonmarine mollusks are known from the Upper Jurassic Morrison Formation and its various members throughout its extent in western Colorado. The Morrison molluscan
fauna of Colorado is relatively well known because of a comprehensive study by T.-C. Yen (1952) and subsequently presented but unpublished observations by J.H. Hanley and others (1986). Morrison molluscan localities are known from Delta, Douglas, El Paso, Fremont, Garfield, Grand, Jackson, Jefferson, Larimer, Mesa, Montrose, Park, Pueblo, Routt, and San Miguel Counties. Yen summarized the collections made by such geological notables as Whitman Cross, N.H. Darton, G.K. Gilbert, and C.A. White in the late 1800s. In southwestern Colorado, mollusks are known from both the lower (Salt Marsh) and upper (Brushy Basin) members of the Morrison Formation. The diverse molluscan fauna consists of unionid clams, including taxa of the genera Hadrodon, Vetulonaia, and "Unio"; both gill and lung-bearing freshwater snails from the archaeogastropod Mesoneritina (Neritidae) and the mesogastropods Amplovalvata (Cyclophoridae), Viviparus (Viviparidae), and Liratina (Valvatidae); the terrestrial archaeopulmonates Liratina (Otinidae), Mesauriculastra, and Mesochitina (Ellobiidae); and the aquatic pulmonates (basommatophorans) Lymnaea (Lymnaeidae) and Gyraulus (Planorbidae). The Morrison record represents the first complex nonmarine molluscan assemblage known from Colorado. The Morrison Formation contains the first occurrence of pulmonates in the Western Interior.

LOWER CRETACEOUS STRATA

The only certain nonmarine molluscan record from the Lower Cretaceous (Aptian) of Colorado of which I am aware is that from the Burro Canyon Formation of San Miguel County, southwestern Colorado. This faunule was identified twice from two separate collections, once by J.B. Reeside, Jr. (Simmons, 1957), and later by Hanley (U.S. Geological Survey–Denver Mesozoic Locality Catalog), and includes the unionid genera Plesielliptio and Nippononnaia, and snails possibly referable to Lioplacodes (Pleuroceridae). A possible second locality of unionids was originally referred to the Upper Jurassic Gunnison Formation (Lee, 1912, p. 24) (the name has since been abandoned). The Burro Canyon Formation species are related to the better known faunas of the Kootenai and Cloverly Formations of Montana and Wyoming (Stanton, 1903; Yen, 1949, 1951)

UPPER CRETACEOUS STRATA

Mesaverde Group. The nonmarine strata of the Upper Cretaceous in Colorado can be divided into two parts representing the progradation of continental strata associated with the regression of the Pierre Sea. The first interval (K-4 of Berman and others, 1980) is represented, in part, by the various lithostratigraphic units of the Campanian-age Mesaverde Group. Nonmarine mollusks are known from the undivided Mesaverde Formation and from the Mount Garfield and Williams Fork Formations. Although Yen (1954) reported mollusks from the Hunter Canyon Formation, Fisher and others (1960) considered these collections to be from the undifferentiated Mesaverde Formation. Localities have been reported from Delta, Garfield, Gunnison, La Plata, Mesa, Moffat, Pitkin, and Rio Blanco Counties in northwestern Colorado. Many of the
nonmarine mollusk localities reported from these counties and units were summarized by Lee (1912) and Fisher and others (1960), with identifications made by Stanton and T.-C. Yen (see Yen, 1954), respectively. The diverse molluscan fauna of the Mesaverde Group consists of a number of bivalves, including the heteroconch freshwater taxa of *Plesielliptio* and *"Unio,"* fingernail clams of the genus *Sphaerium* (Pisidiidae); brackish taxa of *Corbicula* (Corbiculidae), *Corbula* (Corbulidae), and *Teredina* (Pholadidae); and the pteriomorphs *Anomia* (Anomiidae), *Brachidontes* (Mytilidae), and *Crassostrea* (Ostreidae). The snail fauna is dominated by freshwater mesogastropods, including *Viviparus*, *Mesolanistes* (Ampullariidae), a valvatic (Valvatidae), hydrobiids (Hydrobiidae), *Lioplacodes*, and *Elimia* (Pleuroceridae), but brackish thiarids (Thiaridae) are also present.

**Fruitland Formation.** Overlying the marine Pictured Cliffs Formation, the brackish and freshwater environments of the Fruitland Formation commence the last progradational sequence of the Cretaceous (Tewo, 1980). The better exposed Fruitland–Kirtland formational sequence of New Mexico forms the narrow, hogbacked rim of the San Juan Basin in Archuleta and La Plata Counties in southwestern Colorado. The nonmarine mollusks of the Fruitland Formation are Edmontonian in age (North American Land Mammal Age), which is interpreted to span the Campanian–Maestrichtian boundary. The fauna of the Fruitland is, in part, related to the taxa of the Mesaverde Group, both being faunally placed between the Judithian (Campanian) Judith River Formation and the Lancian (Maestrichtian) Lance and Hell Creek Formations of Montana, Wyoming, and elsewhere. Although Stanton's (1916) report on the molluscan fauna of the Fruitland Formation was focused on the collections of C.M. Bauer and others in New Mexico, a number of localities sampled prior to 1914 were used to identify old and name new freshwater taxa. These include freshwater bivalves, such as *Plesielliptio*, *Proparreysia*, *"Unio,"* and *Sphaerium*; brackish bivalves, including *Corbicula*, *Corbula*, and *Teredina*; and pteriomorphs *Anomia*, *Brachidontes*, and *Crassostrea*. Snails are represented by mesogastropods such as *Viviparus*, *Mesolanistes*, *Elimia*; a brackish species of the family Thiaridae; and the aquatic pulmonate genus *Physa* (Physidae). Some of these Colorado occurrences were reported by Lee (1917) in the greater Durango and Yellow Jacket Creek areas.

**Laramie Formation.** The brackish and freshwater mollusks of the Lancian Laramie Formation were part of the studies of C.A. White (1879, 1883a-c) along Crow Creek in the late 1870s and '80s that fueled discussions concerning the Laramie as a time interval between the Cretaceous and Eocene (the Paleocene having yet to be recognized in North America). Faunal studies were subsequently conducted by Junius Henderson (1904, 1907, 1920, 1934, 1935) of the University of Colorado. All of the best known localities are from Weld County, but one record of Laramie fossils occurs at an undetermined location along Bijou Creek. The fauna includes the bivalves *Anodonta* (Unionidae), *Corbicula*, *Corbula*, *Anomia*, *Brachidontes*, and *Crassostrea*; the gastropods *Viviparus*, *Campeloma* (Viviparidae), *Lioplacodes*, *Elimia*, *Physa*, *Aplexa* (Physidae), and a thiarid.
CRETACEOUS–TERTIARY STRATA

Denver Formation. Nonmarine mollusks are rare in strata of the interval of the Cretaceous–Tertiary boundary in Colorado. There is only one fossil occurrence definitely known from the Denver Formation; it is near the present location of Mile High Stadium, just west of Federal Boulevard, and has long since been covered by pavement. In 1889, T.W. Stanton collected a poorly preserved but relatively diverse assemblage of mollusks from a ravine south of St. Luke's Hospital that he reported as from the Denver Formation. This discovery included "Unio," Viviparus, Lioplacodes, Physa, and specimens in matrix that C.A. White (Cross, 1889) assigned to the genus Corbicula, but may more likely be a pisidiid. On the basis of the mollusks, the strata bearing these fossils may be Puercan in age (see Kilm and Middleton, 1980, for use of land–mammal ages in Colorado). One other locality, reported from South Table Mountain, is probably from the Denver Formation. A single specimen in the University of Colorado Museum, with an incorrect reference to a plant, contains a specimen of Campeloma, a form consistent with assignment to the Puercan (as based on the stratigraphically close proximity of Puercan-age mammals; M.D. Middleton, written comm., 1980).


Raton Formation. Only one record of nonmarine mollusks from Las Animas County may be known from the Raton Formation. From the poorly preserved collection of W. Davilwhik from the base of the middle member, Hanley (unpublished 1977 USGS report) referred taxa to Plesielloptio? and to the Viviparidae. The taxa do not provide sufficient information for age assignment of the enclosing strata.

Animas Formation. One deformed land snail was collected from the horizon of the "Tiffany fauna" (Mason Pocket mammal fauna) by J.B. Reeside, Jr., in 1920, in Archuleta County. The Mason Pocket locality, near the town of Tiffany, is Tiffanian (late Paleocene) in age (Archibald and others, 1987). In addition, one large unionid without sculpture was collected by G.G. Simpson from "Tiffany."

TERTIARY STRATA

Coalmont Formation. About seven nonmarine molluscan localities have been sampled from the Coalmont Formation of North Park, all tentatively interpreted to be from Jackson County. The first collection was made as part of the F.V. Hayden survey of Colorado in the 1870s and was referred to the Laramie Group by White (1879). Most of the remaining localities were discovered by field crews of A.L. Beekly (1915), who provided the first report on the geology of North Park. Although the mollusks of the Coalmont Formation are poorly known, consisting of a few species of "Unio," Viviparus, Campeloma?, and Lioplacodes, the fauna is consistent with a Tiffanian–Clarkforkian (late–latest Paleocene) age.

"Fort Union Formation." About 11 nonmarine molluscan localities have been
assigned to strata considered to be post-Mesaverde Fort Union–Wasatch in Moffat and Rio Blanco Counties of northwestern Colorado (Tweto, 1979). The oldest and most diverse assemblage was collected from a poorly delimited area by Stanton and H.S. Gale (1910) from the Yampa coal field. The fauna, including Sphaerium, Viviparus, Campeloma, Elimia, Aplexa, and Pseudolumna? (Subulinae), are consistent with more diverse Paleocene faunas of the Fort Union Group of the northern Great Plains (Hartman and Kihm, 1992). At this time, the remaining localities are not stratigraphically well delimited, prohibiting assignment to the "Fort Union" of Colorado. In those few cases where diverse fossil assemblages have been collected, the fossils are consistent with assignment to a Wasatchian age.

**San Jose Formation.** A single record of a species of unionid, originally reported from the Wasatch Formation, may be known from the Wasatchian-age (early Eocene) San Jose Formation of La Plata County. The fossils are known from unpublished collections made by J.H. Gardner in 1909.

**Wasatch Formation.** Nonmarine mollusks are known from a number of localities, although many are poorly documented, in the Wasatch Formation of Garfield, Mesa, Moffat, and Rio Blanco Counties in northwestern Colorado. Taxa identified by Hanley (1974, 1976) from a few localities in the Niland Tongue include Wasatchian species assigned to the genera Plesielliptio, Viviparus, and Elimia. Hanley (unpublished 1977 USGS reports) also identified the aquatic pulmonates Physa and Biomphalaria (Planorbidae) and the terrestrial pulmonates (stylommatophorans) Oreocanus (Bulimulidae) and Holospira (Urocoptidae) from a few localities in the Shire Member, and Plesielliptio, Viviparus, Elimia, Physa, Biomphalaria, Promenetus (Planorbidae), and Oreocanus from other localities in the undifferentiated Wasatch Formation. A number of uncertain assignments made to the Wasatch Formation include species of Valvata (Valvatidae) and Hydrobia. All stratigraphically well-controlled molluscan localities of the Wasatch Formation appear to be consistent with a Wasatchian (reinterpreted as latest Paleocene to early Eocene) land–mammal age.

**Green River Formation.** The Green River Formation intercalates with and overlies the Wasatch Formation. A number of localities, some of uncertain location, have been reported from Garfield, Mesa, Moffat, and Rio Blanco Counties in northwestern Colorado. The most comprehensive review of Green River mollusks was conducted by Hanley (1974, 1976) in the Piceance Basin as part of his dissertation studies. Nonmarine mollusks identified by Hanley from the Douglas Creek Member include indeterminate unionids, Sphaerium, Viviparus, Elimia, and Hydrobia; the aquatic pulmonates Physa, Biomphalaria, Gyraulus (Planorbidae), Omalodiscus (Planorbidae), and Lymnaea (Lymnaeidae); and the terrestrial pulmonate Oreocanus. As revised, all of the species representing these genera indicate a Wasatchian–Bridgerian age for the enclosing strata.

**Huerfano Formation.** A few Bridgerian-age (middle Eocene) land snails, collected by Peter Robinson from the Huerfano Formation of Huerfano County, have been cataloged into the collections of the University of Colorado Museum.

**Washakie Formation.** As far as I am aware, there are no published reports of nonmarine mollusks from the Washakie Formation in Colorado. Bridger mollusks,
possibly from two localities, may have been collected by J.D. Sears (1925) in his study of the geology of Moffat County (Tweto, 1979). Additional small collection of a probable locality from the Bridger Formation in the same study area near Dry Mountain is housed in the University of Colorado Museum collections, and specimens from the Two-Bar Spring area in the Denver Museum collections. None of these collections has, as of yet, been described.

**Florissant Lake Beds.** The nonmarine molluscan fauna of the Chadronian (uppermost Eocene) Florissant beds in Teller County were described by T.D.A. Cockerell (1906) and included the fingernail clam *Sphaerium*, the aquatic pulmonate *Lymnaea*, and terrestrial pulmonate *Omphalina*? (Zonitidae) (see Evanoff, 1990, for discussion). An additional record of pisidiids was identified by Hanley (unpublished 1978 USGS report).

**Antero Formation.** A few molluscan localities are known from the mostly Chadronian Antero Formation of Park County. Specimens were collected by J.H. Johnson and identified by L.S. Russell (1938) as new species belonging to *Valvata*, *Pseudosuccinea* (Lymnaeidae), and *Radiocentrum* (Oreohelicidae).

**White River Formation.** Nonmarine mollusks are relatively common in the White River Formation (or Group) in Colorado. After many years of prospecting in Chadronian- and Orellan-age (latest Eocene to earliest Oligocene) strata, E.C. Galbreath (1969) identified a number of terrestrial gastropod families from Weld and Logan Counties. His familial assignments include *Pupillidae*, *Succineidae*, *Endodontidae*, *Zonitidae*, and *Polygyridae*. A collection by G.R. Scott from the Brule (or Cedar Creek) Member in Weld County included the common terrestrial pulmonate *Skinnerellia* (Humboldtianidae) (Hanley, unpublished 1975 USGS report) (see Evanoff and Roth, 1992). In addition, Emmett Evanoff (1990), as part of his dissertation studies, reported on the general occurrence of mollusks from the White River Formation in Jackson, Larimer, Logan, and Weld Counties (Evanoff, written comm., 1993). Evanoff (1990) also questioned the assignment of a new species of *Omphalina* named by Cockerell and Henderson (1912) from the Pawnee Buttes area of Weld County.

**Creede Formation.** An unpublished occurrence of a small, flattened, indeterminate snail was collected in 1977 by me from the Oligocene Creede Formation in Mineral County.

**SUMMARY**

This brief review of the Mesozoic and early Cenozoic nonmarine molluscan faunas of Colorado highlights the number of stratigraphic units in which freshwater and terrestrial snails and brackish and freshwater clams are present and frequently common. Nonmarine mollusks are usually of limited use for biostratigraphy at the generic level, in that many species, particularly in the Upper Cretaceous and Tertiary, are assigned to extant genera. However, at the species level, diverse assemblages of nonmarine mollusks provide adequate power to determine many of the North American land–mammal ages. Clearly, much more needs to be done in many sections to provide greater biostratigraphic resolution and strength to environmental reconstructions. I would be pleased to be informed of any additional localities that are known so that they may be incorporated into a developing database of Coloradan nonmarine molluscan occurrences.
I wish to thank Allen Kihm (Minot State University), Dave Krause (State University of New York), Jane Russell (Energy & Environmental Research Center) for their helpful comments on this manuscript. Thanks also to Emmett Evanoff and Steve Good for discussions on topics of their nonmarine molluscan expertise.

BIBLIOGRAPHY

The following bibliography includes some references not cited in the text to provide the reader other sources of paleontologic and stratigraphic information relevant to further studies on the nonmarine mollusks of Colorado.


Society of America, Special Paper 3, 313 p.


Figure 1. Mesozoic and early Cenozoic nonmarine mollusks of Colorado. Each dot represents a township, approximately six miles on a side, and several localities may occur in one township (note that some localities were omitted in that they are too imprecisely known to be plotted at this scale).
Figure 1
Triassic, Jurassic, Cretaceous, and Cretaceous-Paleocene Nonmarine Molluscan Occurrences in Colorado

Chinle (UR)

Burro Canyon (LK)

Morrison (UJ)

Mesaverde (UK)

Fruitland and Laramie (UK)

Denver, Dawson, Raton, and Animas (UK-T)
Figure 1, continued

Tertiary Nonmarine Molluscan Occurrences in Colorado

Coalmont

Wasatch and San Jose

Green River and Huerfano

White River and Washakie

Florissant, Antero, and Creede

Legend:
- 100 mi
- 100 km
COLORADO PALEONTOLOGY 1993

A SYMPOSIUM IN MEMORY OF JOHN JENKINS

LONG ABSTRACTS

NOVEMBER 5 & 6, 1993
DENVER MUSEUM OF NATURAL HISTORY
Denver, Colorado

SPONSORED BY The Denver Museum of Natural History, the Garden Park Paleontological Society, University of Colorado Museum, and the Western Interior Paleontological Society.