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EARLY TORREJONIAN MAMMALIAN LOCAL FAUNAS FROM NORTHEASTERN MONTANA, U.S.A.

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ABSTRACT—Small samples of mammalian local faunas have been recovered from the Farrand Channel and Horsethief Canyon localities in the upper part of the Tullock Formation, Garfield County, northeastern Montana. The Farrand Channel local fauna is of particular significance because it is known from sediments deposited during magnetostratigraphic Chron 28r that are bracketed by volcanic ashes yielding ^{40}Ar/^{39}Ar age determinations of 64.52 ± 0.02 and 64.31 ± 0.04 Ma. On a magnetostratigraphic scale, the age of the Farrand Channel local fauna falls within the temporal gap separating the youngest Puercan (Chron 29n) and oldest Torrejonian (Chron 28n) faunas of the San Juan Basin, New Mexico. *Periptychus carinidens*, the index fossil for the beginning of the Torrejonian, has yet to be discovered in northeastern Montana. Its absence could be attributed to small sample size, taphonomic bias, biogeographic provincialism, or a combination of these factors. The occurrence of *Paromomys* and other taxa making their first documented appearances in the Torrejonian warrants assigning an early Torrejonian (To1) age to the Farrand Channel and approximately contemporaneous Horsethief Canyon local faunas.

INTRODUCTION

Since 1903 when Barnum Brown began exploration of its headwaters, Hell Creek has become internationally renowned for the abundance and completeness of the latest Cretaceous fossils discovered in the deposits that Brown (1907) named the Hell Creek Formation. Although he discovered a few

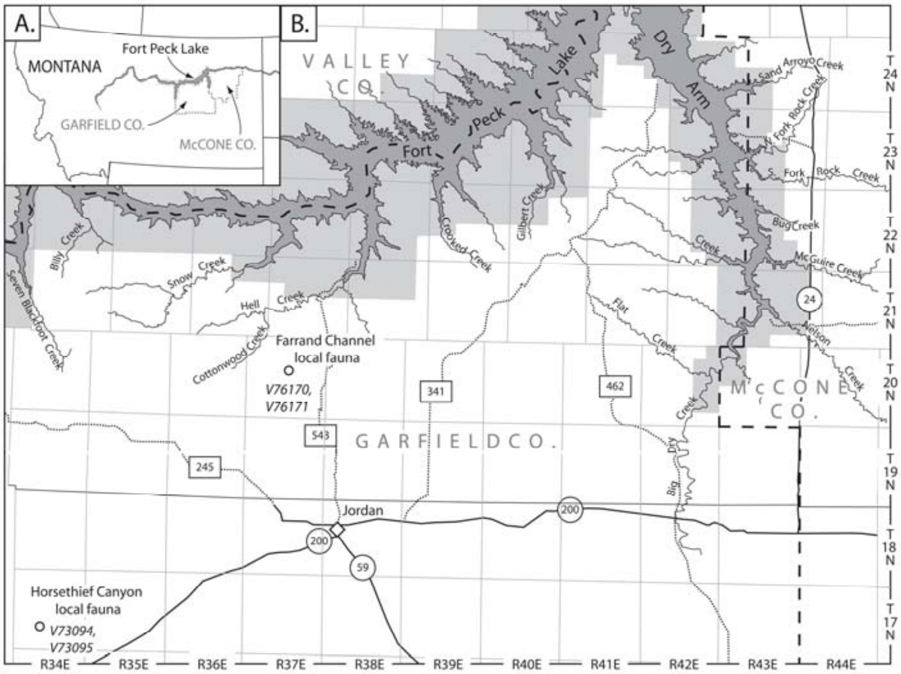

Figure 1. Map of Montana showing location of Garfield and McCone counties (**A**). Map of parts of Garfield and McCone counties showing localities producing the Farrand Channel and Horsethief Canyon local faunas (**B**).

remains of turtles and champsosaurs, the overlying Tertiary beds were not extensively prospected or particularly productive.

In the next half-century a few vertebrate paleontologists worked in the valley of Hell Creek (Fig. 1), but it was not an area of intensive field exploration. Independently, in the late 1960s, two field research projects were initiated in this area. In the first project, focusing on the area around Brownie Butte, Robert Sloan and Bruce Erickson discovered parts of two skeletons of *Triceratops* that are now on display in the Science Museum of Minnesota. By chance, Sloan and his colleague L. Van Valen, like Brown, were drawn eastward into McCone County. Here, in the valley of Bug Creek, Sand Arroyo, and adjacent areas, they spent a number of years collecting at a series of rich microvertebrate localities.

Harley Garbani, then a member of the staff of the Los Angeles County Museum, initiated the second project. He went to the valleys of Snow Creek and Hell Creek with the charge of obtaining dinosaurian skeletons for the museum's exhibits. Garbani and his field crews discovered and collected skeletons of *Triceratops*, *Edmontosaurus*, and an excellent specimen of *Tyrannosaurus rex*. They prospected the overlying Tertiary beds and discovered a series of microvertebrate sites yielding samples of early Paleocene, Puercan North American Land Mammal Age (NALMA) local faunas. The senior author and his students were invited to join the project and study the non-dinosaurian, latest Cretaceous and earliest Paleocene vertebrates, particularly the mammals.

A more detailed history of the research stemming from Garbani's discoveries is given elsewhere (Clemens, 2002). Pertinent to this report it is appropriate to highlight the research of J. D. Archibald (1982), which included the geological mapping and analysis of the stratigraphy of the headwaters of Hell Creek and one of its tributaries, Cottonwood Creek. L. Dingus (1983), D. E. Fastovsky (1987), C. C. Swisher III et al. (1993), and others added to both the depth and refinement of our knowledge of the

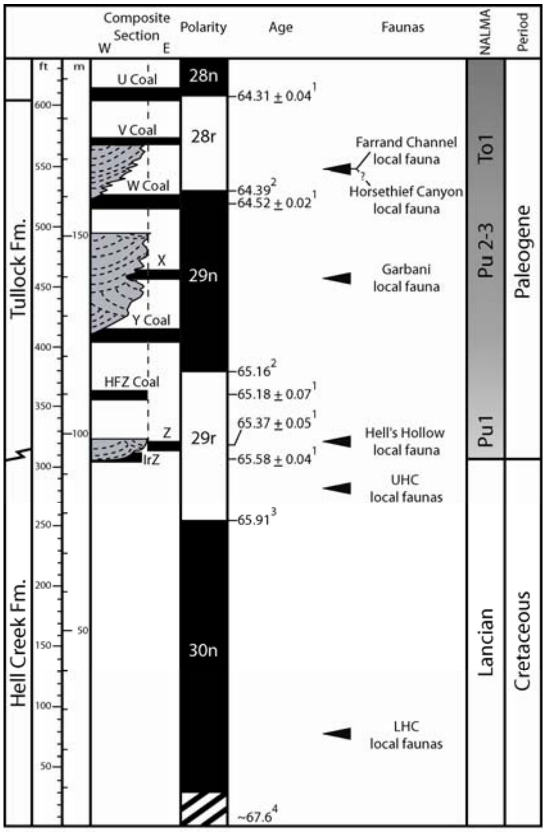

Figure 2. Stratigraphic framework of the Hell Creek and Tullock formations in Garfield and McCone counties. **Sources of data:** **1**, recalibration of age determinations from Swisher et al. (1993) by Wilson (2004); **2**, recalibration of age determinations from GPTS data in Berggren et al. (1995) by Wilson (2004); **3**, based on estimated duration of the Cretaceous part of Chron 29r by D'Hondt et al. (1996); **4**, estimated age of the base of the Hell Creek Formation based on extrapolation of sedimentation rate by Wilson (2004).

stratigraphy of the area. Results of their research are summarized in Figure 2, which locates many of the vertebrate local faunas in a well documented stratigraphic sequence calibrated with both magnetostratigraphic chrons and ^{40}Ar/^{39}Ar radiometric age determinations derived from volcanic ashes preserved in some of the lignites of the Tullock Formation. These determinations have been recalculated by Wilson (2004).

Because of interest in the patterns and processes involved in the mass extinction used to mark the end of the Cretaceous and the subsequent recovery of taxonomic diversity, earlier work has focused on the vertebrates that lived just before, during, and after this extinction (Archibald, 1982; Bryant, 1989; Lofgren, 1995). Currently, the scope of paleontological research is being expanded. The junior author is involved in an analysis of changes in the Lancian NALMA mammalian and other non-dinosaurian lineages throughout deposition of the Hell Creek Formation (Wilson, 2004, 2005). The senior author is in the midst of an analysis of the middle and/or late Puercan (Pu2-Pu3 undifferentiated) mammalian fauna of the Garbani Channel deposits. Here we join forces to present the first systematic analysis of the stratigraphically highest local fauna of the Tullock Formation found in the headwaters region of Hell Creek, the early Torrejonian (To1) Farrand Channel local fauna. The sample of the Horsethief Canyon local fauna, which was obtained from sites discovered by Harley Garbani approximately 20 miles (32 km) southwest of the exposures of the Farrand Channel, appears to document another To1 local fauna and is also considered here. In the systematic paleontology section of this study the junior author prepared the analysis of the "archaic ungulates;" the senior author analyzed the other members of the mammalian fauna.

Institutional abbreviations—**AMNH**, American Museum of Natural History, New York, New York; **BYU**, Brigham Young University, Provo, Utah; **CU**, University of Colorado Museum, Boulder, Colorado; **KU**, University of Kansas Museum of Natural History, Lawrence, Kansas; **UALP**, University of Arizona Laboratory of Paleontology, Tucson, Arizona; **UCMP**, University of California Museum of Paleontology, Berkeley, California; **UMVP**, University of Minnesota Museum of Paleontology, Minneapolis, Minnesota; **USNM**, United States National Museum, Washington, District of Columbia.

Other abbreviations—**BL**, buccal length of upper molars; **DW**, greatest distal width of upper molars or talonid width of lower molars; **GPTS**, Geomagnetic Polarity Time Scale; **L**, length of crown; **M**, mean; **MW**, greatest mesial width of upper molars or trigonid width of lower molars; **N**, number; **NALMA**, North American Land Mammal Ages; **OR**, observed range of variation; **W**, width.

GEOLOGICAL SETTING

In northeastern Montana, deposition of the lower part of the Ft. Union Group was characterized by periods of accumulation of primarily lignites and carbonaceous siltstones. These alternated with intervals when deposition of fine-grained clastics predominated. Locally, channel fillings mark the courses of streams and rivers that crossed what were then swampy lowlands. The lithostratigraphic nomenclature for the Ft. Union Group evolved from the pioneering work of Collier and Knechtel (1939) in McCone County. In their study, they referred to the predominantly carbonaceous zones in the lower part of the Ft. Union as coals but stressed that lithologically they were a mixture of lignites, higher-grade coals, and carbonaceous siltstones with some interbeds of non-carbonaceous sandstones and siltstones. These coals were designated alphabetically from the stratigraphically lowest, the Z coal, to the stratigraphically highest, the U coal. The boundary between the Tullock and Lebo Formations was set at the base of the U coal.

In the nomenclature employed in northeastern Montana the Ft. Union Group is divided into the Tullock and overlying Lebo Formations. This assignment of ranks of these units differs from that adopted in other areas of the Western Interior where the Ft. Union is accorded a formational rank and the Tullock and Lebo are treated as members.

Because coals of the Tullock represent times when accumulation of carbonaceous deposits was favored, they can be used to make approximate correlations between sections in different parts of Garfield and McCone Counties. Magnetostratigraphic correlations and ^{40}Ar/^{39}Ar age determinations have demonstrated, however, that within the resolution of these methods the patterns of inception, duration, and cessation of deposition of the coals varied somewhat within the region. For example, detailed studies

(Fig. 2) have shown that inception of the Z coal complex began earlier, at the Cretaceous-Tertiary boundary, in central Garfield County and later, during the early Paleocene, in western McCone County (Swisher et al., 1993; Lofgren, 1995).

Farrand Channel

Outcrops of the Farrand Channel were mapped by Archibald (1982, fig. 4–Geologic Map of the Headwaters of Hell Creek, Garfield County, Montana). The channel is intermittently exposed in the eastern branch of Cottonwood Creek in an area on the northern side of the divide separating the drainages of Hell Creek and its tributary, Cottonwood Creek, to the north and Dry Creek to the south (Fig. 1). The Farrand Channel consists primarily of coarse to very coarse, yellowish to white sand. As noted by Archibald (1982) the part of the channel deposits that has produced mammalian fossils also contains clay balls, iron concretions, and occasionally lignite stringers.

Archibald (1982, see Section S15, fig. 5–Stratigraphic Sections in the Headwaters of Hell Creek, Garfield County, Montana) found that the base of the Farrand Channel deposits cuts into the W coal. The channel is overlain in turn by the V coal, 5.5 meters of light yellow to orange yellow mudstone, and then the U coal. The base of the U coal is taken as the boundary between the Tullock and Lebo Formations. In Garfield County, neither mammalian nor other vertebrate fossils have been found in the Lebo Formation. The W and U coals were traced from the outcrops of the Farrand Channel approximately three miles (4.8 km) westward to the area of Biscuit Butte (Archibald, 1982). In the latter area a magnetostratigraphic study revealed that the W and U coals were deposited during Chron 28r and radiometric age determinations of volcanic ashes in these outcrops of the W and U coals have yielded ^{40}Ar/^{39}Ar age determinations of 64.52 ± 0.02 and 64.31 ± 0.04 Ma (Swisher et al., 1993; Renne et al., 1998; Knight et al., 2003, erratum; Wilson, 2004).

The deposits of the Farrand Channel, which were intensively prospected in 1976, are sparsely fossiliferous. The most complete fossil recovered was a major part of the skull and a small portion of the upper caudal lobe of a paddlefish, which were discovered by Harley Garbani in one of the southern exposures of the channel. These now form the holotype of *Polyodon tuberculata* (Grande and Bemis, 1991). Rick Farrand discovered mammalian and other small vertebrate fossils at two localities (V-76170, V-76171) in northern exposures of the channel. These localities (referred to as the Mosquito Gulch localities in Lofgren et al., 2004) are at about the same level within the channel deposits and only approximately 30 feet (10 m) apart. After surface prospecting, sediments from these localities were screen-washed. They have yielded relatively small but taxonomically diverse samples of vertebrate fossils including all the mammalian material described here. Detailed locality descriptions are archived at UCMP.

Horsethief Canyon

A second group of localities discovered by Harley Garbani is in Horsethief Canyon on the Bliss Ranch. These localities are distant (approximately 27 miles [44 km] southwest) from the headwaters of Cottonwood Creek and the exposures of the Farrand Channel (Fig. 1). Archibald (1982) described the geology of the productive section noting that the fossil localities were in a channel filling bracketed by lignites. Prior to the discovery of these localities William Rohrer of the United States Geological Survey mapped the area and suggested (personal communication to Archibald) that the lignite overlying the localities might be lithostratigraphically correlative with the U coal exposed in the Cottonwood Creek and Hell Creek area. This would place the localities in the uppermost Tullock Formation. Identification of the lignites below the fossil localities was open to question but one might be lithostratigraphically correlative with the W coal in the headwaters of Hell Creek. As Archibald (1982) cautioned, these lithostratigraphic correlations are open to question.

Sediments from two of the Horsethief Canyon localities (V-73094, V-73095) were processed by screen-washing and produced mammalian fossils. As will be discussed in a following section the similarity in composition of the Horsethief Canyon and Farrand Channel local faunas, particularly the co-occurrence of the same species of *Paromomys* and *Mimotricentes*, suggests that they are approximately contemporaneous and the Horsethief Canyon local fauna is of early Torrejonian (To1) age. Detailed locality descriptions are archived at UCMP.

SYSTEMATIC PALEONTOLOGY

MAMMALIA Linnaeus, 1758
ALLOTHERIA Marsh, 1880
MULTITUBERCULATA Cope, 1884a
CIMOLODONTA McKenna, 1975

Discussion—The classification of cimolodontan multituberculates continues to be in a state of flux. The authoritative classification presented by McKenna and Bell (1997) has been revised by several later workers. Here we adopt the systematic arrangement proposed by Weil and Krause (2008). Pertinent to this study is their elevation of the subfamilies Neoplagiaulacinae, Ptilodontinae, and Microcosmodontinae of McKenna and Bell (1997) to family rank. It should be noted that Weil's (1999) phylogenetic analyses shed doubt on the monophyly of the Neoplagiaulacidae and the systematics of the family is in need of revision (Weil and Krause, 2008).

NEOPLAGIAULACIDAE Ameghino, 1890
Mesodma cf. *M. garfieldensis* Archibald, 1982
(Fig. 3A-C)

Referred material—V-76170, UCMP 189555, right P4; V-73094, UCMP 157968, left M1.

Description—UCMP 189555 is a relatively small P4 (L = 2.45 mm, W = 0.71 mm) with a cusp formula of 3:7:1 (Fig. 3A-C). A distinct wear facet covers most of the lingual face of its crown but does not fully obscure the grooves separating the cusps and a remnant of a small distal basal cusp. Relative to the base of the crown, the medial row of cusps only slightly increases in height distally. UCMP 157968 is an M1 (L = 3.10 mm, W = 1.06 mm). Its cusp formula is 9:11:6. The lingual row begins opposite the sixth cusp in the medial row.

Discussion—This is the only neoplagiaulacid in the Farrand and Horsethief Canyon local faunas represented by a complete P4. The lateral profile of the crown of UCMP 189555 resembles those of P4s of *Mesodma thompsoni* and some P4s of *M. garfieldensis* (note UCMP 116751, Archibald 1982, fig. 14) in that the crest of the main ridge of cusps nearly parallels the base of the crown. Length of its crown and cusp formula of UCMP 189555 fall within the observed ranges of variation of *M. thompsoni* and *M. garfieldensis*, however its crown is somewhat narrower. The crown length of UCMP 157968, an isolated M1, falls within the observed range of variation of M1s of *M. garfieldensis*, and its cusp formula differs only in the presence of one more cusp in the external row. Resembling UCMP 189555 the crown of UCMP 157968 is slightly narrower than M1s of *M. garfieldensis*.

Species of *Mesodma* have been recognized in many Late Cretaceous, Puercan, and Torrejonian faunas of the Western Interior (Cifelli et al., 2004; Lofgren et al., 2004). As noted above, UCMP 189555 and 157968 show a number of similarities to their counterparts in the dentitions of some species of *Mesodma*. Discovery of a species of *Mesodma* comparable to the Puercan *M. garfieldensis* in a To1 fauna is not surprising. Until more material is recovered reference to this species is best regarded as a working hypothesis.

Cf. *Neoplagiaulax* sp.
(Fig. 3E-F)

Referred material—V-76170, UCMP 189558, mesial fragment of a left p4; V-76171, UCMP 189567, mesial fragment of a right p4; V-73094, UCMP 157965, distal fragment of a left p4.

Description—UCMP 189558 (Fig. 3E-F) is a fragment of the mesial end of a left p4. Assuming that the apogee of the arch between the roots lies distal to the crown's midpoint, the specimen preserves more than half of the crown. Its ventrobuccal lobe is long but not greatly expanded. The height of the first serration above the mesial edge of the crown is 1.8 mm. Buccal and lingual ridges descending from the serrations are closely spaced, gently curved, and end ventrally at a level slightly below the top of the depression in the base of the mesial end of the crown. The depth and morphology of this depression suggests that a p3 might have been present. What remains of the crown has a length of ca. 3.0 mm. Apices of five serrations are preserved; buccal ridges document the presence of another seven.

UCMP 189567 is another fragment of the mesial end of a p4. In size, it resembles UCMP 189558. Apices of seven serrations are preserved and buccal ridges document the presence of at least another six serrations. UCMP 157965 is a fragment of the distal end of a p4. Its size and morphology of the buccal ridges suggest it might be referable to this species. Twelve serrations are preserved. The rim of the distobuccal basin is worn but what remains indicates that the basin was not large.

Discussion—Assuming that the association of these fragmentary specimens is correct, the p4 of this species can be reconstructed as having been approximately four to five millimeters in length with a serration count of at least 13. These fragments show some similarities in estimated size, serration count and curvature of the lateral view of the crown to the p4s of species of *Neoplagiaulax*, for example *N. kremnis* (Rav W-1 locality, Johnston and Fox, 1984). Lofgren et al. (2004) assigned a Pu3? age to the Rav W-1 locality, however Fox (1997) suggested an older, Pu2, age assignment. Other occurrences of *Neoplagiaulax* include records of an undescribed species from a Pu3 locality in Montana mentioned by Sloan (1981) as well as records of *N. macintyrei* in the Pu2 fauna of the San Juan Basin (Sloan, 1981) and the Dragon (To1) fauna of Utah (Robison, 1986; Cifelli et al.. 1999). *Neoplagiaulax* cf. *N. hunteri* is well represented in the Swain Quarry (To2) fauna, Wyoming (Rigby, 1980). Given the extensive geographic

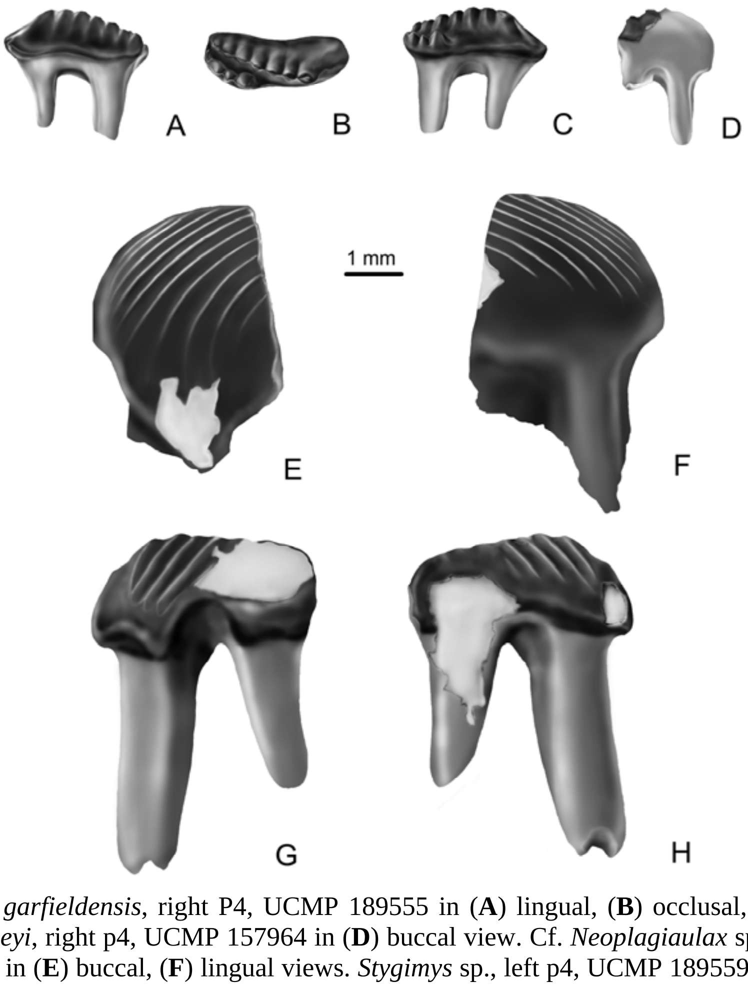

Figure 3. *Mesodma* cf. *M. garfieldensis*, right P4, UCMP 189555 in (**A**) lingual, (**B**) occlusal, (**C**) buccal views. *Microcosmodon* cf. *M. harleyi*, right p4, UCMP 157964 in (**D**) buccal view. Cf. *Neoplagiaulax* sp., mesial fragment of a left p4, UCMP 189558 in (**E**) buccal, (**F**) lingual views. *Stygimys* sp., left p4, UCMP 189559 in (**G**) buccal, (**H**) lingual views.

and temporal range of the genus occurrence of a species of *Neoplagiaulax* in the Farrand and Horsethief Canyon local faunas is not unexpected, but discovery of more complete material will be needed to fully document its presence.

Neoplagiaulacid and ptilodontid diversity—Twelve genera of neoplagiaulacids and ptilodontids have been recognized in Puercan and Torrejonian faunas of the Western Interior. Their pattern of occurrence (see Lofgren et al., 2004) highlights the diversity of these families in the middle and late Puercan (Pu2 and Pu3) and middle and late Torrejonian (To2 and To3). Five genera (*Ectypodus*, *Mesodma*, *Neoplagiaulax*, *Parectypodus*, and *Ptilodus*) are known to occur in Pu2, Pu3, To2, and To3 faunas. *Xyronomys* and possibly *Viridomys* might also have been long-ranging. One genus (*Kimbetohia*) has its last known occurrence in a Pu3 fauna. Four other genera (*Baiotomeus, Krauseia, Mimetodon, and Xanclomys*) make their first appearances in To2 or To3 faunas.

In contrast to the diversity of multituberculates currently recorded in Pu2, Pu3, To2, and To3 faunas, to date only species of three or possibly four genera of neoplagiaulacids and ptilodontids–*Neoplagiaulax* (*N. macintyrei*), *Parectypodus* (*P.* sp.), *Ptilodus* (*P. ferronensis* and ?*P.* sp,), and ptilodontid, gen. and sp. indet.–have been identified in To1 faunas (Cifelli et al., 1999). Collections from the Farrand and Horsethief Canyon localities contain several fragments of neoplagiaulacid or ptilodontid p4s and isolated molars that do not appear to be referable to either *Mesodma* or *Neoplagiaulax*. These may well represent additional genera as the currently relatively lower number of records of neoplagiaulacids and ptilodontids in To1 faunas probably reflects some combination of biogeographic, taphonomic, as well as collecting biases (see discussions by Weil, 1999; Lofgren et al., 2005).

MICROCOSMODONTIDAE Holtzman and Wolberg, 1977
Microcosmodon cf. *M. harleyi* Weil, 1998
(Fig. 3D)

Referred specimen—V-73094, UCMP 157964, right p4.

Description—UCMP 157964 (Fig. 3D) is a damaged, relatively small right p4. The enamel has been lost from most of the crown, but what remains along its distodorsal margin preserves two serrations separated by a deep, broad notch. Dimensions of the specimen are: L = 1.68 mm, W = 0.63 mm, which underestimates the original size of the crown. The morphology of the dentine core of the tooth shows that, in lateral view, the mesial end of the crown had a short vertical face; the dorsal margin of the crown formed a low, symmetrical arc; and the preserved serrations were preceded by at least two more serrations. A bulge in the dentine suggests the distobuccal lobe was large. The two roots appear to have been of approximately equal size.

Discussion—In comparison to p4s of species of Paleocene multituberculates the small size; lateral outline of its crown; and presence of a relatively low number of coarse, well separated serrations on this heavily damaged specimen indicate phylogenetic affinity with members of the Microcosmodontidae. The content, stratigraphic range, and monophyly of this family were analyzed by Weil (1998) who recognized three genera including the monospecific *Acheronodon* (Pu1) and *Pentacosmodon* (Ti5). The four species of the third genus, *Microcosmodon*, were relatively rare members of geographically widespread Paleocene–Puercan (Pu2) through Clarkforkian (Cf 2)–local faunas of the northern Western Interior. Subsequently Fox (2005) described *Allocosmodon* (To3 – Ti3). Weil (1998) described *M. harleyi* on the basis of specimens from several sites in the Pu2-Pu3 Garbani Channel deposits. Another species, *M. arcuatus*, is known from the Pu3? Rav W-1 local fauna, Saskatchewan. *M. conus* and *M. rosei* are members of Tiffanian and Clarkforkian local faunas.

As currently preserved, UCMP 157964 is slightly smaller than p4s of *M. harleyi*. However, making allowance for loss of enamel from most of its crown, the difference in size does not appear to be significant. The lateral outline of its crown more closely resembles the low arc of p4s of *M. harleyi* than the higher arc of *M. arcuatus*. These and the few other taxonomically significant characters preserved in UCMP 157964, low number and morphology of the serrations for example, warrant recognition of a microcosmodontid resembling *M. harleyi* in the Horsethief Canyon local fauna.

EUCOSMODONTIDAE Jepsen, 1940
Stygimys sp.
(Fig. 3G-H)

Referred material—V-76170, UCMP 189559, left p4; UCMP 189563, fragment of mesial end of a right P4.

Description—UCMP 189559 is a complete, relatively large (L = 3.97 mm, W = 1.51 mm) isolated p4. In lateral view (Fig. 3G-H), the mesial edge of the crown rises steeply to the first serration, which is lower than, and well separated from, the second. The remaining seven somewhat damaged serrations are regularly spaced across the essentially straight dorsal margin of the crown. The mesiobuccal lobe is small. When viewed mesially the base of the crown is straight; lack of an arch suggests that p3 was either very small or lost.

Very weak buccal ridges descending from the apex of the first serration and the mesial face of the second merge midway down the crown. Similarly, more distinct ridges descending from the apices of the second and third serrations merge at approximately the same level. Separate, almost straight buccal ridges descend from the fourth and fifth serrations. A distinct wear facet on the distobuccal side of the crown has obliterated any evidence of more distal ridges and there is only a slight indication of a distolateral ledge. The lingual ridges are shorter than the buccal. Although a fragment of enamel is missing near the mesiolingual base of the crown, enough of its surface remains to show the merger of weak lingual ridges descending from the apex of the first serration and the mesial face of the second. The lingual ridge from the apex of the second serration is shorter than that originating from the third. Distal to the ridge from the fifth serration the lingual surface of the crown is irregularly rugose.

Ventrally from the base of the crown, the two roots diverge slightly. The distal root has an approximately oval cross section with its mesiodistal axis longer than the transverse. In both width and, particularly, length the mesial root is larger than the distal. The flattened buccal and lingual sides give the mesial root a blade-like shape. In lateral view, the mesial edge of this root is slightly concave.

UCMP 189563, a fragment of the mesial end of the crown of a P4, preserves the first three low, bulbous cusps of the main row. Two cusps of the mesiobuccal row are preserved.

Discussion—The very low arc of the serrated crest of UCMP 189559, relatively small mesiobuccal lobe, and large size of the mesial relative to the distal root are the bases for reference of this p4 to *Stygimys*. Lofgren (1995) presented a detailed analysis of two species of *Stygimys* (*S. kuszmauli* and *S. gratus*) and subsequently Lofgren et al. (2005) provided a thorough review of the entire content of the genus. In the Western Interior, the genus is now known to have been present from the beginning of the Puercan into the Torrejonian (To2) (Lofgren et al., 2004). Geographically its documented range includes northern localities, in Montana and Alberta for example, and southern localities in New Mexico and Texas. Records are lacking from Puercan localities in the Hanna and Denver Basins. Although missing from the small sample of the To1 Dragon fauna of Utah, the genus is represented in the older (Pu3) Gas Tank fauna (Lofgren et al., 2005).

In comparison to the currently recognized species of *Stygimys*, the length of the crown UCMP 189559 (3.97 mm) falls below the observed range of variation of *S. camptorhiza* (OR = 4.20-4.30 mm, M. = 4.25 mm, Johnston and Fox [1984]) that dentally is the smallest named species of the genus. The p4s of *S. camptorhiza* have eleven serrations while UCMP 189559 has only nine. In its low number of serrations, UCMP 189559 resembles *S. vastus*–the type and only specimen has only eight–from a locality of uncertain age (Pu3 or To1) in Texas. The p4 of *S. vastus* is longer than those of *S. camptorhiza, S. jepseni* and UCMP 189559. UCMP 189559 more closely resembles the p4 of *S. jepseni* in its short, nearly vertical edge of the crown below the first serration; the low arcuate almost horizontal profile of the serrate crest of the crown; and small mesiobuccal lobe. The length of p4 of *S. jepseni* is comparable to those of *S. camptorhiza*. In addition to its larger size, the p4 of *S. jepseni* differs from UCMP 189559 in the presence of 11 or possibly 10 serrations (Lofgren et al., 2005).

Identification of UCMP 189559 as a p4 of a species of *Stygimys* appears well founded. Of the currently recognized species, UCMP 189559 most closely resembles the type and only specimen of *S.*

vastus and might be referable to this species. Evaluation of this possibility must await the discovery of more material.

Isolated incisors—Three fragments of lower incisors (UCMP 189552 and 189554, V-76170 and UCMP 189571, V-76171) are distinctly laterally compressed. Distally from their fully covered tips enamel is restricted to a ventral band. Two isolated upper incisors (UCMP 189553, V-76170 and UCMP 189570, V-76171) have a large mesial cusp followed by a lower, smaller cusp. These are typical morphologies for eucosmodontids and microcosmodontids but, given the fragmentary nature of the available specimens, they cannot be uncontrovertibly referred to *Stygimys* sp., *Microcosmodon* cf. *M. harleyi*, or another genus.

EUTHERIA Huxley, 1880
LEPTICTIDA McKenna, 1975
LEPTICTIDAE Gill, 1872
Prodiacodon cf. *P. crustulum* Novacek, 1977
(Fig. 4)

Referred material—V-76171, UCMP 189532, fragment of a right dentary preserving the distal wall of alveolus of p3, both alveoli of the two-rooted p4, m1, and m2. V-76170, UCMP 189533, fragment of dp4.

In his initial description of this species, Novacek (1977) designated the premolars of the species P/p1, P/p2, P/p4, and P/p5 reflecting the discovery that primitive eutherians had five premolars in their dentitions. Cifelli (2000) summarized the evidence that the reduction in premolar number to four probably resulted from the loss of the middle (third) premolar, which might have been a retained deciduous premolar. He argued that the five premolars of primitive eutherians should be designated P/p1-2, PX/x, P/p4-5. This system of identification is adopted here and, in contrast to Novacek's (1977) study, the distal two lower premolars are designated p3 and p4.

Description—Buccally a mental foramen is present ventral to the wall between the alveoli of p3 and p4 (Fig. 4). Total length of the alveoli of the two-rooted p4 (3.15 mm) is greater than the alveolar lengths of m1 (2.56 mm) or m2 (2.65 mm). The preserved molars, m1 and m2 (see Table 1 for their dimensions), are slightly etched. On both, low paraconids are situated lingual to the midline of the crown and approximated to distinctly higher metaconids. Apices of the protoconids of both molars are slightly

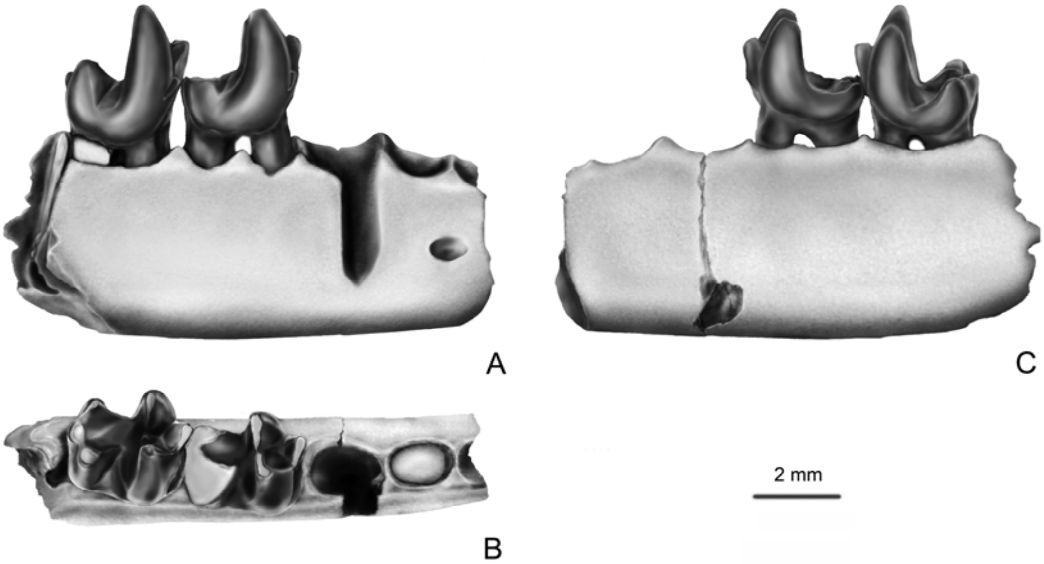

Figure 4. *Prodiacodon* cf. *P.crustulum*, fragmentary right dentary preserving posterior wall of alveolus of p3, both alveoli of the two-rooted p4, and m1-2, UCMP 189532 in (**A**) buccal, (**B**) occlusal, (**C**) lingual views.

worn, but what remains of these cusps suggests they were approximately the same height as the metaconids.

The talonid of m1 is heavily damaged in contrast to the much better preserved talonid of m2. On m2, the hypoconid is the highest talonid cusp. The high cristid obliqua ends at the back of the trigonid below the low point in the protocristid. Midway between the hypoconid and trigonid the cristid is slightly expanded but lacks a distinct median cusp. Although the hypoconulid's apex is missing it clearly was higher than the entoconid. The entocristid decreases in height mesially and is separated from the base of the trigonid by a small notch. An entoconulid is not present. The floor of the talonid slopes steeply lingually from the hypoconid and hypoconulid to the low point between the mesial end of the entocristid and the base of the trigonid.

Discussion—Novacek (1977) established *Prodiacodon crustulum* on the basis of isolated upper and lower postcanines from Biscuit Springs (V-74122) and other localities in the Tullock Formation yielding the Garbani Channel fauna (Pu2-Pu3 undifferentiated). Williamson (1996:35) noted the occurrence of one Puercan and two Torrejonian unnamed genera and species of leptictids in the San Juan Basin. The Puercan taxon, "gen. et sp. nov. A," was based on a single isolated lower molar from his loc. 11 (Pu2) that he thought might be referable to an unpublished species of *Prodiacodon* from the Black Toe Locality (Pu2) in the San Juan Basin described by Standhardt (1980). Standhardt (1980) compared this new species with *P. crustulum* noting that its postcanine dentition is smaller. Its lower molars were characterized as having relatively larger paraconids and lower trigonids than those of *P. crustulum*. She also specifically noted the absence of an entoconulid on m3 but did not mention the presence or absence of this cusp on the other molars.

Prodiacodon n. sp. (Rav W-1, Pu3?) and *Prodiacodon* sp. (Croc Pot, Pu3) have been reported in Canadian local faunas (Fox, 1997). Interestingly *Prodiacodon* or another leptictid was not represented in the large samples of Pu1 local faunas in northeastern Montana studied by Archibald (1982) and Lofgren (1995). More material has been discovered since their studies were completed, and three isolated leptictid teeth have been recovered from Pu1 localities (Wilson, 2004). Leptictids have yet to be reported in Puercan (Pu1) faunas of the Denver Basin, Colorado (Dewar, 2003); Hanna Basin (Pu1-Pu2), Wyoming (Eberle and Lillegraven, 1998); southeastern (Pu2) (Hunter et al., 1997) and southcentral (Pu2 or Pu3) Montana (Buckley, 1994).

Torrejonian leptictids include *Prodiacodon puercensis*, which ranges from To1 to To3 in the San Juan Basin. Also, Williamson (1996) noted occurrences of two then unnamed Torrejonian genera and species. One, "gen. et sp. nov. B," was recognized on the basis of a fragment of dentary with p4-m3 described as being "…much larger than other known Paleocene leptictids" (Williamson 1996:35). This jaw fragment, found somewhere in Kutz Canyon, is probably of Torrejonian age. Fossils on which "gen. et sp. nov. C" was based are now the hypodigm of *Escavadodon zygus*, a Torrejonian (To3) palaeanodont (Rose and Lucas, 2000).

To the north of the San Juan Basin, Robison (1986) reported the leptictid, *Myrmecoboides* n. sp., in the Dragon Canyon fauna (To1) of Utah. This record is based on an isolated lower molar described as being significantly larger than those of the type species, *Myrmecoboides montanensis* from the Gidley Quarry (To2) Crazy Mountain Field, Montana. Lower molars of *Myrmecoboides* can be distinguished from those of *Prodiacodon* by their larger size and twinned paraconid and metaconid, which are higher than the protoconid.

Although the diagnosis of *Prodiacodon crustulum* was based primarily on characters of the upper dentition, its dentition was characterized as being smaller than that of *P. puercensis* (Novacek, 1977). Since Novacek completed his study, more material of *P. crustulum* has been collected and the sample now includes 48 isolated lower molars that are either m1s or m2s. Dimensions of the molars preserved in UCMP 189532 fall well within the ranges of variation but are slightly larger than the mean values of the current sample of *P. crustulum* (Table 1). In contrast, the molar dimensions of the specimen of *P. puercensis* (AMNH 16748) described by Novacek (1977) are distinctly larger than those of the expanded sample of *P. crustulum.*

In addition to the differences in size, Novacek (1977) noted that m1 and m2 of *Prodiacodon crustulum* differed from those of *P. puercensis* in the absence of an entoconulid. This is the case on the four m1s or m2s available for his study. The current larger sample documents variation in this character. Of the 32 teeth preserving the talonid basin, an entoconulid is present on nine. Where present, the entoconulid usually is a minute cusp; only on UCMP 192083 does it approximate the entoconid in size and height. Variation in the development of a cusp on the cristid obliqua approximately midway between the apex of the hypoconid and the back of the trigonid is documented in the larger sample. Of the 24 teeth preserving the crest of the cristid obliqua, a cusp is present on 13.

In summary, the molars of UCMP 189532 resemble those of *Prodiacodon crustulum* in morphology of their major cusps, height of the trigonid relative to the talonid, and absence of an entoconulid on m2, the common condition of the species. Reference to the genus *Prodiacodon* appears well founded and none of the available characters argues against reference to *P. crustulum*. However, *P. crustulum* was diagnosed primarily on characters of the upper postcanine dentition and until upper molars of the Farrand Channel leptictid are discovered identification of UCMP 189532 is best limited to *P.* cf. *P. crustulum*.

Table 1. Comparison of dental dimensions (mm) of *Prodiacodon* cf. *crustulum* (UCMP 189532), and m1-m2s, undifferentiated, of *Prodiacodon crustulum* from V-73080 and other localities in the Garbani Channel.

Prodiacodon cf. c*rustulum*			
	Length	Mesial Width	Distal Width
m1	2.93	2.12	1.73
m2	2.85	2.19	1.86
Prodiacodon crustulum			
Number of specimens	44	48	47
OR	2.35-3.17	1.36-2.50	1.24-2.01
Mean	2.73	2.01	1.65

CIMOLESTA McKenna, 1975
CIMOLESTIDAE Marsh, 1889
Genus and species indet.
(Fig. 5A)

Referred material—V-76170, UCMP 189535, left ?M1; UCMP 189536, 189537, left m1 or m2s; UCMP 189538, fragment of a lower molar.

Description—The parastyle of UCMP 189535 is missing (Fig. 5A). What remains of the ectocingulum is relatively narrow, continuous, and indented by a shallow ectoflexus suggesting it is an M1. The paracrista ends buccally at what appears to have been a small stylocone, but the morphology of this area is obscured by wear and breakage. The apices of the paracone and metacone are blunted by wear. What remains indicates the paracone was slightly larger and probably higher than the metacone. Their bases are merged through approximately half the height of the paracone. The relatively short metacrista is low but a distinct wear facet indicates it functioned as a shearing blade. Wear obscures the morphology of the trigon basin, but its surface suggests the para- and metaconules were weakly developed and lacked distinct postparaconular and premetaconular crests. A preparaconular crista extends buccally to the broken surface at the mesiobuccal corner of the crown. The postmetaconular crista extends onto the distal slope of the metacone but does not reach the distobuccal corner of the crown. The protocone and trigon basin are narrow mesiodistally, and the crown is distinctly canted mesially. The narrow precingulum is longer (buccolingually) than the postcingulum. Dimensions: BL (to parastylar break) = 2.0 mm, W = 3.9 mm.

On the lower molar, UCMP 189536, the paraconid is much lower and smaller than the metaconid, which is slightly smaller than the protoconid. The paracristid is slightly bowed mesiobuccally. The protocristid forms a sharp shearing blade with its lowest point at about the midline of the trigonid. From below this low point in the protocristid, the cristid obliqua extends to the hypoconid forming the high

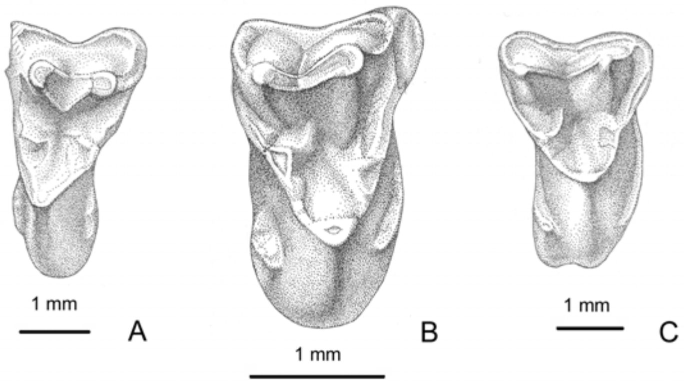

Figure 5. **A**, Cimolestidae, genus and species indet., left ?M1, UCMP 189535; **B**, ?Purgatoriidae, genus and species indet. A, right ?M2, UCMP 157829; **C**, ?Purgatoriidae, genus and species indet. B, right M1 or M2, UCMP 157826.

buccal wall of the talonid basin. The hypoconid is the highest and largest talonid cusp. The hypoconulid is smaller and lower than the hypoconid, and the entoconid is by far the smallest talonid cusp. A deep notch separates the entoconid from the metaconid, and the talonid basin is widely open lingually. Dimensions: L = 3.2 mm, MW = 2.3 mm, DW = 1.8 mm. The crown of UCMP 189537 is slightly shorter and broader than that of UCMP 189536, and the trigonid is noticeably more compressed mesiodistally. The apices of the major cusps of both lower molars are worn but it appears that, measured from the base of the enamel, the trigonids were approximately twice as high as the talonids. Dimensions: L = 3.1 mm, MW = 2.5 mm, DW = 1.9 mm.

Discussion—A well agreed upon definition of the Cimolestidae and its membership are still goals for future research (note Strauss, 2007). Most of the currently referred species are known only from isolated teeth or dentulous fragments of dentaries and maxillae. Their cheek teeth are essentially of abasic tribosphenic pattern with few specializations reflecting divergence from what might well be the primitive morphology of crown group eutherians. Discovery of new and more complete material will be required to reveal their phylogenetic interrelationships.

Central to the current concept of the Cimolestidae (sensu McKenna and Bell, 1997) are the at least six species of *Cimolestes.* The Cretaceous record of the family begins with a few questionably identified fossils of Judithian age (see Kielan-Jaworowska et al., 2004). In contrast, at least five species of *Cimolestes* are present in Lancian faunas of the Western Interior. *Batodon,* a minute Lancian mammal, is usually included in the family. A single Late Cretaceous occurrence of *Procerberus* cf. *P. formicarum* has been reported from the Long Fall locality in Alberta (Fox, 1997).

In the Puercan, currently recognized species of *Procerberus* are much more numerous than those of *Cimolestes.* In some Pu1 local faunas of Montana, *P. formicarum* is one of the most abundant mammals (Archibald, 1982; Lofgren, 1995). Van Valen (1978) described *P. plutonis,* a member of the Pu2-Pu3 undifferentiated Purgatory Hill local fauna. Fragmentary material from the Simpson Quarry (Pu2-Pu3 undifferentiated) suggests that several species of both *Procerberus* and *Cimolestes* were present in that local fauna (Buckley, 1994). *Alveugena* from the Pu2 of the Hanna Basin currently is the largest known cimolestid. Probably it is closely related to *Procerberus* and has been interpreted as a member of the ancestral stock of the taeniodonts (Eberle, 1999). Discovery of the stylinodontid taeniodont *Schowalteria* from the Lancian of Alberta challenged the latter interpretation and indicated a Lancian or earlier origin and initial diversification of the taeniodonts (Fox and Naylor, 2003).

Cimolestes simpsoni is known from Pu2 and possibly Pu3 local faunas of the San Juan Basin along with a questionable Pu2 record of *Procerberus* sp. (Williamson, 1996). The fossil record of the Palaeoryctidae, which some workers do not differentiate from the Cimolestidae at the family level (e.g., Fox and Youzwyshyn, 1994), might begin with a fragmentary specimen from the Pu2 of the San Juan Basin, but *Palaeoryctes* first appears in the To2 of the area (Williamson, 1996). The early Torrejonian record of cimolestids begins with the To1 occurrence of *Acmeodon*. This genus is also recorded in To2 local faunas along with species of *Avunculus*, *Gelastops*, and *Paleotomus*.

Assuming that the upper and lower molars described here represent one species, the following characters argue in favor of its reference to the Cimolestidae. Although the parastylar region is missing, what remains of the crown of UCMP 189535 suggests its width was significantly greater than its length and resembled molars of *Cimolestes simpsoni*, for example, and differs from those of *Procerberus formicarum*. The paracone and slightly smaller metacone are connate and their bases are conjoined for at least half the lingual height of the paracone thus distinguishing it from upper molars of palaeoryctids. Both the protocone and trigon basin are narrow mesiodistally, and the protocone is distinctly canted mesially. In these characters, UCMP 189535 resembles *C. simpsoni* and some other species of *Cimolestes* and differs from species of *Procerberus*. Depending upon the species, pre- and postprotoconal cingula are absent or variably developed on the molars of both *Cimolestes* and *Procerberus*. The relatively high trigonids of the referred lower molars; their small paraconids relative to the subequal protoconids and metaconids; and their narrow talonids relative to the trigonids are characters common in cimolestids.

Comparisons were made with cimolestids known from Torrejonian local faunas. Upper and lower dentitions of *Acmeodon* have been described from the To2 and To3 of the San Juan Basin (Matthew, 1937; Van Valen, 1966; Wilson, 1985). Additional material was discovered in the Swain Quarry (To2), Wyoming (Rigby, 1980). Van Valen (1966) described an isolated upper premolar (P3 or DP3) from the Dragon fauna (To1) and referred it to *Acmeodon*. In addition to its smaller size, UCMP 189535 differs from M1 or M2 of *Acmeodon* in the absence of minor cuspules on the buccal edge of a broader ectocingulum and lack of pre- and postcingula.

Avunculus was established by VanValen (1966) on the basis of two lower jaws from Gidley Quarry (To2), Montana. Only one preserves a molar, m1, which is smaller than either of the isolated molars from the Farrand Channel. Also, unlike these molars, the talonid of m1 of *Avunculus* is only slightly narrower than its trigonid.

The available samples of the dentition of *Gelastops* are from To2 localities in the Crazy Mountain Field, Montana (Simpson, 1937) and the Swain Quarry, Wyoming (Rigby, 1980) and consist almost entirely of lower postcanines. Only one upper molar, USNM 9554, probably an M2, has been referred and described (Simpson, 1937; Van Valen, 1966). It differs from UCMP 189535 in the presence of a deep ectoflexus, apparently more mesiodistally compressed protocone, absence of pre- and postcingula, and larger size.

The genus *Paleotomus* was established by Van Valen (1967) on a species (*Paleosinopa senior*) represented by an isolated lower molar, probably an m3, from the Scarritt Quarry (Pu2), Montana. Rigby (1980) described a larger sample of a new species of *Paleotomus*, *P. milleri*, from the Swain Quarry (Pu2), Wyoming. M1 and M2 of *P. milleri* are distinguishable from UCMP 189535 in their distinctly enlarged, fan-shaped metacristae, the greater buccal extent of the postmetaconular cristae, significantly larger postcingulum that, on some teeth, bears a hypocone, and their larger size. The isolated lower molars UCMP 189536 and 189537 are distinguishable from those of *P. milleri* by their relatively lower trigonids, shorter length, and narrower talonids.

In summary, the three isolated teeth from the Farrand Channel described here and provisionally assumed to represent one species exhibit a complex of characters to be expected in a cimolestid. This species is not referable to any currently described species of *Cimolestes* or *Procerberus*. Similarly, reference to *Acmeodon* or other cimolestids known from To1 and To2 can be excluded.

PRIMATES Linneaus, 1758
?PURGATORIIDAE Van Valen and Sloan, 1965
Genus and species indet. A
(Fig. 5B)

Referred specimens—V-73094, UCMP 157829, right M2, and provisionally referred UCMP 157828, left M1 or M2.

Description—The buccal margin of the crown of UCMP 157829 (Fig. 5B) is slightly concave suggesting it is an M2. The narrow ectocingulum extends from the robust parastylar spur to the distobuccal corner of the crown. Its parastyle and very small stylocone are separated by a deeply worn groove. The paracone is slightly higher than the metacone. They are well separated but linked by a straight centrocrista. Paraconule and metaconule are distinct. Preparaconular and postmetaconular cristae are continuous with the paracingulum and metacingulum respectively. The premetaconular crista is oriented toward the center of the centrocrista. In comparison to the postprotoconal crista, the preprotoconal crista is low. A narrow precingulum and slightly broader postcingulum, the latter slightly blunted by wear, are present on the anteriorly canted protocone. The distolingual slope of the protocone is gently rounded with no indication of a break in curvature or development of a crest (postprotocingulum *sensu* Silcox and Gunnell (2008) or postprotoconal fold *sensu* Scott and Fox [2005]) linking the protocone and postcingulum. Dimensions of UCMP 157828 and 157829 are given in Table 2.

Discussion—In her preliminary review of *Purgatorius*, based primarily on published material, Silcox (2001 and see Silcox and Gunnell, 2008) recognized four species: *P. unio* (including *P. titusi*), *P. janisae*, *P.* sp. (part of the Rav W-1 local fauna [Johnston and Fox, 1984]), and *P. ceratops*. M1s or M2s of only the first three have been discovered and described. In comparison to the M1 and M2 of the type specimen of *P. janisae* (LACM 28128), UCMP 157829 differs slightly in the lesser development of the pre- and postprotoconular cristae as well as the more mesial position of the protocone relative to the paracone and metacone. Table 2 presents the dimensions of M1 and M2 as well as the length/width ratio for the molars of the currently recognized species of *Purgatorius*. Postmortem abrasion probably has slightly reduced the width of UCMP 157828, but even making an allowance for this loss, both UCMP

Table 2. Comparisons of dimensions (in mm) of UCMP 157828 and 157829, ?Purgatoriidae, genus and species indet. A with those of *Purgatorius janisae*, sample from the Pu2-Pu3 Garbani Channel fauna; *P. unio*, including both specimens from Purgatory Hill local fauna (dimensions from Van Valen, 1994) and, following Silcox (2001), M1s and M2s of *P. titusi* from Simpson Quarry (dimensions taken from Buckley 1994); and *P.* sp from Rav W-1 (dimensions taken from Johnston and Fox, 1984).

?Purgatoriidae, genus and species indet. A (Horsethief Canyon fauna)

	L	MW	DW	L/DW
UCMP 157828	1.50	>2.03	>2.10	<0.71
UCMP 157829	1.44	2.27	2.32	0.62

Purgatorius janisae (Garbani Channel fauna)

		BL			MW			DW			BL/DW	
	N	OR	M	N	OR	M	N	OR	M	N	OR	M
M1	28	1.71-2.11	1.91	28	2.32-2.86	2.55	28	2.46-3.05	2.75	28	0.65-0.80	0.70
M2	24	1.77-2.18	1.95	25	2.46-3.04	2.71	24	2.64-3.13	2.85	23	0.63-0.75	0.68

Purgatorius unio (Purgatory Hill fauna)

		BL		W		BL/W
	N	OR	N	OR	M	
M1	1	1.8	3	2.9-3.0	2.93	0.61
M2	1	1.9	2	2.8-2.9	2.85	0.67

Purgatorius unio (*P. titusi*, Simpson Quarry fauna)

		BL			MW			DW			BL/DW	
	N	OR	M	N	OR	M	N	OR	M	N	OR	M
M1	4	1.7-1.9	1.75	3	2.6	2.6	3	2.6-2.7	2.67	3	0.63-0.75	0.66
M2	4	1.9-2.0	1.98	4	2.7-2.9	2.78	4	2.8-2.9	2.83	4	0.67-0.71	0.70

Purgatorius sp. (Rav W-1 fauna)

	BL	MW	DW	BL/DW
UA 16070, M2	1.95	2.70	2.90	0.67

157828 and 157829 are smaller than molars of *P. unio*, *P. janisae*, and *P.* sp. from Rav W-1. The length/width ratio of UCMP 157829, probably an M2, is lower (more transverse) than those of either *P. unio* or *P. janisae.* In summary, the small sizes of UCMP 157828 and 157829 as well as at least the length/width ratio of UCMP 157829 fall outside the observed ranges of variation of *P. unio*, *P. janisae*, and *P.* sp. from Rav W-1. If referable to *Purgatorius* they document the presence of yet another species.

Members of Pu2, Pu3, and To1 local faunas document a significant diversity of plesiadapiforms including palaechthonids, paromomyids, picrodontids, and *Pandemonium dis*, a plesiadapiform of uncertain familial affinities (Silcox and Gunnell, 2008). Silcox's (2001) phylogenetic analysis suggested the Palaechthonidae is a paraphyletic assemblage of primitive forms that probably includes species from which various other lineages originated. As summarized by Silcox and Gunnell (2008) currently the oldest records of palaechthonids (Pu3) are representatives of *Palaechthon*, *Plesiolestes*, *Torrejonia*, and *Anasazia*. *Talpohenach* is known from a To1 record. *Palenochtha* and *Premnoides* appear in the To2. All members of the Palaechthonidae are characterized by upper molars with distinct postprotocingula that enclose a distolingual basin. Absence of this derived character on UCMP 157829 precludes its identification as an upper molar of a palaechthonid. However, M1s and M2s of *Plesiolestes*, *P. problematicus* for example, differ from UCMP 157829 only in their somewhat larger size; lower, more bulbous paracones and metacones; and weak development of the postprotocingula. The possibility of a close phylogenetic relationship cannot be rejected.

A new paromomyid in the Farrand Channel local fauna is described below. Particularly in the development of postprotocingula, its upper molars differ significantly from UCMP 157829. *Draconodus* from the Dragon Canyon fauna of Utah (To1) is the oldest and probably the most primitive member of the Picrodontidae (Tomida, 1982). Unlike UCMP 157829 the postprotocingula and distolingual basins of its upper molars are distinctly enlarged and, among other characters, clearly illustrate the apomorphies characterizing this family. The upper molars referred to *Pandemonium dis*, differ from UCMP 157829 in the presence of a small but distinct hypocone.

Genus and species indet. B

(Fig. 5C)

Referred specimens—V-73094**,** UCMP 157826, right M1 or M2 and V-76170, UCMP 189583, provisionally referred lingual fragment of an upper molariform.

Description—UCMP 157826 is a relatively large right upper molar (BL = 2.44 mm, MW = 3.63 mm, DW = 3.62 mm). From the paracone, a low, short preparacrista extends buccally to join the crest of the narrow ectocingulum. In occlusal view, the parastyle is rounded and broad transversely and the buccal margin of the crown is shallowly concave. The paracone and slightly lower metacone are linked by a low, straight centrocrista. Damage has essentially obliterated the paraconule of UCMP 157826 but a trace of the postparaconular crista is present on the lingual side of the paracone and the preparaconular crista extends to the parastyle. This area is preserved on UCMP 189583 and supports this interpretation of the courses of these cristae. The premetaconular crista of UCMP 157826 extends to the mesiolingual side of the metacone, the postmetaconular crista is directed buccally distal to the metacone but does not quite reach the buccal margin of the crown. The distance from the apex of the protocone, which is only slightly deflected mesially, to the buccal margin of the crown is approximately 60% of the total crown width. The trigon basin is small and the lingual side of the protocone forms a long, gradual slope. The precingulum is narrow and long. In contrast, the postcingulum is broader, extends lingually only from above the metaconule to the posterior slope of the protocone where it terminates in a small hypocone. There is no evidence of a postprotocingulum. A groove extending from the notch between the protocone and hypocone to the dorsal edge of the enamel gives the lingual margin of the crown a slightly bilobed outline.

Discussion—UCMP 157826 and, to the extent it is preserved, UCMP 189583 resemble isolated upper molars referred to *Pandemonium dis* by Van Valen (1994), particularly UMVP 1630, in size and many morphological characters. They differ from molars of *P. dis* in their narrower ectocingula and lesser difference in height of the higher paracone and lower metacone.

Unlike upper molars of *Purgatorius*, the protocone of UCMP 157826 is not positioned distally relative to the paracone and metacone. Comparisons also were made with upper molars of Puercan arctocyonids including *Oxyprimus, Protungulatum,* and *Baioconodon* as well as the primitive periptychid *Mimatuta*. The degree of buccal shift of the protocone of UCMP 157826 resembles that of primitive arctocyonids but is not as extreme as found in *Mimatuta* (see Luo, 1991 and Lofgren, 1995). In comparison to upper molars of these taxa the lingual half of the crown of UCMP 157826 is not as mesiodistally expanded.

In summary, UCMP 157826 most closely resembles upper molars of *Pandemonium dis*. The few morphological differences might be interpreted as derived characters of a new taxon closely related to *P. dis.* Until more material is discovered, the phylogenetic affinities of the taxon represented by UCMP 157826 are best regarded as uncertain.

PAROMOMYIDAE Simpson, 1940

Paromomys Gidley, 1923

Discussion—The currently recognized species of *Paromomys, P. maturus and P. depressidens* (Silcox and Gunnell, 2008), are characterized by derived molar morphologies including, for example, striking enlargement of the distolingual region of the crowns of the upper molars without differentiation of a distinct hypocone and reduction in height, mesial canting, and mesiodistal compression of the trigonid. For descriptions and discussions of these and other synapomorphies of the genus see Silcox and Gunnell (2008) and references cited therein. The teeth preserved in collections from the Farrand Channel and Horsethief Canyon local faunas are characterized by these generic synapomorphies.

Paromomys farrandi n. sp.

(Figs. 6-7)

Type specimen—V-76170, UCMP 189520, fragment of a right dentary with p4, m2-3.

Referred specimens—V-73094; p4, UCMP 157701, 157702; m1, UCMP 157709; m2, UCMP 157704, 157705, 192153; m3, UCMP 157707; P4, UCMP 157712, 157713; M1, UCMP 157717, 157718, 157719; M2, UCMP 157714, 157715. V-73095; m1, 157703, 192152; m3, UCMP 157708, M1, UCMP 157720; M2, UCMP 157716. V-76170; p4, UCMP 189521, 189522; m1, UCMP 189523, 189524, 192151; m2, UCMP 189525, 189526, 189527, 189528; M2, UCMP 189529, 189530, 189531.

Etymology—Named for Mr. Rick Farrand to recognize his many contributions to our field program in northeastern Montana including his discovery of the microvertebrate sites in the Farrand Channel deposits.

Diagnosis—Shares with *Paromomys maturus* and *P. depressidens* the derived characters of molar morphology characteristic of the genus noted above. Differs from both *P. maturus* and *P. depressidens* in the plesiomorphic character of a smaller lower incisor whose root does not extend distally below the alveoli of p2. In comparison to the large samples from Swain Quarry (Rigby, 1980), the mean values and observed ranges of variation of the length and width of the distal premolars and molars of *P. farrandi* (Table 3) are smaller than those of *P. maturus*. For example, the lengths of the lower molars of *P. farrandi* are approximately 75% of those of *P. maturus.* Most of the observed ranges of variation do not overlap; the exception is the width of the trigonid of m2 where the ranges overlap by 0.05 mm. Similarly the mean values of the comparable dimensions of *P. farrandi* are larger than those of *P. depressidens.* For example, the lengths of the lower molars of *P. farrandi* are approximately 115% of those of *P. depressidens.* However, most observed ranges of variation of the widths of p4 and the molars overlap slightly.

Description—Two P4s (Fig. 7A), one fragmentary, have a distinct paracone and protocone. The crest of the markedly expanded postcingulum of UCMP 157712 is blunted by wear. On both a small mesiobuccal basal cingulum, but not a distinct parastyle, is present. The distal crest of the paracone meets the buccal extension of the margin of the postcingulum at the distobuccal corner of the crown. Neither a metacone nor conules are present. P4 was supported by three roots.

The isolated upper molars identified as M1s have a narrow ectocingulum, usually slightly bowed by a shallow ectoflexus. The ectocingulum extends along the entire buccal margin of the crown linking the buccal ends of the preparacrista and postmetacrista (Fig. 7B). Parastylar and metastylar cusps are not present. Paracone and metacone are low, approximately equal in size and height, and linked by a straight centrocrista. Paraconule and metaconule are not distinct cusps but simply the junctions of low pre- and postparaconular and pre- and postmetaconular cristae. The preparaconular and postmetaconular cristae are directed to the bases of the parastylar and metastylar regions. The postparaconular and premetaconular cristae extend partway down the slopes of the paracone and metacone. The basin of the trigon is broad and shallow. The postprotocrista is little more than a line marking a change in slope from the trigon basin onto the expanded postcingulum, which is encircled lingually and distally by the postprotoconal crista and postcingulum but is not basined. A distinct hypocone is not present. The protocone rises slightly above the trigon basin. Lingually from a point dorsal to the paracone the precingulum extends onto the mesial face of the protocone.

Isolated molars identified as M2s (Fig. 7C) differ subtly from the M1s in their deeper ectoflexus. Also, on M2s, the postcingulum is relatively broader and extends farther distally. On the buccal face of the crown, the groove separating postcingular lobe from the protocone tends to be broader. M3s referable to *Paromomys farrandi* have not been recovered.

The dentary of UCMP 189520 (Fig. 6) increases slightly in depth from below p2 to m3. Mental foramina are present below the mesial root of p2 and the distal root of p4. Mesial to p4 two pairs of

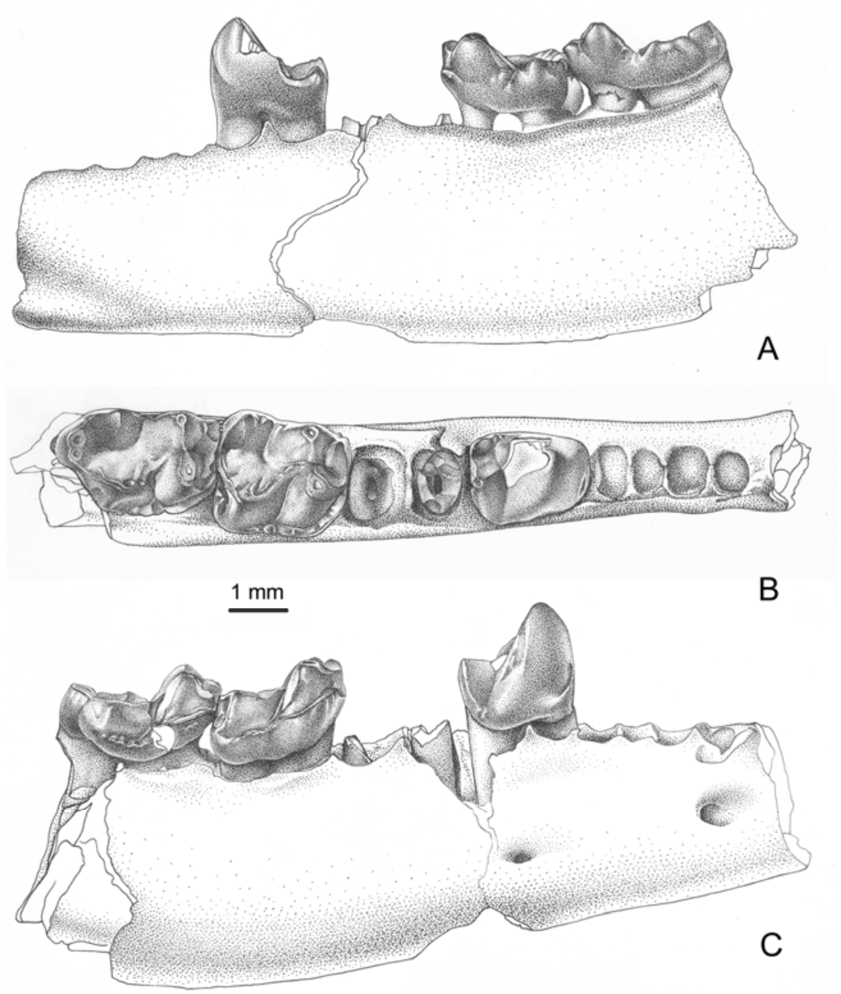

Figure 6. *Paromomys farrandi* n. sp., type specimen, fragment of a right dentary with p4, m2-3, UCMP 189520 in (**A**) lingual, (**B**) occlusal, (**C**) buccal views.

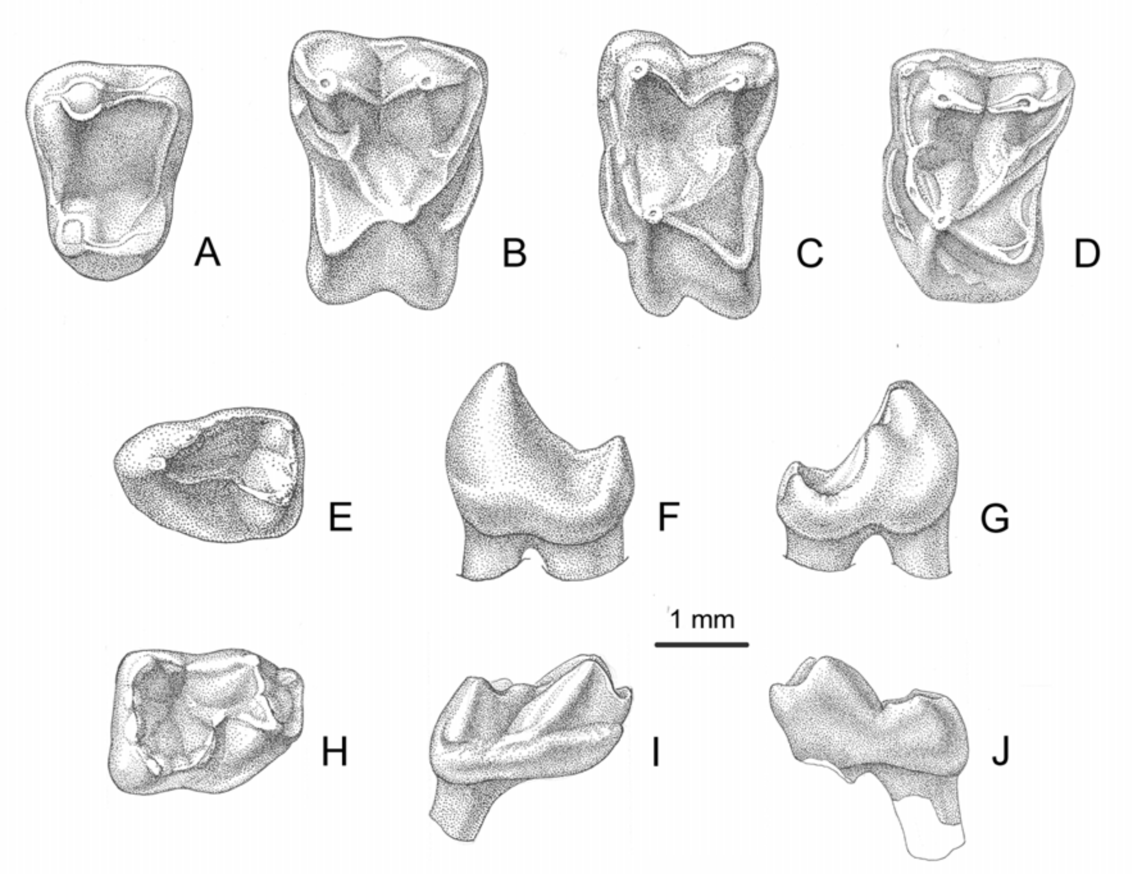

Figure 7. *Paromomys farrandi* n. sp., left P4, UCMP 157712 in (**A**) occlusal view; right M1, UCMP 157717 in (**B**) occlusal view; left M2, UCMP 157715 in (**C**) occlusal view. *Paromomys* cf. *P. farrandi* n.sp., left M1 or M2, UCMP 189575 in (**D**) occlusal view. *Paromomys farrandi* n.sp., left p4, UCMP 189522 in (**E**) occlusal, (**F**) buccal, (**G**) lingual views; right m1, UCMP 157703 in (**H**) occlusal, (**I**) buccal, (**J**) lingual views.

alveoli, with the mesial alveolus of each pair of slightly smaller diameter, probably received the roots of p2 and p3. A short diastema separates the mesial alveolus of p2 from the distal wall of what appears to have been the alveolus for a large canine. In mesial view, the broken margins of the dentary are thin except lingually where the thicker broken margin of the distal end of the symphysis is exposed. The distal wall of the canine alveolus forms the remainder of the dorsal half of the specimen. This wall ends ventrally in a pocket that opens distally into the dental canal. A small groove on the ventrolingual side of this pocket might mark the course of the mesial segment of the dental canal. The remainder of the pocket is interpreted as part of the wall alveolus of an enlarged incisor. This chamber extended distally slightly beyond the canine alveolus to about the level of the front of the alveolus for the mesial root of p2.

The p4 of UCMP 189520 is dominated by a high protoconid that is about twice the height of the talonid (Fig. 6). The mesial end of the crown is swollen. It lacks a distinct mesiobasal cusp but minute buccal and lingual basal crests are present. The prominent cristid obliqua descends from the protoconid to the hypoconid separating the small talonid basin from the hypoflexid. The distolingual side of the p4 of UCMP 189520 is damaged, but on four isolated p4s, this area is intact. On three of these premolars, the cristid obliqua is slightly enlarged below the apex of the protoconid, and on one, the expansion rises high enough to have a minute but distinct apex (Fig. 7E-G). Of the cusps of the talonid, the hypoconid is the largest, the entoconid is small but distinct, and a hypoconulid is not differentiated.

The m1 is missing from UCMP 189520, but six isolated molars are referred (Fig. 7H-J). Resembling m2 and m3 the trigonid of m1 is relatively low and mesially canted. Protoconid and metaconid are bulbous and of approximately the same height. The protocristid, oriented obliquely relative to the mesiodistal axis of the crown, is shallowly notched. The small, low paraconid is slightly salient mesially. The paracristid, which extends mesially from the protoconid and then turns lingually to the paraconid, and the protocristid, partially delimit a very small trigonid basin. Both the hypoconid and entoconid are distinct linked by a crenulated cristid. A distinct hypoconulid is not present. The floor of the talonid basin is relatively shallow and somewhat undulating. The cristid obliqua extends partway up the back of the trigonid ending near the low point of the protocristid. Lingual basal cingulids are lacking but a mesiobuccal basal cingulid is weakly developed and irregularly crenulated. It extends around the trigonid to end on the mesial or buccal face of the hypoconid.

Unlike m1s, the small but distinct paraconid of m2 is closely appressed against the metaconid (Fig. 6). The protocristid is more transversely oriented, and the mesial and buccal basal cingulids tend to be more strongly developed.

The m3 of UCMP 189520 (Fig. 6) and isolated m3s are longer but tend to be narrower than m2. Morphologically the trigonids of m3 and m2 are similar in their relatively small size, position of the paraconid, and orientation of the protocristid. Resembling m2s, the cristid obliqua of the m3s intersects the distal wall of the trigonid below or slightly buccal to the middle of the protocristid. A low hypoconid and entoconid flank the floor of the mesial part of the shallow talonid basin. The elongated hypoconulid is expanded buccally but does not exceed half the width of the mesial portion of the talonid basin. On UCMP 189520, the hypoconulid terminates in two small but distinct cusps; on other m3s the hypoconid has a single apical cusp.

Discussion—The dental morphologies and dimensions of samples of *Paromomys maturus* and *P. depressidens* from their type locality, Gidley Quarry, Crazy Mountain field, Montana, as well as Swain Quarry, Wyoming, have been thoroughly analyzed (see Simpson, 1937 and 1955; Bown and Rose, 1976; Rigby, 1980; Gunnell, 1989; Bloch et al., 2002). In both samples, *P. maturus* is more abundantly represented and its dentition is distinctly larger than that of *P. depressidens*. Dental dimensions of *P. farrandi* are, for the most part, slightly larger than those of *P. depressidens* and smaller than those of *P. maturus* from the Gidley and Swain Quarries.

Morphologically the lower dentition of *Paromomys farrandi* most closely resembles that of *P. depressidens*. It lacks synapomorphies of *P. maturus* including greater reduction in size and distinctness of the paraconids, reduction in size and prominence of the mesiobuccal and buccal cingulids of the lower molars**,** and greater lateral expansion of hypoconulid of m3. In contrast, the presence of a very small metaconid on p4 and the buccal position of the intersection of the cristid obliqua with the trigonid of m3 can be interpreted as derived characters. The upper dentition of *P. farrandi* also shows a mixture of primitive and derived characters, for example, the lack of a parastylar cusp on P4, and the distinctly

Table 3. Dimensions (in mm) of specimens of *Paromomys farrandi* n. sp.

UCMP 189520, holotype

	p4	m2	m3
Length (L)	2.16	2.49	3.07
Trigonid width (MW)	1.55	2.01	1.80
Talonid width (DW)		2.14	1.84

Hypodigm

	P4			M1			M2		
	N	OR	M	N	OR	M	N	OR	M
BL	2	1.99-2.27	2.13	3	2.33-2.46	2.40	3	2.17-2.34	2.25
MW	1	2.63		3	3.24-3.53	3.41	4	3.15-3.63	3.40
DW				2	3.16-3.29	3.23	3	3.07-3.35	3.22

	p4			m1			m2			m3		
	N	OR	M	N	OR	M	N	OR	M	N	OR	M
L	5	1.99-2.27	2.18	5	2.22-2.24	2.30	8	2.30-2.50	2.39	3	2.74-3.07	2.88
MW	5	1.28-1.55	1.42	5	1.48-1.73	1.61	8	1.70-2.15	1.93	3	1.71-1.82	1.78
DW				5	1.62-1.92	1.74	8	1.68-2.17	1.96	3	1.50-1.84	1.69

bilobed lingual margins of the upper molars appear to be derived relative to those of *P. depressidens*. Recently Bloch et al. (2002) analyzed the phylogenetic relationships of *Paromomys* to other currently known genera of paromomyids. Recognition of *P. farrandi* does not alter the branching patterns of these relationships. In contrast, the limitation of the stratigraphic range of the genus to the younger part of the Torrejonian shown by Bloch et al., 2002 (note fig. 7) must be modified. In addition to its type locality, *P. depressidens* or taxa compared with this genus and species have been reported from Tiffanian localities in the Western Interior and California (see Lofgren et al., 2004 and 2008).

Discovery of *Paromomys farrandi* clearly extends the documented range of *Paromomys* earlier into the early Torrejonian (To1). Two isolated lower molars from the School Well Local Fauna of southeastern Montana were referred to *P. maturus* (Hunter et al., 1997). This local fauna probably is of Torrejonian age, but the sample is small and the local fauna cannot be allocated to a particular interval zone. To the south, isolated paromomyid molars have been reported from two To1 localities, Upper Kimbetoh Arroyo (UALP loc. 77113) in the San Juan Basin, New Mexico, and Dragon Canyon, Utah (Tomida and Butler, 1980; Tomida, 1981; Cifelli et al., 1999). Gunnell (1989) tentatively referred some of these teeth to *P. depressidens*. He noted that the lower molar from Kimbetoh Arroyo differed from those of typical *Paromomys* in its size and distinctness of the paraconid. “It is slightly larger than expected for *P. depressidens*, but smaller than would be expected for *P. maturus*” (Gunnell, 1989:14). Robison (1986) tentatively referred a lower molar from the To1 Dragon fauna, Utah, to *Paromomys* cf. *P. depressidens* and noted its intermediate size when compared to large samples of *P. depressidens* and *P. maturus*. Larger samples from these southern localities might well reveal that these few isolated teeth were derived from individuals referable to *P. farrandi*. Whatever the outcome, the evidence currently available supports the conclusion of Bloch et al. (2002) that the differentiation of *Paromomys* from a clade including *Acidomyomys, Ignacius*, and *Phenacolemur* occurred very early in the Torrejonian if not in the Puercan.

Paromomys cf. *P. farrandi*
(Fig. 7D)

Referred specimen—V-73094, UCMP 189575, left M1 or M2.

Description—UCMP 189575 (Fig. 7D) is of appropriate size (L = 2.46 mm; DW = 3.24 mm) to be referred to *Paromomys farrandi* and morphologically its ectocingulum, paracone, and metacone closely resemble those of the isolated upper molars referred to this species. In contrast, lingually the crown differs significantly. Its conules and associated crests are more distinct. Also, the trigon basin is more distinctly separated from the expanded postcingulum. Above the metaconule, the postvallum wall of the crown separates the trigon basin from the postprotoconal cingulum. Lingually the height of the postvallum wall decreases to disappear in the region above the protocone. Here the postprotocrista is reduced to a break in slope between the talon basin and the postcingulum. Finally, the lingual face of the protocone is essentially flat, lacking the pronounced vertical cleft that in *P. farrandi* and other species of *Paromomys* divides it into distinct mesial and distal lobes.

Discussion—On all the isolated upper molars referred to *Paromomys farrandi* the conules are greatly reduced. Between the minute metaconule and protocone the junction of the trigon basin and postcingulum is marked by a low postprotocrista, which is little more than a break in slope. The lingual face of the crown is distinctly bilobed. These three characters are accentuated in *P. maturus* and other paromomyids. UCMP 189575 appears to document a more primitive condition in which these characters were just beginning to be expressed. Given the small size of the available sample from the To1 localities in Montana UCMP 189575 might either exemplify an extreme in the range of morphological variation of *P. farrandi* or document the survival of a sister species retaining more primitive traits. Until larger samples of these local faunas are obtained it is appropriate to leave this question unanswered and simply highlight the more primitive morphology of UCMP 189575.

UNGULATA Linneaus, 1766
PROCREODI Matthew, 1909

ARCTOCYONIDAE Giebel, 1855
CHRIACINAE Osborn & Earle, 1895
Chriacus Cope, 1883
Chriacus cf. *C. calenancus* Van Valen, 1978
(Fig. 8A-C)

Referred specimen—V-76170, UCMP 189541, left M2.

Description—UCMP 189541 is a well preserved, left M2 that is missing only the distal root and distobuccal corner of the crown. The crown shows minor wear. In occlusal view, the crown has a subquadrate appearance. The paracone and metacone are relatively low, conical, and moderately separated from each other. Of the three main cusps, the paracone is the tallest and is in a slightly more buccal position than the metacone. The postpara- and premetacrista are distinct; whereas the preparacrista and postmetacrista are less distinct. The preparacrista extends mesiobuccally to a small parastylar lobe that forms a sharp angle and ends in a small parastyle. A narrow stylar shelf is bordered by a narrow but distinct ectocingulum. The ectoflexus is shallow and appears symmetrical although the distobuccal corner of the crown is missing.

The conules are distinct and well separated with the paraconule being slightly larger than the metaconule. Separation of the conules contributes to a mesiodistally expanded conule region and a quadrate rather than a triangular occlusal outline. The internal cristae of the conules are faint whereas the external cristae are more distinct. An additional crista extends from the apex of the paraconule to the midpoint of the base of the paracone. The preparaconular crista intersects the precingulum, whereas the postmetaconular crista ends at the lingual base of the metacone. The protocone has a slightly more inflated appearance than the buccal cusps, is not mesially recumbent, and has a somewhat lingually

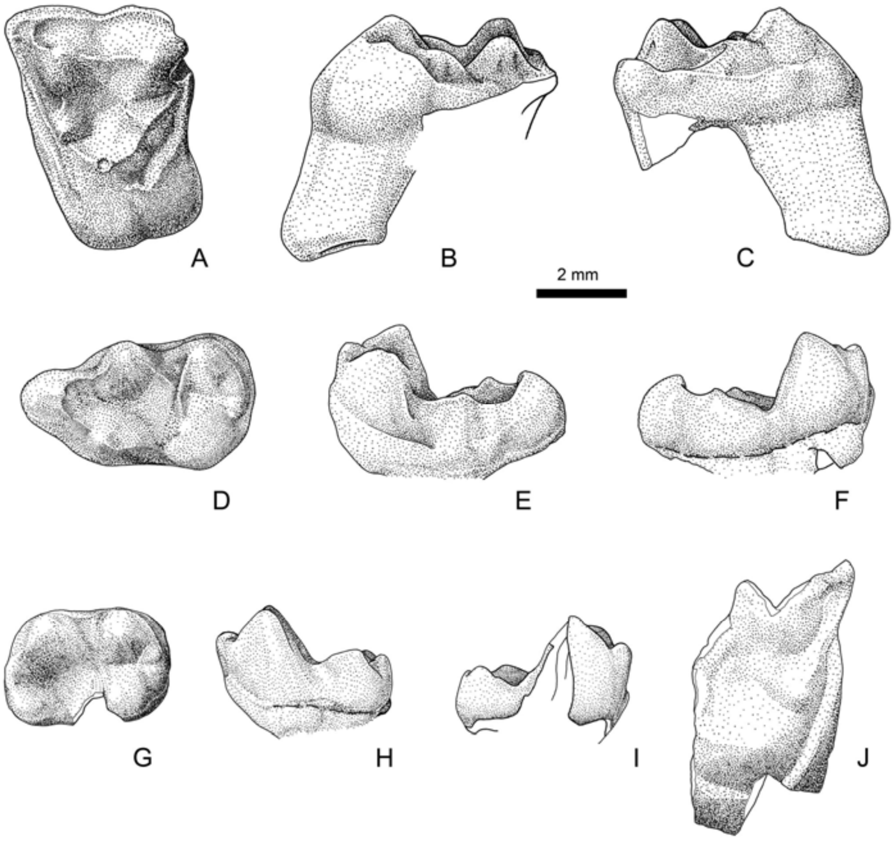

Figure 8. *Chriacus* cf. *C. calenancus*, left M2, UCMP 189541 in (**A**) occlusal, (**B**) distal, (**C**) mesial views. *Chriacus* cf. *C. punitor*, left m3, UCMP 189547 in (**D**) occlusal, (**E**) buccal, (**F**) lingual views. *Prothryptacodon albertensis*, left m1 or m2, UCMP 189545 in (**G**) occlusal, (**H**) buccal, (**I**) lingual views. *Chriacus baldwini*, right M1 or M2, UCMP 152405 in (**J**) occlusal view.

expanded base. The precingulum is broad and extends lingually from the parastylar lobe beyond the apex of the protocone but does not connect to the postcingulum; instead, it swings gently ventrad toward the apex of the protocone. The postcingulum strongly swings ventrad just lingual to the metaconule and forms a moderately developed hypocone with a linguodistally-inflated base. As a result, the distal margin of the crown appears concave in occlusal view. The dental dimensions of UCMP 189541 are as follows: minimum BL = 4.59 mm, MW = 5.74 mm, DW = 5.91 mm.

Discussion—UCMP 189541 is referred to *Chriacus* based on the subquadrate occlusal outline, the separation of the buccal cusps, the slightly lingual position of the metacone, and the moderate development of the lingual cingula and hypocone. It is not as transversely expanded as upper molars of more primitive taxa, such as *Oxyclaenus* and *Carcinodon*. Upper molars of *Chriacus pelvidens*, *C. oconostotae*, *C. katrinae*, and *C. baldwini* are considerably larger than UCMP 189541 and they tend to have complete endocingula. The Farrand Channel specimen is somewhat similar in size to *C. metocometi* (Van Valen, 1978), but is most similar in size and degree of inflation to *C. calenancus*. Direct comparisons of UCMP 189541 with M2s of *C. calenancus* from Purgatory Hill (UMVP 2255, UMVP 1608) indicate that the Farrand Channel form differs from the latter in some morphological details: it has a larger, more linguodistally expanded hypocone; the crown is more transversely expanded; it has a larger stylar shelf; and the protocone is not as mesially recumbent. These may be turn out to be interspecific differences, but until more material is available, we tentatively refer UCMP 189541 to *C. calenancus*. This taxon has been reported from the Tullock Formation in northeastern Montana (Purgatory Hill; Van Valen, 1978) and tentatively from the Bear Formation in south central Montana (Simpson Quarry; Buckley, 1994), both of which are considered late Puercan (Pu2 or Pu3; Lofgren et al., 2004).

Chriacus baldwini (Cope, 1882a)
(Fig. 8J)

Referred specimen—V-73094, UCMP 152405, fragment of a right M1 or M2.

Description—UCMP 152405 preserves most of the mesial half of the crown. The lingual half of the paracone is preserved, as is the preparacrista, most of the trigon basin, the protocone, the precingulum, and some of the distal aspect of the protocone and postcingulum. The paracone is a conical with sharp pre- and postparacrista extending from the apex. The preparacrista extends in a mesiobuccal direction to a small, broken parastylar area with a small but distinct parastyle. The paraconule is well developed and well separated from what remains of the metaconule. Internal cristae are not evident, as the conules are rounded on their internal faces. The preparaconular crista is sharp and extends past the mesiolingual base of the paracone to form a paracingulum that extends to the parastyle. The protocone is mesiodistally broad and the pre- and postcristae that extend from the protocone apex form a broad angle. At its base, the protocone is not lingually expanded. The buccal extremity of the precingulum extends dorsally to the paracingulum and just buccal to the lingual base of the paracone. The nature of the lingual extremity of the precingulum is uncertain, as a sliver is missing from the mesiolingual base of the crown. Nevertheless, based on the width of the lingualmost preserved extremities of the precingulum and postcingulum, the precingulum likely connects or nearly connects with the postcingulum. Of the postcingulum, only the lingual extremity is preserved. The hypocone is not preserved, but in the presumed position of the hypocone, the postcingulum shows evidence of an abrupt widening suggestive of the presence of a small cusp. The lingual margin appears rounded in occlusal view. Dental dimensions of UCMP 152405 are: minimum BL = 3.75 mm, minimum MW = 5.93 mm.

Discussion—UCMP 152405 is referred to *Chriacus* based on what remains of a subquadrate occlusal outline, a conical paracone with sharp cristae, a complete or nearly complete endocingulum, a broad protocone, and evidence of a small hypocone. The specimen is referable to *C. baldwini* rather than *C. pelvidens* based on its smaller size and more rounded lingual margin. *C. baldwini* makes its first occurrence at the beginning of the Torrejonian and persists into the Tiffanian (e.g., Williamson, 1996; Fox, 1988).

Chriacus cf. *C. punitor* (Simpson, 1935)
(Fig. 8D-F)

Referred specimen—V-76170, UCMP 189547, left m3.

Description—UCMP 189547 is a well preserved, left m3, although its roots are missing. Its enamel is weakly wrinkled. The trigonid is moderately taller and wider than the talonid. The trigonid cusps have a somewhat inflated appearance. The paraconid is reduced, in a mesiobuccal position relative to the metaconid, and appressed against the base of the metaconid. The metaconid is taller than and in a slightly distal position relative to the protoconid. The paracristid is weakly developed; whereas the protocristid is slightly more distinct. In distal view, the bases of the protoconid and metaconid are laterally expanded and sloped. The buccal cingulid is strong and extends from the mesial aspect of the crown to the buccal base of the hypoconulid, but is interrupted at the widest part of the hypoconid. The talonid is mesiodistally elongate and in occlusal view, its outline resembles a mitten. Talonid cristids are sharp and interrupted by small talonid cusps. The hypoconid is in a more mesial position than the entoconid and the hypoconulid is well separated from both the entoconid and hypoconid. The entocristid-postcristid ridge is taller than the cristid obliqua. The cristid obliqua meets the base of the distal aspect of the trigonid just buccal to the protocristid notch. The hypoconulid is large and its apex is mesially recurved. Dental dimensions of UCMP 189547 are: L = 5.35 mm, MW = 3.23 mm, DW = 2.95 mm.

Discussion—Direct comparisons were made with casts, specimens, and figures of the following arctocyonid genera: *Oxyclaenus*, *Carcinodon*, *Chriacus*, *Mimotricentes*, *Prothryptacodon*, *Thryptacodon*, and *Loxolophus*. The Farrand Channel form is larger than m3s of *Carcinodon aquilonius* and the expected size of m3s of *Prothryptacodon albertensis*. It also differs from the m3s of those taxa in having more wrinkled enamel and a more inflated crown. UCMP 189547 differs from m3s of *Loxolophus*, *Mimotricentes*, and *Thryptacodon* in having taller trigonids and less developed enamel wrinkling. It differs from m3s of species of *Oxyclaenus*, except perhaps *O. simplex*, in that the paraconid is much reduced and more buccal in position, the crown is more inflated, and the talonid is wider. It is nearly identical in size and morphology to m3s of *Chriacus punitor* (holotype USNM 9288 and USNM 9285). Although Van Valen (1978) suggested that *C. punitor* is a junior synonym of *C. orthogonius*, Archibald et al. (1987) considered *C. punitor* a separate species. Archibald (1998) later followed Van Valen (1978) in considering *C. punitor* a junior synonym of *C. orthogonius.* Scott et al. (2002) recombined *C. orthogonius* including *C. punitor as Thryptacodon orthogonius*. We tentatively consider *C. punitor* a separate species that belongs within *Chriacus* rather than *Thryptacodon*. The height of the trigonid, relative sharpness of cusps, and degree of wrinkling are more similar to *Chriacus* than to *Thryptacodon*.

Prothryptacodon Simpson, 1937
Prothryptacodon albertensis Fox, 1968
(Fig. 8G-I)

Referred specimens—V-76170, UCMP 189545, left m1 or m2; UCMP 192150, left m1 or m2.

Description—UCMP 189545, a left m1 or m2, is missing its roots and a vertical sliver from the distolingual side of the metaconid, otherwise, the crown is in good condition (Fig. 8 G-I). The trigonid is significantly taller than and slightly wider than the talonid. The metaconid is taller and positioned more distally than the protoconid. The paraconid is reduced but still rises above the level of the trigonid basin. It is somewhat appressed to and slightly mesiobuccal to the base of the metaconid. The paracristid is faint and the protocristid apex is below the level of the trigonid basin. The buccal cingulid is strong and continuous from the mesial aspect of the crown to the hypoconulid. The distal face of the trigonid is flat and slightly sloped in the ventrodistal direction, especially near the metaconid.

The hypoconid is the largest talonid cusp, followed by the entoconid, and then the hypoconulid. The hypoconid is positioned mesially relative to the entoconid and hypoconulid, which are in close proximity to each other at the distal margin of the crown. The cristid obliqua meets the distal aspect of the trigonid ventral to the protocristid notch. A weak distal metacristid runs dorsolingually toward the metaconid. The talonid basin is moderately deep and runs mesiolingually toward a low talonid notch. The enamel in the talonid basin is slightly wrinkled. In distal view, the base of the crown is not buccally expanded. In lingual view, the base of the metaconid is slightly inflated.

UCMP 192150 is in excellent condition and is nearly identical to UCMP 189545 in morphology. It differs in that the paraconid is not as reduced, the buccal cingulid is interrupted at the widest buccal aspect of the talonid, and the crown is slightly wider. Dental dimensions are: UCMP 189545, L = 3.86, minimum MW = 2.69, DW = 2.65; UCMP 192150, L = 3.84 mm, MW = 2.79 mm, DW = 2.84 mm.

Discussion—Direct comparisons were made with casts, specimens, or figures of many arctocyonid genera, including *Carcinodon*, *Prothryptacodon*, *Mimotricentes*, *Oxyclaenus*, and *Chriacus*. The Farrand Channel form differs from lower molars of *Oxyclaenus* and *Chriacus* in having moderately high trigonids and in lacking the buccal expansion and inflation of the talonid. It is most similar to lower molars of *Carcinodon aquilonius* and *Prothryptacodon albertensis* (Russell, 1974; Fox, 1968). Russell (1974) distinguished *C. aquilonius* from *P. albertensis* based on a mesially projecting paraconid; however, Van Valen (1978) made *C. aquilonius* a junior synonym of *P. albertensis* and placed the latter species in *Oxyprimus*. Johnston and Fox (1984) later revalidated the two separate species, citing the mesially projecting paraconid of *C. aquilonius* and its larger size. They also removed *P. albertensis* from *Oxyprimus*, citing the more derived premolars of *O. erikseni*. We agree with Johnston and Fox (1984). Because the Farrand Channel form lacks the mesially projecting paraconid, and its dental dimensions agree with those of *P. albertensis* given by Fox (1968) (corrected by Van Valen, 1978) and Scott (2003), we refer UCMP 189545 and UCMP 192150 to *P. albertensis* rather than *C. aquilonius*. As a side note, Johnston and Fox (1984) questioned whether specimens that Van Valen (1978) referred to "*Oxyprimus albertensis*" from Purgatory Hill, northeastern Montana belong to *C. aquilonius*, *P. albertensis*, or another species of *Oxyprimus*. Casts of "*Oxyprimus albertensis*" lower molars from Purgatory Hill that were available to us are larger than UCMP 189545 and UCMP 192150, and a few have mesially projecting paraconids and buccal cingulids that are incomplete or undetectable. These specimens may be referable to *C. aquilonius* rather than *P. albertensis*; a pending analysis of the large samples from the approximately contemporaneous and nearby Garbani Channel localities should help clarify this taxonomic confusion. *P. albertensis* from the Farrand Channel local fauna might be the first occurrence of this taxon in the early Torrejonian. This taxon also occurs in the Who Nose? local fauna of south central Alberta (Scott, 2003), which Lerbekmo and Sweet (2000) considered early Torrejonian in age based on magnetostratigraphy and biostratigraphy, but Scott (2003) considered it late Torrejonian based on the mammals.

OXYCLAENINAE Scott, 1892
Oxyclaenus Cope, 1884b
Oxyclaenus cf. *O. simplex* (Cope, 1884b)
(Fig. 9A-C)

Referred specimen—V-73094, UCMP 148325, left m3.

Description— A portion of the crown of UCMP 148325 mesial to the trigonid cusps is missing, as well as the buccal base of the trigonid and the distalmost part of the talonid, including the hypoconulid. The trigonid is moderately taller and wider than the talonid. The talonid cusps are not greatly inflated. The metaconid is taller than the protoconid and in a slightly more distal position. The paraconid is smaller than the protoconid but still well developed. It is well separated from the metaconid. The paracristid is largely lost, except the portion immediately descending from the paraconid apex and the portion ascending the protoconid, which both appear sharp. The protocristid is also sharp and forms a deep protocristid apex. As in other oxyclaenine specimens, a rounded ridge or subtle fold extends from the metaconid notch down the distal aspect of the trigonid. The ridge has a kink or swelling near its ventral termination. Otherwise, the distal aspect of the trigonid is flat and slopes slightly ventrodistally. Although the hypoconulid is missing from the talonid, the hypoconulid seems to have been distally expanded as is typical for m3s. The hypoconid is slightly taller and significantly more voluminous than the entoconid. The talonid is broad and relatively shallow. The enamel lingual to the hypoconid is weakly wrinkled. The cristid obliqua is sharp and contacts the distal aspect of the trigonid immediately below the protocristid notch. The entocristid is relatively low and forms a talonid notch at the distal aspect of the trigonid.

Although much of the base of the buccal aspect of the crown is missing, a discontinuous buccal cingulid is minimally present at the hypoflexid and between the hypoconid and the hypoconulid. In distal view, the lingual aspect of the crown is weakly convex; whereas the buccal aspect of the crown appears to have been subvertical to slightly buccally sloped. Dental dimensions of UCMP 148325 are: minimum L = 4.47 mm, minimum MW = 2.99 mm, DW = 2.73 mm.

Oxyclaenus cf. *O. subbituminus* Middleton and Dewar, 2004
(Fig. 9D-F)

Referred specimens—V-73094, UCMP 148324, right M1 or M2; UCMP 148328, left m2; V-76170, UCMP 189546, left dp4.

Description—UCMP 148324 is well preserved except for loss of the mesiobuccal corner and a small sliver at the lingual base of the crown. The paracone is largely missing, but its distal and lingual bases suggest that it was noticeably larger than the metacone and positioned closer to the buccal margin. The metacone is conical in shape and uninflated, as are all of the other cusps and cuspules. The metacristae are faint but sharp. The postmetacrista extends in a buccal direction toward a small but distinct metastyle. A thin ectocingulum borders the narrow metastylar shelf. The paraconule is larger than the metaconule and positioned slightly closer to the protocone. The internal and external conule cristae are distinct. The preparaconular crista is broken buccally. The postmetaconular crista swings around the distolingual base of the metacone to form a relatively broad metacingulum. The metacingulum, which connects to the metastyle, exhibits natural wear. The precingulum is broken buccally, but lingually it is low and extends just past the apex of the protocone. The buccal end of the postcingulum terminates at a point dorsal to the metacingulum and just lingual to the base of the metacone. In distal view, the postcingulum slopes ventrolingually. It terminates at a point just lingual to the apex of the protocone and slightly ventral to the lingual extremity of the precingulum. The hypocone is a small cuspule on the postcingulum that is distal and just lingual to the apex of the protocone. The uninflated nature of the cusps and the low cingula give the crown a triangular to subquadrate shape in occlusal view. Dental dimensions of UCMP 148324 are: minimum BL = 3.28 mm, minimum MW = 5.04 mm, DW = 5.19 mm.

UCMP 148328 (Fig. 9D-F) is a well-preserved, left m2 that is only missing a small chip of enamel from the lingual aspect of the metaconid and the mesial root. The trigonid is moderately taller and slightly narrower than the talonid. The m2s of this taxon tend to have trigonids and talonids that are subequal in width (Middleton and Dewar, 2004). The metaconid is more voluminous, somewhat taller, and more distally positioned than the protoconid. The paraconid is small, distinct, and mesial to the metaconid. A strong paracristid extends buccally from the paraconid and turns sharply in the distal direction toward the protoconid. The protocristid has a narrow V-shape and exhibits wear. The distal aspect of the trigonid is flat and slopes slightly distoventrally. A strong cingulid is present on the mesial aspect of the trigonid. It continues as a subtle trace along the buccal aspect of the trigonid and as a more distinct cingulid in the hypoflexid and along the buccal aspect of the talonid between the hypoconid and hypoconulid. The talonid basin is deep and open lingually because the entocristid abruptly terminates just before reaching the distolingual base of the metaconid, a condition found in m2s and m3s of this taxon and only sometimes in m1s (Middleton and Dewar, 2004). The enamel in the talonid basin is slightly wrinkled. The entoconid and hypoconid are subequal in height. The entoconid is positioned just distal relative to the hypoconid. The hypoconulid is small. The cristid obliqua contacts the distal aspect of the trigonid ventral and just buccal to the protocristid notch. The distal metacristid exhibits wear as it extends toward the protocristid notch. In distal view, the lingual aspect of the crown is slightly convex; whereas the buccal aspect of the crown is convex and slopes buccally. Dental dimensions of UCMP 148328 are: L = 3.95 mm, MW = 3.14 mm, DW = 3.28 mm.

UCMP 189546 is a well-preserved, left dp4. The trigonid is moderately higher than and notably narrower than the talonid. The crown is somewhat inflated, especially the medial aspects of the metaconid and protoconid. The paraconid is small, low on the trigonid, and mesially projecting. The metaconid is slightly shorter than and distolingual to the protoconid. The strong paracristid extends buccally from the paraconid a short distance before ascending dorsodistally to the protoconid. The protocristid forms a high, acute V-shaped apex. A cingulid is present low on the mesial aspect of the trigonid. It fades on the buccal aspect of the trigonid just mesial to the protoconid apex. It reappears across the hypoflexid and on the distobuccal aspect of the talonid between the hypoconid and hypoconulid. In distal view, the apex of the metaconid is somewhat lingually canted, and from this apex, a rounded ridge extends ventrally to the talonid with a subtle medial kink or bend that is occasionally observed in other oxyclaenines. The distal aspect of the trigonid is otherwise flat and slightly distoventrally sloped. On the talonid, the hypoconid is slightly larger than the entoconid, followed by the hypoconulid. The entoconid is positioned slightly closer to the hypoconulid than the hypoconid and is just distal relative to the hypoconid. The cristid obliqua meets the distal aspect of the trigonid just buccal to the protocristid notch and the distal metacristid extends toward the protocristid notch. The entocristid abruptly terminates before reaching the trigonid; with the rounded ridge from the distal aspect of trigonid, the mesial end of the entocristid forms a notch. The talonid basin is deep and runs in a mesiolingual direction toward the talonid notch. The lingual aspect of the crown is subvertical, whereas the buccal aspect of the crown is somewhat buccally sloped. Dental dimensions of UCMP 189546 are: L = 3.80 mm, AW = 2.23 mm, PW = 2.60 mm.

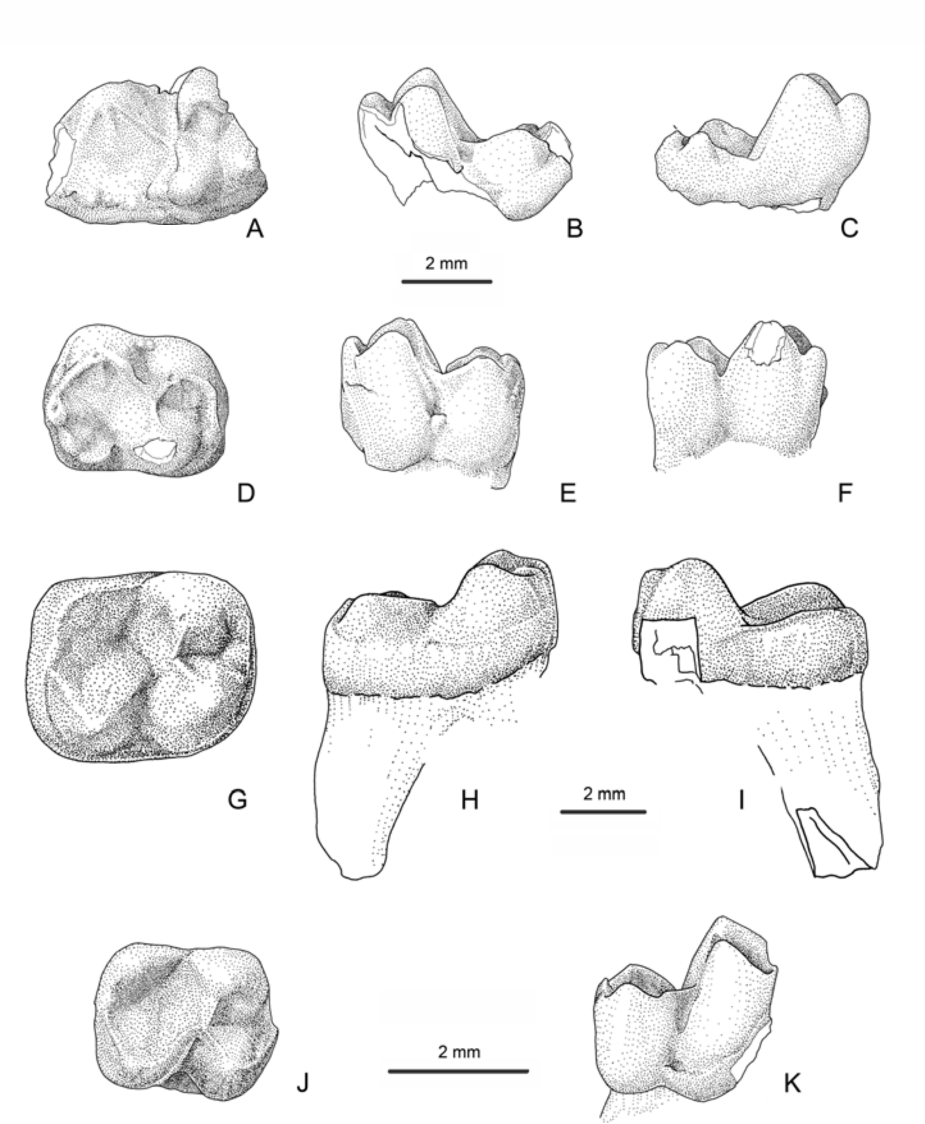

Figure 9. *Oxyclaenus* cf. *O. simplex*, left m3, UCMP 148325 in (**A**) occlusal, (**B**) buccal, (**C**) lingual views. *Oxyclaenus* cf. *O. subbituminous*, left m2, UCMP 148328 in (**D**) occlusal, (**E**) buccal, (**F**) lingual views. *Mimotricentes subtrigonus*, right m2, UCMP 189551 in (**G**) occlusal, (**H**) buccal, (**I**) lingual views. *Oxytomodon* cf. *O. perissum*, right m1 or m2, UCMP 148319 in (**J**) occlusal, (**K**) buccal views.

Discussion—Direct comparisons were made with specimens, casts, and figures of arctocyonids and mioclaenids. Relative to UCMP 148324, upper molars of mioclaenids and *Chriacus* tend to be more inflated and quadrate in occlusal view. Upper molars of *Chriacus*, with the possible exception of *C. calenancus*, also possess a nearly complete endocingulum. UCMP 148324 is similar in size to upper molars of *Carcinodon aquilonius*, but the latter is more transversely expanded, has a wider stylar shelf, and greater appression of the paracone and metacone. UCMP 148324 shares these differences to *Carcinodon* with *Oxyclaenus* (Buckley, 1994). In estimated size, UCMP 148324 is significantly smaller than *O. simplex*, *O. cuspidatus*, *O. pugnax*, and *O. antiquus*, and is more transverse than *O. corax*. It is most similar in estimated size and proportions to *O. subbituminus* from the early Puercan fauna of the Alexander locality, Denver Formation, Colorado (Middleton, 1983; Middleton and Dewar, 2004). Direct comparison of UCMP 148328 and lower molars of *O. subbituminus* (CU 47727, CU 48753) support its referral to this taxon. Deciduous premolars were not available for comparisons, but morphological features and size of UCMP 189546 suggest it is also referable to this taxon. However, due to the small sample size and the large temporal difference with the Alexander locality fauna, we tentatively refer these specimens to *O. subbituminus*.

LOXOLOPHINAE Van Valen, 1978
Mimotricentes Simpson, 1937
Mimotricentes subtrigonus Cope, 1881a
(Fig. 9G-I)

Referred specimens—V-73095, UCMP 148327, left M3. V-76170, UCMP 189543, left M3; UCMP 189549, left m1 or m2; UCMP 189588, right m1? talonid fragment; UCMP 189589, right m1 trigonid fragment; UCMP 189550, right m2; UCMP 189551, right m2.

Description—UCMP 189543 and UCMP 148327 are M3s. The former is worn, but in both specimens, the occlusal outline is ovate, the paracone is considerably taller than the metacone. Their buccal cusps are positioned near the buccal margin of the crown, such that the base of the metacone interrupts the otherwise broad ectocingulum. Neither crown has an ectoflexus. The centrocristae are strong. A weak preparacrista is evident on both specimens. The worn conules are poorly developed and well separated to form a broad trigon basin. On UCMP 189543, wear has exposed dentine along the preprotocrista and preparaconular crista. The paracingulum continues past the mesiolingual base of the paracone and connects with the very small parastyle. The pre- and postcingula are broad and discontinuous around the lingual aspect of the protocone. Buccally, the precingulum terminates dorsally and lingually to the lingual base of the paracone, and the postcingulum terminates dorsally and lingually to the metaconule. Strong wear facets are evident on the lingual cingula. UCMP 148327 is larger than UCMP 189543. Dental dimensions are: UCMP 189543, BL = 4.10 mm, MW = 5.38 mm, DW = 4.96 mm; and UCMP 148327, BL = 4.72 mm, MW = 5.86 mm, DW = 5.47 mm.

UCMP 189550 and UCMP 189551 (Fig. 9G-I) are m2s, UCMP 189549 is either an m1 or m2, and UCMP 189589 is a trigonid fragment of an m1. They are relatively well preserved, except for most of the crown of UCMP 189589, a sliver of the mesiolingual corner of UCMP 189551, and most of the mesial base of UCMP 189550, which are missing. In all three specimens, the crown is wide and low and the enamel wrinkling is weak if present. The trigonid is mesiodistally compressed. It is subequal to or slightly narrower than the talonid. It is also only slightly taller than the talonid. The paraconid is much reduced and closely appressed to the metaconid. The position of the paraconid varies from slightly lingual (UCMP 189549) relative to the metaconid to directly mesial relative to the metaconid. The metaconid is subequal to or slightly larger (UCMP 189549) than the protoconid. The metaconid and protoconid are inflated and well separated on the trigonid. Consequently, the protocristid forms a broad V-shaped apex in distal view. From the apex of the paraconid, a faint paracristid extends buccally for some distance before turning distobuccally to ascend the protoconid. The trigonid of UCMP 189589 is identical to the trigonids of the other lower molar specimens in most respects, except that in occlusal view the mesial arc of the trigonid suggests that it had a smaller mesial width and is likely an m1. On all crowns, a cingulid extends from the mesial aspect along the buccal aspect to the hypoconulid. The cingulid is thickest at the hypoflexid and weakest along the buccal aspect ventral to the hypoconid, especially on UCMP 189549. The distal aspect of the trigonid is flat and slightly sloped ventrobuccally. The talonid is wide. The hypoconid is the largest cusp of the talonid. Its internal aspect forms a broad lingual slope that extends lingually across most of the talonid width. The cristid obliqua contacts the distal aspect of the trigonid just buccal to or immediately below the protocristid notch. On UCMP 189550 and UCMP 189551, the cristid obliqua has a swollen area or kink just distal to its mesial termination. The entoconid is small and barely discernible. The hypoconulid is even smaller than the entoconid and in UCMP 189549 almost indistinguishable from small cuspids along the postcristid. The entocristid is much lower than the cristid obliqua, and it terminates at the distal aspect of the trigonid below the metaconid or just past it along the distolingual aspect of the trigonid. The talonid basin is shallow and not contained by the low entocristid. Like UCMP 189589, UCMP 189588 (right talonid) is similar to but narrower than the talonids of the other specimens. Its smaller size, side of the dentition, locality, coloration, and degree of wear suggest that it and UCMP 189589 may belong to the same crown. In distal view, the lingual aspects of all of the crowns are convex, whereas the buccal aspects are buccoventrally sloping. Dental dimensions of the specimens are: UCMP 189588, minimum DW = 4.64 mm; UCMP 189589, minimum MW = 4.23 mm; UCMP 189549, L = 5.59 mm, MW = 4.76 mm, DW = 4.84 mm; UCMP 189550, L = 5.78 mm, MW = 5.67 mm, DW = 5.87 mm; UCMP 189551, L = 6.09, MW = 5.31 mm, DW = 5.25 mm.

Discussion—Comparisons were made with specimens and casts of the following taxa: *Mimotricentes subtrigonus* (including *M. latidens* type), *Colpoclaenus*, *Desmatoclaenus*, *Baioconodon*, *Loxolophus*, *Protoselene*, *Litaletes*, *Ellipsodon*, *Choeroclaenus*, *Tiznatzinia*, *Mioclaenus*, and *Promioclaenus*. Additional comparisons were made with published descriptions and figures. The new specimens most closely resemble *Mimotricentes subtrigonus*. The M3s (UCMP 189543, UCMP 148327) differ from some comparative specimens of *M. subtrigonus* (UCMP 30001, AMNH 16563, 3240) in that the pre- and postcingula do not form a complete endocingulum (but see cast of KU 7767 and description of *M. latidens* in Simpson, 1937). The dental dimensions of UCMP 148327 fall within the range of published measurements (e.g., Rigby, 1980; Taylor, 1984). However, the dental dimensions of UCMP 189543 fall on the small end of the ranges for the large Swain Quarry sample (Rigby, 1980, table 38, note L and W ranges are inadvertently switched for M3) and below the ranges published for the smaller San Juan Basin sample (Taylor, 1984, tables 31-32). Many authors have observed a large amount of variability within this taxon (Matthew, 1897, 1937; Gazin, 1956; Van Valen, 1978; Taylor, 1984). For example, Rigby (1980:103) noted, “M3’s [of *M. subtrigonus*] are exceptionally variable, particularly in width, which affects the metaconule, posterior cingulum, and confluence of the labial and posterior cingula.” Before Williamson (1996) made *M. elassus* a junior subjective synonym of *M. subtrigonus*, Taylor (1984) suggested that it might be a smaller variant of *M. subtrigonus*. Simpson (1937) also mentioned that in the only known upper molars of *M. latidens*, the endocingulum did not encircle the protocone, as in the specimens described here. Thus, UCMP 148327 and UCMP 189543 are presently referred to *M. subtrigonus*, but larger samples sizes may show that they are referable to a smaller species, possibly a revalidated *M. elassus* or *M. latidens*.

The lower molars (UCMP 189589,189549, 189550, 189551) are also most similar to *M. subtrigonus*. That said, they share some morphological features with the lower molars of the mioclaenid genus *Promioclaenus*, including a reduced, lingual paraconid that is strongly appressed to the metaconid, moderately inflated crowns, and a tendency to reduce the hypoconulid and entoconid to a smooth ridge (Williamson, 1996). However, the specimens from the northeastern Montana faunas are considerably larger than the published lower molar measurements for all recognized *Promioclaenus* species (Gazin, 1956; Robison, 1986; Eberle and Lillegraven, 1998; Secord, 1998), and they differ in the presence of a buccal cingulid and the lack of a talonid notch. More likely, these specimens are referable to the loxolophine genus *Mimotricentes*. The similarities among mioclaenids and loxolophines that have been recognized by other authors (Hunter et al., 1997) are likely the result of convergent evolution.

The lower molars (UCMP 189589, 189549, 189550, 189551) do not exactly match comparative material of *M. subtrigonus*; however, as mentioned above, its broad range of morphological variation complicates characterization of this species. A number of species (*M. latidens*, *M. angustidens*, *M. elassus*) that were distinguished from *M. subtrigonus* based on size and slight morphological differences were made junior synonyms of the latter taxon by various workers (Van Valen, 1978; Hartman, 1986; Williamson, 1996). In support of these synonymies, Taylor (1984) cited the large sample (352 specimens) of *M. subtrigonus* from the Swain Quarry (Rigby, 1980) with a range of dental dimensions that encompasses the ranges of most previously proposed species. Yet, we suggest that important morphological variation exists in the resultant taxon that may eventually warrant resurrection of some or all of the former species. Among the various species that are now synonymized with *M. subtrigonus*, our lower molar specimens are nearly identical to the lower molars of the holotype of *M. latidens* (USNM 9269). Simpson (1935), who formally proposed this taxon, distinguished it from *M. subtrigonus* by a number of features, including broader and flatter crowns and a paraconid that is reduced, lingual, and closely appressed to the metaconid, both of which are shared with UCMP 189549, UCMP 189550, and UCMP 189551. Furthermore, the measurements for the m2 on the type specimen (USNM 9269, m2, L = 6.0 mm, W = 5.5 mm) are very close to those of our specimens. Thus, although we believe that the range of variation in size and morphology seems large for a single species (*M. subtrigonus*), we refer the lower molars in our sample to *M. subtrigonus* until larger sample sizes are available or more detailed studies of the variation within known samples of *M. subtrigonus* are complete.

ARCTOCYONIDAE?
Oxytomodon Gazin, 1941
Oxytomodon cf. *O. perissum* Gazin, 1941
(Fig. 9J-K)

Referred specimen—V-73095, UCMP 148319, right m1 or m2.

Description—UCMP 148319 is well preserved, except that it is missing a very mesial portion of the trigonid. The trigonid and talonid are subequal in width. The trigonid is moderately taller than the talonid. The protoconid and metaconid have an inflated appearance, but their apices are acute. The metaconid is slightly taller and more distal than the protoconid. Just mesial to the metaconid is a very small, discolored swelling (the apices of the protoconid and metaconid are also discolored) that we interpret as the paraconid or at least the distal portion of the paraconid apex. What remains of the paraconid portion of the paracristid is distinct and extends buccally before turning distally and ascending the protoconid. The trigonid basin between the protoconid and metaconid is deep and narrow. The protocristid forms a narrow, asymmetrical V-shaped notch. A discontinuous cingulid is present. It is strong and low along the mesial aspect of the crown; it is a thin trace along the buccal aspect of the trigonid; it picks up again at the distobuccal aspect of the trigonid and across the hypoflexid; and then is only a trace along the distal aspect of the crown. The distal aspect of the trigonid is flat and subvertical. The talonid is wide and the well excavated talonid basin is rimmed by thin, distinct talonid cristids. The hypoconid and entoconid are subequal in height and at nearly the same mesiodistal position on the crown. The hypoconulid is a much-reduced cuspid. From the hypoconid, the cristid obliqua winds sinuously to contact the distal aspect of the trigonid directly below the protocristid notch. The entocristid descends from the entoconid and terminates very low on the distal aspect of the trigonid, leaving the talonid basin nearly open. In distal view, the lingual aspect of the crown is convex, whereas the buccal aspect of the crown is convex and sloped buccally. Dental dimensions of UCMP 148319 are: minimum L = 2.65 mm, MW = 2.28 mm, DW = 2.17 mm.

Discussion—Direct comparisons were made to casts and specimens of *Litomylus*, *Haplaletes*, *Haplomylus*, and *Oxytomodon*. UCMP 148319 differs from lower molars of *Litomylus* in that the latter taxon has a larger paraconid with a more medial position and the talonid cusps are much taller, especially the hypoconulid. It differs from lower molars of *Haplaletes* in that the cristid obliqua of the latter taxon contacts the distal aspect of the trigonid buccal to the protocristid notch, and its cusps and cristids are blunter and less acute. It also differs from lower molars of *Haplomylus* in that the trigonid of the latter taxon is lower and more inflated and the metaconid has a more distal position. It is nearly identical to the lower molars of the type of *Oxytomodon perissum* (USNM 16183, dentary with m2-3). The only difference is that dental dimensions of the m2 of USNM 16183 (L = 3.47 mm, MW = 2.73 mm, DW = 2.66 mm) are larger than those of UCMP 148319 (minimum L = 2.65 mm, MW = 2.28 mm, DW = 2.17

mm). The difference may be due to tooth position (i.e., UCMP 148319 is an m1), intraspecific variation, or intrageneric variation. We tentatively assigned the Horsethief Channel form to *Oxytomodon perissum* with expectations that additional specimens will clarify its taxonomic referral. *Oxytomodon perissum* is only known from the Dragon Canyon local fauna of the North Horn Formation in central Utah.

BULBULODENTATA Archibald, 1998
CONDYLARTHRA Cope, 1881b
MIOCLAENIDAE Osborn and Earle, 1895
Mioclaeninae Osborn and Earle, 1895
Litaletes cf. *L. sternbergi* Simpson, 1935
(Fig. 10A-C)

Referred specimens—V-76170, UCMP 189542, right M2. V-76171, UCMP 189581, left M3.

Description—UCMP 189542 is a right M2 with portions of all three roots preserved. The cusp apices and cristae, especially the centrocrista, show a moderate degree of wear. In occlusal view (Fig. 10A), the crown has a subquadrate and somewhat inflated appearance. The cusps are relatively low and rounded, though the metacone is slightly taller than the paracone. The centrocrista is strong and wear has exposed underlying dentine. The preparacrista extends in a mesiobuccal direction to a small, rounded parastylar lobe. The parastyle, which shows some apical wear, is positioned just buccal to the mesiodistal line formed by the paracone and metacone. The postmetacrista is short and extends distally from the metacone to the ectocingulum. A stylar shelf is absent; instead, the buccal bases of the paracone and metacone abut the ectocingulum. The ectocingulum is well developed with the exception of some thinning distally. Midway between the paracone and metacone, the distal half of the ectocingulum turns lingually and terminates in a cuspule that may represent the incipient development of a mesostyle. The ectoflexus is very shallow and nearly symmetrical.

The conules are fairly large, inflated, and subequal. The internal cristae are distinct and show some degree of wear. The preparaconular crista continues past the mesial face of the paracone to form a paracingulum that extends to the parastylar region. The rounded postmetaconular crista ends at the distolingual base of the metacone and is separated from the postcingulum by a sulcus. The precingulum is relatively broad and exhibits a minor degree of wear. Lingually, it extends beyond the apex of the protocone and maintains a relatively constant height; it does not swing distally around the lingual end of the protocone or swing ventrally toward the protocone apex. Buccally, the precingulum terminates just dorsal to the paracingulum and the lingual base of the paracone. The postcingulum is relatively broad and has a more oblique wear facet than the precingulum, which is prominent lingual to the metacone. Lingually, the postcingulum also extends beyond the apex of the protocone. Its path has a slight ventral grade, but does not swing toward the protocone apex. It does swing slightly in the mesial direction. The lingual bases of the pre- and postcingula are inflated and the postcingulum may have had an incipient hypocone. The protocone is mesiodistally and lingually expanded and the apex is slightly mesially recumbent. The protocristae outline a broad trigon basin. Dental dimensions of UCMP 189542 are: BL = 3.96 mm, MW = 5.54 mm, DW = 5.48 mm.

Except for the lack of roots and a minor degree of wear on the cingula UCMP 189581 is a well-preserved, left M3. Its crown is ovoid in occlusal outline with a transverse width that is greater than its mesiodistal length. The paracone and metacone are rounded, and the metacone is considerably reduced in height. A faint ectocingulum extends distally from the parastyle along the buccal margin of the crown until it is interrupted by the buccal base of the metacone. The centrocrista and preparacrista are distinct; a postmetacrista is not evident. The paraconule is more prominent than the metaconule and in a more lingual position. Both have distinct internal and external cristae. The postmetaconular crista ends at the distolingual base of the metacone, whereas the preparaconular crista continues past the mesial base of the paracone to form a paracingulum that extends to the parastyle. The pre- and postcingula are broad, extend lingually beyond the apex of the protocone, but do not connect. Buccally, the precingulum terminates just dorsal to the paracingulum and the lingual base of the paracone. The postcingulum terminates just dorsal to the postmetacrista and the lingual base of the metacone. The protocone is somewhat lingually expanded and mesially recumbent. Dental dimensions of UCMP 189581 are: BL = 2.65 mm, MW = 3.78 mm, DW = 3.45 mm.

Discussion—The low cusps, quadrate occlusal outline, and inflated appearance suggest the Farrand Channel form is referable to the family Mioclaenidae. The upper molars of a few arctocyonids (e.g., *Baioconodon*) also have mesostyles or incipient mesostyles, but their molar cusps tend to be conical, well separated, and lack the inflation seen in the upper molars of mioclaenids. Muizon and Cifelli (2000) and Williamson and Carr (2007) recently reviewed the Mioclaenidae and provided an analysis of molar characters. Among mioclaenids, the Farrand Channel form possesses the following derived features: (1) it shares with *Bubogonia*, *Protoselene*, and *Litaletes* the tendency for the paracone to be subequal to rather than larger than the metacone; (2) it shares with all mioclaenids, except *Valenia wilsoni* and *Choeroclaenus turgidunculus*, a postcingulum that connects to the metastyle; (3) in particular, it shares with *Promioclaenus*, *Litaletes*, *Mioclaenus*, and *Ellipsodon* the Type 6 arrangement of Muizon and Cifelli (2000) in which the metacingulum is “captured” by the postcingulum; (4) it shares with *Promioclaenus*, *Litaletes*, *Mioclaenus*, and *Choeroclaenus* a postcingulum that at its lingual extremity is more ventrally elevated on the posterior flank of the protocone than that of the precingulum on the anterior flank of the protocone; and (5) it shares with at least the type specimen (USNM 15747) of *Litaletes mantiensis* (possible junior synonym of *L. sternbergi*; Williamson and Carr, 2007) an incipient mesostyle. Direct comparisons were made with casts of *Protoselene opisthacus* (USNM 409144), *P*.

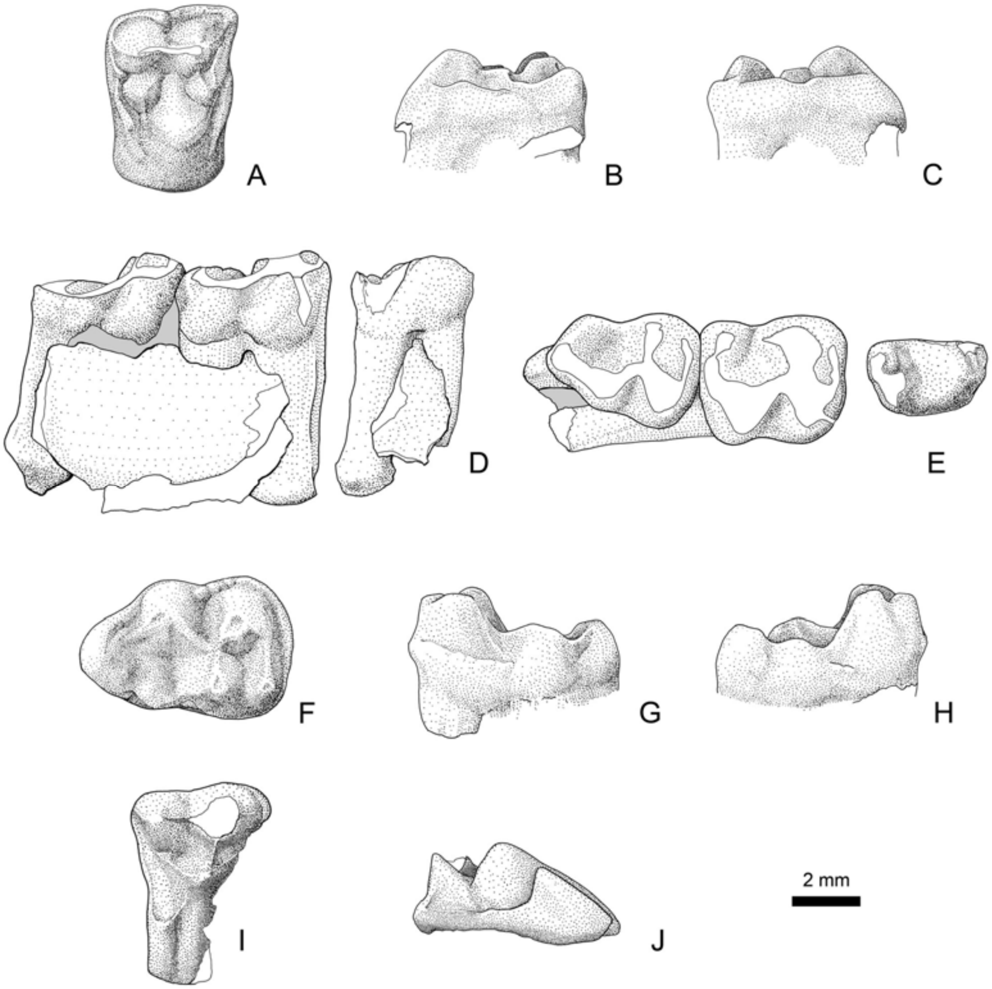

Figure 10. *Litaletes* cf. *L. sternbergi*, right M2, UCMP 189542 in (**A**) occlusal, (**B**) distal, (**C**) mesial views. *Litaletes* cf. *L. disjunctus*, right dentary fragments with p4 and m1 and m2, UCMP 189565 in (**D**) buccal, (**E**) occlusal views. ?*Promioclaenus*, left m3, UCMP 189548 in (**F**) occlusal, (**G**) buccal, (**H**) lingual views. *Anisonchus* cf. *A. athelas*, right M2, UCMP 120413 in (**I**) occlusal, (**J**) distal views.

griphus (USNM 16203), *Promioclaenus acolytus* (USNM 15294, 9575), *Mioclaenus turgidus* (AMNH 3135), *Litaletes disjunctus* (USNM 9660), *L. sternbergi* (USNM 18547, 15790), and *L. mantiensis* (USNM 15747, UCMP 47240, AMNH 87595). The Farrand Channel form is most similar to upper molars of *Litaletes*. It is considerably smaller and less inflated than upper molars of *Mioclaenus turgidus*. It differs from upper molars of *Protoselene* in that the latter are derived in having more a prominent hypocone and a well developed mesostyle; not to mention that *P. opisthacus* and *P. griphus* are also significantly larger than the Farrand Channel form. It differs from upper molars of *Promioclaenus* in that the latter are more derived in having a reduced parastylar lobe, a mesiodistally directed preparacrista, a more prominent hypocone, a postcingulum with a lingual extremity that is more ventrally elevated, and a precingulum that “captures” the paracingulum and connects with the parastyle. Although the Farrand Channel form retains more primitive characters than *Litaletes* in that the preparaconular crista rather than the precingulum connects to the parastyle and the protocone is lower, it shares with *Litaletes* all of the derived features listed above as well as primitive features, such as a medium-sized parastylar lobe, a mesiobuccally directed preparacrista, and an incipient hypocone. Williamson and Carr (2007) observed intraspecific variation in the relationship of the postcingulum, metacingulum, and postmetaconular crista. We have also observed variation within the molar series of a single individual in the relationship of the precingulum, paracingulum, and preparaconular crista. The derived condition (precingulum “capturing” the paracingulum) seems to progress in development from M1 to M3, as does the development of other derived conditions (Muizon and Cifelli, 2000). In USNM 5790, referred to *Litaletes sternbergi*, the precingulum “captures” the paracingulum on M1 (derived condition) but stops short of “capturing the paracingulum on M2 (primitive condition). Thus, the main difference between UCMP 189542 and M2s of *Litaletes* examined (the buccal extent of the precingulum) may be due to individual variation, molar position, intergeneric differences, or interspecific differences; however, additional specimens are needed to verify this. *Litaletes disjunctus* differs from the Farrand Channel form and *L. mantiensis* and *L. sternbergi* in that the M3 is not reduced and the upper molars possess a distinct hypocone (Williamson and Carr, 2007: Appendix 3; pers. obs.); thus, among *Litaletes* spp., the Farrand Channel form is most similar in morphology to *L. mantiensis* and *L. sternbergi*. UCMP 189542 is slightly smaller than M2s of *L. mantiensis* and *L. sternbergi* available for study, but may be in an acceptable range of variation. Van Valen (1978) suggested that *L. mantiensis* is a junior synonym of *L. sternbergi* and Williamson and Carr (2007) tentatively agreed. We follow these authors and tentatively refer the Farrand Channel form to *L. sternbergi*, noting that additional specimens will determine if it represents a separate species. *L. sternbergi* has previously been reported from the Dragon Canyon local fauna (Gazin, 1938, 1939, 1941; Van Valen, 1978; Williamson, 1996).

Litaletes cf. *L. disjunctus*
(Fig. 10D-E)

Referred specimens—V-76170, UCMP 189565, right dentary fragment with m2 and m3 and an associated dentary fragment with p4.

Description—The two dentary fragments included in UCMP 189565 are associated based on the proximity of discovery, color of preservation, and degree of wear. Only a small portion of the dentary on the buccal side holds m2 and m3 in place, and a smaller fragment of dentary bone remains between the two roots of p4. Despite the level of wear, the occlusal outlines and the general morphology, including the relative positions and heights of cusps, are largely discernible.

The double rooted p4 has a robust crown, of which the trigonid has been apically worn to form a nearly flat surface (Fig. 10D-E). A low, mesiolingually positioned paraconid is connected to the protoconid by a paracristid. A distolingual bulge on the trigonid suggests that a metaconid was distinct from the protoconid prior to wear. Enamel has been worn away from the distal and buccal margins of the talonid, but there is a mesiodistal ridge that connects to a talonid cuspid and asymmetrically divides the talonid into a small, nearly level lingual side and a steep buccal slope.

The m3 is not significantly reduced relative to m2. On both the trigonid is wider than and only slightly taller than the talonid. The paraconid is small, lingual, and appressed against the mesial base of the metaconid. Based on the circumferences of the metaconid and protoconid bases and on their current heights, the metaconid may have been the taller cusp. On m3, the circumference of the metaconid is not as large as on m2, giving the trigonid a more mesiodistally-compressed appearance. On both crowns, the metaconid is distally positioned relative to the protoconid, although less so on m3. The distal aspect of the trigonid is flat and distoventrally sloped. A cingulid is present low across the mesial aspect of both crowns, though it is largely obscured on m3. It appears discontinuously as a faint ectoflexid and as a trace of a cingulid along buccal aspect of the talonid between the hypoconid and hypoconulid. On both crowns, the hypoconid is large and mesially positioned relative to the other talonid cusps. The cristid obliqua contacts the distal aspect of the trigonid ventral to the protocristid notch. In fact, the worn cristid obliqua connects to the protocristid at the protocristid notch. The m3 talonid is narrower and more distally elongate than the m2 talonid. On both m2 and m3, the talonid basin appears shallow and open lingually. In distal view, the lingual aspects of the crowns are subvertical, whereas the buccal aspects of the crowns are buccally sloped and convex. Dental dimensions of UCMP 189565 are: p4 L = 3.45 mm, W = 2.38 mm; m2 L = 4.19 mm, MW = 3.76 mm, DW = 3.67 mm; m3 L = 4.35 mm, MW = 3.39 mm, DW = 2.84 mm.

Discussion—Several characters suggest that UCMP 189565 is referable to the Mioclaenidae, including mesiodistally compressed molar trigonids; reduced, lingually positioned paraconids that are appressed to the base of the metaconids; weakly developed cingulids; and inflated appearance. Among mioclaenids, the Farrand Channel form is similar to *Litaletes, Choeroclaenus*, and *Protoselene* in that the cristid obliqua contacts the distal aspect of the trigonid dorsal to the protocristid notch (Muizon and Cifelli, 2000). However, it differs from *Protoselene* in that its molar paraconids are lingually, not medially, positioned, and it differs from *Choeroclaenus* in that its molar metaconids are slightly distal to the protoconids (Muizon and Cifelli, 2000; Williamson and Carr, 2007). The Farrand Channel form differs from *Litaletes sternbergi* in that its m3 is not reduced relative to its m2, as in *L. disjunctus*. The dental dimensions are consistent with those of *L. disjunctus*. Direct comparisons with *L. disjunctus* specimens, including USNM 9323 (holotype), 9582, 9666, and AMNH 87581, further support referral of UCMP 189565 to this taxon.

?*Promioclaenus* Trouessart, 1904
(Fig. 10F-H)

Referred specimen—V-76170, UCMP 189548, left m3.

Description—UCMP 189548 is a well-preserved, left m3 with moderate apical wear. Its trigonid is somewhat taller and wider than the talonid. The trigonid is mesiodistally compressed (Fig. 10F). The metaconid is slightly taller and more distally positioned than the protoconid. The paraconid is small but distinct and mesial to and somewhat appressed to the metaconid. The paracristid is rounded. The paraconid portion of the paracristid is longer than the protoconid portion. The former extends buccally and the latter ascends distobuccally to the protoconid apex. The apices of the metaconid and protoconid are worn, but the protocristid appears to form a broad V-shaped apex. The distal aspect of the trigonid is flat and slopes slightly ventrobuccally to the talonid. The cingulid is discontinuous. It extends from low on the mesial aspect of the crown along the buccal aspect of the trigonid to the hypoflexid. It is interrupted by the widest portion of the buccal aspect of the talonid, but is evident on the buccal aspect of the talonid between the hypoconid and hypoconulid. There also appears to be a small metastylid and a stylid between the entoconid and hypoconulid. The hypoconulid is in a moderately distal position and slightly larger relative to the other talonid cusps. The hypoconid is slightly mesial relative to the entoconid. The cristid obliqua contacts the distal aspect of the trigonid directly below the protocristid notch. The entocristid slopes down to meet the distal aspect of the trigonid, but it does not leave the talonid basin open. In distal view, the lingual aspect of the crown is convex, whereas the buccal aspect is convex and slopes buccally. Dental dimensions of UCMP 189548 are: L = 4.66 mm MW = 3.27 mm, DW = 2.94 mm.

Discussion—UCMP 189548 is referable to the Mioclaenidae based on its low trigonid, inflated appearance, and paraconid in a lingual position appressed to the metaconid. In size and degree of inflation, UCMP 189548 is similar to lower molars of *Litaletes disjunctus*, *L. sternbergi*, and *Promioclaenus lemuroides*. Direct comparisons were made with casts of *L. disjunctus*, *L. sternbergi*, and *P. acolytus*. Casts or specimens of *P. lemuroides* were not available. The m3 hypoconulid of *L. disjunctus* is larger and more distally expanded than UCMP 189548. In both *Litaletes* species the talonid tends to be open due to the termination of the entocristid distal to the distal aspect of the trigonid. The m3s of *L. sternbergi* also tend to be smaller than UCMP 189548. The Farrand Channel form is morphologically closest to *P. acolytus*, but it is considerably larger than published measurements and available casts for this species. *P. lemuroides* is known to be 20% larger than *P. acolytus* and thus, this specimen may eventually be referred to that taxon, which first appears in the San Juan Basin in the earliest Torrejonian localities and may be present in the Dragon Canyon local fauna in central Utah (Williamson, 1996).

Periptychidae Cope, 1882b
Anisonchinae Osborn and Earle, 1895
Anisonchus cf. *A. athelas* Van Valen, 1978
(Figs. 10I-J, 11)

Referred specimens—V-73094, UCMP 120413, right M2. V-76170, UCMP 189564, left dentary fragment with roots of m1 and damaged crowns of m2 and m3.

Description—UCMP 120413 (Fig. 10I-J) is a moderately preserved right M2. The paracone and a segment of the mesial margin of the crown have suffered breakage. The crown is transversely elongate. The apex of the paracone is broken, but its base is larger than that of the metacone suggesting that the paracone was at least as tall as the metacone. A subtle preparacrista extends from the mesial aspect of the paracone to a weakly developed ectocingulum. The ectocingulum is discontinuous; it forms a narrow but distinct ridge on the buccal margin mesial to the midpoint of the paracone but is only a slight swelling more distally. A mesostyle is not evident. From the metacone, a strong premetacrista extends toward the broken postparacrista, whereas a less distinct postmetacrista, which exhibits minor wear, extends to the distobuccal corner of the crown. The apex of the protocone is buccally shifted and subequal in height to that of the metacone. The base of the protocone is lingually expanded, making up nearly 60% of the transverse width of the crown. Most of the preprotocrista has been lost through breakage. A postparaconular crista extends from the midpoint of the lingual base of the paracone toward the apex of the protocone. A short premetaconular crista extends from the midpoint of the lingual base of the metacone to a very small metaconule. The postmetaconular crista extends from the metaconule to the distolingual base of the metacone without intersecting the more dorsal postcingulum. The distal margin of the crown is slightly concave in occlusal view. The postcingulum forms a broad shelf that extends the length of the distal margin of the crown but does not wrap mesially around the base of the protocone; it terminates in a moderately sized hypocone distal to the protocone. The mesial margin of the crown has been lost, but based on associated characters (e.g., a well-developed hypocone), a precingulum was likely present but did not extend onto the lingual aspect of the protocone. Dental dimensions of UCMP 120413 are: BL = 4.05 mm, MW = 5.96 mm, DW = 5.67 mm.

UCMP 189564 is a left dentary fragment with the roots of m1 and the damaged crowns of m2 and m3 (Fig. 11). Some morphological details are still discernible. Despite a significant amount of damage to their occlusal surfaces, it appears that on both m2-3 the trigonid was moderately taller than the talonid. The trigonid cusps are in close proximity to each other. The paraconid was small and medially positioned. On m2, the lingual aspects of the metaconid and paraconid are crushed, and on m3, the entire lingual aspect of the trigonid is lost. Nevertheless, on m2 it appears that the metaconid was subequal to or slightly shorter than the protoconid. On both crowns, the protoconid is still intact and shows no inflation or other distinctive morphology. Both crowns appear to have mesial cingulids. On m2, the talonid is slightly wider than the trigonid, and on m3 it is slightly narrower than the trigonid. On both crowns, the talonid cusps are distinct and well separated. On m2, the hypoconid and entoconid are the tallest cusps. The entoconid is just distal relative to the position of the hypoconid. The cristid obliqua appears to have contacted the distal aspect of the trigonid buccal to the protocristid notch. The enamel is removed from the talonid basin, but it appears to have been fairly deep and wide and closed by the entocristid. On m3, the talonid is distally elongate by a very distally positioned hypoconulid that is buccolingually pinched. A distal cingulid may have been present between the hypoconid and hypoconulid. Both crowns are uninflated, and in distal view, their lateral aspects are subvertical. Dental dimensions of UCMP 189564 are: m2 L = 3.97 mm, minimum MW = 2.79 mm, DW = 2.87 mm; m3 L = 4.70 mm, minimum MW = 2.79 mm, DW = 2.70 mm.

Discussion—As mentioned by Williamson (1996) and Archibald (1998), the Anisonchinae is in need of systematic revision, but that is beyond the scope of this paper. Nevertheless, UCMP 120413 and UCMP 189564 are confidently placed within *Anisonchus* based on (1) a well-developed hypocone that is positioned distal to the protocone rather than the more lingual position in *Haploconus* and conacodontines; (2) a postmetaconular crista that does not intersect the postcingulum as in *Mithrandir* (Van Valen, 1978), although it is very similar to *Mithrandir oligistus* in almost all other morphological features; (3) the presence of a paraconid in contrast to lower molars of *Haploconus*, which do not have a paraconids; and (4) well separated talonid cusps and distally expanded m3 talonid in contrast to conacodontines. Among the species of *Anisonchus*, UCMP 120413 is nearly identical in size to M2s of *A. athelas*: (type specimen, USNM 23279: BL = 3.9 mm, W = 6.0 mm, and UCMP 69260: BL = 3.9 mm, W = 6.5 mm, in Van Valen, 1978; BYU 3770: BL = 4.10 mm, W = 5.90 mm, and BYU 3839: BL = 3.9 mm, W = 5.90 mm, in Robison, 1986). UCMP 120413 and M2s of *A. athelas* are significantly smaller than those of *A. sectorius* (= *A. dracus*; e.g., BYU 4920: BL = 4.65 mm; W = 6.5 mm).

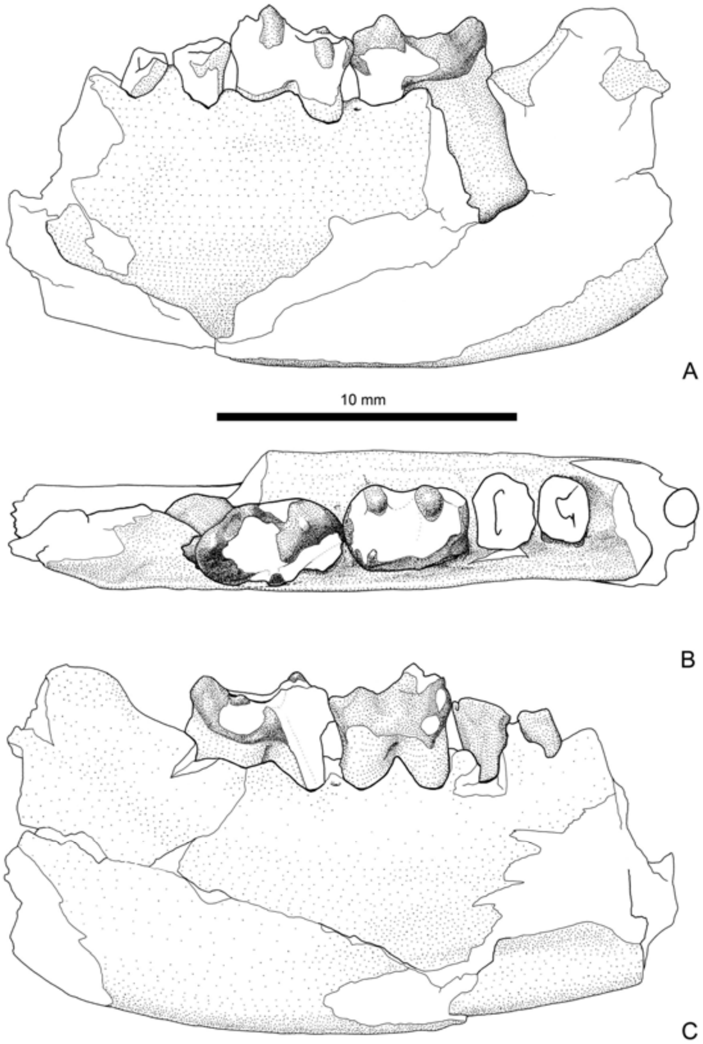

Figure 11. *Anisonchus* cf. *A. athelas*, right dentary with roots of m1 and m2 and m3, UCMP 189564 in (**A**) lingual, (**B**) occlusal, (**C**) buccal views.

Morphologically, UCMP 120413 differs from *A. athelas* and is more similar to *A. sectorius* in having a weakly developed ectocingulum (although a cast of BYU 3839 M2 did not have a complete ectocingulum), however, it differs from *A. sectorius* and is more similar to *A. athelas* in lacking a mesostyle and in having a transversely elongate crown (W : BL > 1.4), a moderately large hypocone that is distal rather than lingual to the protocone, and a slightly concave distal margin of the crown as seen in occlusal view. UCMP 120413 further differs from *A. athelas* in having a poorly developed M2 metaconule (but similar to *A.* cf. *A. athelas* of Middleton, 1983) and a more developed parastylar lobe than at least BYU 3839. *A. eowynae* is now a junior synonym of *A. athelas*, but its holotype (UCMP 69260) from the Wagonroad locality of the North Horn Formation in central Utah is nearly identical to UCMP 120413, except that it has a better developed ectocingulum. The morphological differences from *A. athelas* may represent species-level differences, but additional specimens are needed to support this.

The poor preservation of UCMP 189564 makes lower level allocation challenging, however, the small size of the specimen and the relatively uninflated nature of its crowns exclude a number of taxonomic possibilities. Comparisons focused on anisonchine periptychids. UCMP 189564 differs from *Mithrandir* in that its m2 talonid is wider and mesiodistally longer. It differs from *Haploconus* in having molar paraconids and having a distally expanded m3 talonid. UCMP 189564 appears most similar to the genus *Anisonchus,* but is considerably smaller than *A. sectorius*. Direct comparisons were made with lower molars and casts of the smaller *Anisonchus* species (*A. athelas*, *A. willeyi*, *A. onustus*). UCMP 189564 is most similar in size and discernible morphology to lower molars of *A. athelas*. Thus, we refer the abraded UCMP 189564 and UCMP 120413 to *A. athelas*. This taxon is otherwise known from the Gas Tank and Wagonroad local faunas of the North Horn Formation of central Utah, which have tentatively been placed within the Pu2 and Pu3 interval zones, respectively, by Lofgren et al. (2004) and their equivalents by Williamson (1996). A specimen from the West Bijou Creek-1 locality of the Denver Formation of Colorado also has been tentatively assigned to the species by Middleton (1983). The West Bijou Creek-1 and Corral Bluffs localities have been tentatively assigned an age of Pu2-3 undifferentiated.

CETUNGULATA Irwin and Wilson, 1993
CETE Linneaus, 1758
ACREODI Matthew, 1909
TRIISODONTIDAE Trouessart, 1904
?*Eoconodon* sp.
(Fig. 12)

Referred specimens—V-76170, UCMP 189539, right m1 or m2; UCMP 157975, fragment of a left molar trigonid; V-73094, UCMP 157976, fragment of a right upper molar.

Description—UCMP 189539, an isolated m1 or m2, is the most complete specimen in this sample (Fig. 12). Its paraconid is distinctly reduced in size and height relative to the protoconid and metaconid and positioned on the midline of the crown mesial to the cleft in the protocristid. The apices of the slightly worn protoconid and metaconid appear to have been of approximately equal height and distinctly higher than the talonid. UCMP 157975, a fragment of a trigonid from the same locality, preserves the apices and buccal slopes of the protoconid and paraconid and the undamaged metaconid. On this fragment, the protoconid is slightly higher than the metaconid.

On UCMP 189539 a large mesiobuccal cingulum is present on the base of the trigonid. Lingually the talonid basin is broadly open reflecting the distal position of the entoconid, which is almost of equal height and closely approximated to the hypoconulid. The hypoconid, the highest talonid cusp, is slightly more distantly separated from the hypoconulid than the entoconid and linked to the distal face of the trigonid by the high cristid obliqua. Dimensions of UCMP 189539: L = 9.05 mm, MW = 5.10 mm, DW = 4.70 mm.

Enough remains of the heavily corroded crown of UCMP 157976 to illustrate the bulbous morphology of its paracone and smaller, lower metacone. It documents the presence of a triisodontid in the Horsethief Canyon local fauna with a dentition of about the same size as that represented by UCMP

189539.

Discussion—In the northern Western Interior two species of *Eoconodon* are recognized in the Pu2 - Pu3 undifferentiated faunas of Garfield and McCone counties: *E. nidhoggi* and a dentally larger species provisionally designated *E.* cf. *E. gaudrianus* (Clemens and Williamson, 2005; Clemens, in review). Broadly contemporaneous faunas of the San Juan Basin contain three species of *Eoconodon: E. coryphaeus*, *E. gaudrianus*, and *E. ginibitohia.* The crown of UCMP 189539 is longer and wider than m1s or m2s of *E. nidhoggi*. Its length is within the observed ranges of variation in length of lower molars of *E.* cf. *E. gaudrianus* and *E. gaudrianus*. UCMP 189539 differs from the m1s and m2s of those species and resembles *E. copanus* (Pu1) in its distinctly narrower length/width ratio (Table 4). In comparison to the range of variation of currently recognized species of *Eoconodon* the mesiobasal cingulum on the trigonid of UCMP 189539 is relatively large and the paraconid small.

Comparisons were made with two other genera of triisodontids, *Goniacodon* and *Triisodon.* Currently *Goniacodon* is known to range from Pu3 to To3 (Lofgren et al., 2004). Van Valen (1966) suggested that a fragment of a p4 from the Dragon Canyon fauna (To1) was referable to *Goniacodon* sp. Subsequently Van Valen (1978) described the oldest currently recognized species of *Goniacodon*, *G. hiawathae,* on the basis of a right M2 and left M1-2 (UCMP 47254) from the Pu3 Wagonroad fauna, Utah. He diagnosed the species as being "almost as large as *G. crassicuspis* but the molar hypoconid is not yet at the distobuccal corner of the talonid. Ml L, 10.2; W, 11.3 (Van Valen 1978:58)". He did not cite a referred lower dentition and the basis of his statement about the position of the hypoconid is unknown. A dentary of *G. hiawathae* (USNM 494436) now under study by T. E. Williamson preserves the m2. This molar is longer (11.2 mm) and relatively broader (MW = 7.6 mm, DW = 6.8 mm) than UCMP 189539 (measurements courtesy of T. E. Williamson, pers. com.).

In the San Juan Basin *Goniacodon levisanus* ranges through To2 and To3 (Williamson 1996). In a sample of 12 specimens, the mean lengths of m1 and m2 of *G. levisanus*, (7.8 mm and 7.7 mm respectively) and mean widths of the trigonid (5.4 mm and 5.3 mm respectively) and talonids (5.5 mm and 5.6 mm respectively) differ from those of UCMP 189539 (data on *G. levisanus* courtesy of T. E. Williamson, pers. com.). In contrast to the differences in dimensions of the crown, the cusps of the trigonid of UCMP 189539 resemble those of *Goniacodon* in reduction in size of the paraconid and subequal heights of the protoconid and metaconid. Also, the talonids are similar in relative development of the cusps and formation of their basins. *Goniacodon* is not represented in the small sample of a To1

Table 4. Comparisons of width/length ratios of m1 and m2 of species of *Eoconodon*. Ratios for *Eoconodon nidhoggi*, *E.* cf. *gaudrianus*, and *E. gaudrianus* based on mean values of samples reported by Clemens and Williamson (2005).

UCMP 189539	
MW/L = 0.56	DW/L = 0.52
Eoconodon nidhoggi	
m1 MW/L = 0.66	
m2 MW/L = 0.66	DW/L = 0.63
E. cf. *gaudrianus*	
m1 MW/L = 0.62	DW/L = 0.67
m2 MW/L = 0.72	DW/L = 0.65
E. gaudrianus	
m2 MW/L = 0.76	DW/L = 0.83
E. ginibitohia	
m2 MW/L = 0.66	DW/L = 0.60
E. copanus	
m1 MW/L = 0.56	DW/L = 0.51

local fauna of the San Juan Basin (Tomida, 1981).

Two species of *Triisodon, T. guivirensis* (including *T. antiquus*) and *T. crassicuspis,* are recognized at To1 and To2 localities in the San Juan Basin (Williamson, 1996, Lofgren et al., 2004). Tomida (1981:230) referred three specimens from To1 localities "*T.* cf *T. antiquus*". The m1 and m2 of the type of *T. guivirensis*, AMNH 3352, differ from UCMP 189539 in their much greater length (15.5-15.8 mm respectively). UCMP 189539 resembles the molars of *Eoconodon* and *Goniacodon* and differs from those of *Triisodon* in which the protoconid is distinctly larger and higher than the metaconid. Also, in *Triisodon* the paraconid tends to be mesial to the metaconid and not positioned medially as in molars of *Eoconodon*. Talonids of *Triisodon* molars are distinctively modified. The hypoconid is the largest cusp on the talonid–its height approximates that of the metaconid–and the cristid obliqua is blade-like. Lingually the entoconid and, in some specimens, an entoconulid form the lower margin of the trough-like basin of the talonid. The hypoconulid is slightly lower than the entoconid and blocks the distal end of the talonid basin. A second, significantly smaller To2 species of *Triisodon*, *T. crassicuspis*, is based on two specimens. Quantitative data have yet to be published, but Van Valen (1978) noted that its dentition is slightly larger than that of *G. hiawathae*.

Based on the available information, UCMP 189539 differs from lower molars of *Triisodon guivirensis* in its smaller size, greater height of the metaconid relative to the protoconid, and talonid morphology. Disposition and relative sizes of the cusps of UCMP 189539 are not as distinctly different from those of *Goniacodon*, but lower molars of the latter can be distinguished by their relatively broader crowns. Provisionally UCMP 189539 and the two fragments of triisodont teeth are referred to ?*Eoconodon.* This is done with the recognition that UCMP 189539, particularly in the narrowness of its crown, differs from the lower molars of most of currently recognized species of *Eoconodon*. The exception is the significantly older (Pu1) species *E. copanus.*

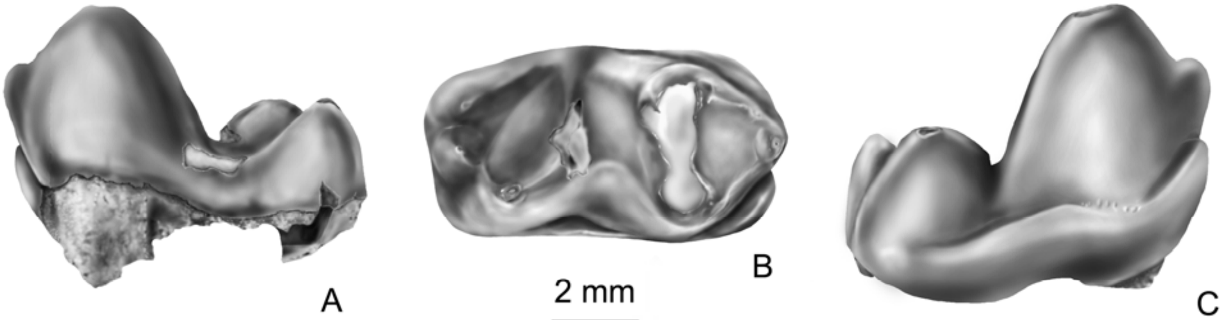

Figure 12. ?*Eoconodon* sp., right m1 or m2, UCMP 189539 in (**A**) lingual, (**B**) occlusal, (**C**) buccal views.

Triisodontidae, gen. et sp. indet.

Referred specimen—V-76170, UCMP 189587, trigonid of left m1.

Description—UCMP 189587 is a fragment of a trigonid of a left m1. Based on the distal aspect of the specimen, the trigonid appears to have been tall relative to the talonid. The protoconid and metaconid are rounded, subequal in height, and medially connected for most of their height. The paraconid is very low (about half the height of the metaconid and protoconid) and has a submedian position. A portion of a strong mesiobuccal cingulid is present. A faint distal metacristid is evident directly below the protocristid notch. The dental dimensions of UCMP 189587 are as follows: trigonid L = 3.08 mm, MW = 3.22 mm.

Discussion—UCMP 189587 is a fragmentary specimen, but its distinctive morphology matches well with the morphology of *Goniacodon* lower molars. The trigonid morphology is nearly identical to available casts of *G. levisanus* (USNM 408056, USNM 408053), except that UCMP 189587 is considerably smaller. It resembles but is smaller than the trigonids of the molars from the Farrand Channel local fauna provisionally identified as ?*Eoconodon* sp. and those of the smallest known species of *Eoconodon, E. ginibitohia* (Clemens and Williamson, 2005). UCMP 189587 documents the presence of a second triisodontid in the Farrand Channel local fauna and apparently adds to the taxonomic diversity of triisodontids. Until more material is discovered, we refrain naming a new genus and species.

DISCUSSION AND CONCLUSIONS

The numbers of identifiable mammalian specimens from the Farrand Channel (44) and the Horsethief Canyon localities (34) are small, but appear to document two taxonomically diverse local faunas (Table 5). Currently 18 taxa are recorded in the Farrand Channel local fauna and 14 in the Horsethief Canyon local fauna. Many of the generic and specific identifications are provisional being based on one or two specimens. We suspect that additional collecting at these sparsely fossiliferous sites would not only provide data enabling refinement of these identifications but also increase the documented taxonomic diversity.

The localities producing the Farrand Channel local fauna, including the Mosquito Gulch localities (Lofgren et al., 2004), are bracketed between the underlying W and overlying V coals as these units are developed in the headwaters region of Hell Creek (Fig. 2). The study by Swisher et al. (1993) in this region demonstrated that the V and overlying U coals were deposited during magnetostratigraphic Chron 28r. The W coal, into which the Farrand Channel cuts, was deposited at the end of Chron 29n or the beginning of Chron 28r. Although the possibility of time averaging must always be considered in fossil assemblages recovered from channel fillings, the hypothesis that the members of the Farrand Channel local fauna lived during Chron 28r is strongly supported. Radiometric age determinations of volcanic ashes in outcrops of the W and U coals in the headwaters region of Hell Creek have yielded ^{40}Ar/^{39}Ar age determinations of 64.52 ± 0.02 and 64.31 ± 0.04 Ma, respectively (Swisher et al., 1993; Renne et al., 1998; Knight et al., 2003, erratum; Wilson, 2004).

The bases for correlation of the Horsethief Canyon and the Farrand Channel local fauna are tenuous. The Horsethief Canyon localities lie some 27 miles (44 km) to the southwest of the outcrops of the Farrand Channel (Fig. 1). As noted by Archibald (1982) preliminary geological mapping of the Horsethief Canyon area by William Rohrer of the U.S. Geological Survey suggested that the Horsethief Canyon localities were underlain by a coal that might be a continuation of the W coal of the Hell Creek region and overlain by a continuation of the U coal. We regard these observations as suggestive but not definitive evidence that the two local faunas are approximately contemporaneous. In Garfield and McCone counties only a few radiometric age determinations have been obtained from volcanic ashes in geographically well-separated outcrops of the same coals. The Z coal complex is an exception and radiometric age determinations demonstrate that local initiation of deposition of this complex was time transgressive (Fig. 2; Swisher et al., 1993). Note the differences in age of the IrZ coal in central Garfield County and the Z coal in eastern Garfield County and western McCone County. The possibility that the U and W coals are also time transgressive cannot be ignored.

Many taxa are limited to one local fauna or the other. We suspect that in some part this is a product of the small sample sizes. *Paromomys farrandi* is the most abundantly represented species in the two local faunas. We also put weight on the co-occurrence of *Mimotricentes subtrigonus.* Co-occurrence of *Mesodma* cf. *M. garfieldensis* and *Anisonchus* cf. *A. athelas*, for example, contribute to the general similarity in composition of the two local faunas. We feel that the provisional interpretation of the lithostratigraphy of the bracketing coals and general similarity in composition of the two local faunas are sufficient bases for the working hypothesis that the Farrand Channel and Horsethief Canyon local faunas are approximately contemporaneous, i.e., their ages fall within the same interval zone. Additional collecting at these localities will provide a test of this hypothesis, as will radiometric age determinations of ashes within the coals or a magnetostratigraphic study of the Horsethief Canyon section.

A number of workers (e.g., Williamson, 1996; Weil, 1999; Lofgren et al., 2005) have analyzed the biogeographic provincialism of early and middle Paleocene mammalian faunas of the Western Interior. The differences in composition of the northern faunas and southern faunas that serve as the bases of currently recognized interval zones are a major impediment to their biochronological correlation.

Table 5. Composition of the Farrand Channel and Horsethief Canyon Local Faunas. Number of identified specimens for each taxon is shown in parentheses.

Farrand Channel Local Fauna	Horsethief Canyon Local Fauna
Mesodma cf. *M. garfieldensis* (1)	*Mesodma* cf. *M. garfieldensis* (1)
cf. *Neoplagiaulax* sp. (2)	cf. *Neoplagiaulax* sp. (1)
	Microcosmodon cf. *M. harleyi* (1)
Stygimys sp. (2)	
Prodiacodon cf. *P. crustulum* (2)	
Cimolestidae, gen. et sp. indet. (4)	
	Purgatoriidae, gen. et sp. indet. A (2)
Purgatoriidae, gen. et sp. indet. B (1)	Purgatoriidae, gen. et sp. indet. B (1)
Paromomys farrandi n. sp. (13)	*Paromomys farrandi* n. sp. (19)
	Paromomys cf. *P. farrandi* n. sp. (1)
Chriacus cf. *calenancus* (1)	
	Chriacus baldwini (1)
Chriacus cf. *C. punitor* (1)	
Prothryptacodon albertensis (2)	
	Oxyclaenus cf. *O. simplex* (1)
Oxyclaenus cf. *O. subbituminus* (1)	*Oxyclaenus* cf. *O. subbituminus* (2)
Mimotricentes subtrigonus (6)	*Mimotricentes subtrigonus* (1)
	Oxytomodon cf. *O. perissum* (1)
Litalestes cf. *L. sternbergi* (2)	
Litalestes cf. *L. disjunctus* (1)	
?*Promioclaenus* sp. (1)	
Anisonchus cf. *A. athelas* (1)	*Anisonchus* cf. *A. athelas* (1)
?*Eoconodon* sp. (2)	?*Eoconodon* sp. (1)
Triisodontidae, gen et sp. indet. (1)	

Similarly, the lack of radiometric age determinations from late Puercan and early Torrejonian strata in Utah and New Mexico is another impediment. Currently magnetostratigraphy is the most widely applicable method for determining the relative ages of northern and southern faunas of late Puercan or early Torrejonian age.

In the San Juan Basin, New Mexico, the stratigraphically highest records of Pu3 faunas have been found in rocks deposited during Chron 29n and the earliest records of To1 faunas occur in rocks deposited in Chron 28n. The intervening strata deposited during Chron 28r have yet to yield vertebrate fossils (Williamson, 1996). In the Dragon Canyon area, Utah, the To1 Dragon fauna is known from localities in strata deposited during the transition from Chron 28n to Chron 27r and thus are younger than the To1 faunas of the San Juan Basin (Lofgren et al., 2004). No mammalian local faunas were known from strata surely correlated with Chron 28r, with the possible exception of one of the Wagonroad (Pu3) localities in Dragon Canyon, until the discovery of the Horsethief Canyon and Farrand Channel local faunas. On the basis of magnetostratigraphic correlation, the Farrand Channel and possibly the Horsethief Canyon local faunas appear to represent a hitherto undocumented period in mammalian evolution in the Western Interior.

Should the Farrand Channel and Horsethief Canyon local faunas be correlated with the late Puercan (Pu3) or early Torrejonian (To1)? As reviewed by Woodburne (2006), current use of Pu3, the *Taeniolabis taoensis/Periptychus carinidens* interval zone, and To1, the *Periptychus carinidens/Protoselene opisthacus* interval zone, is based on the analysis presented by Archibald et al. (1987) and followed by Lofgren et al. (2004). In these studies the boundary between the Puercan and Torrejonian NALMAs was set at the boundary between the Pu3 and To1 interval zones, which was recognized by the first appearance of *P. carinidens*. Woodburne (2006) noted that in his review of *Periptychus* Williamson (1996) argued that *P. coarctatus*, known from Pu2 and Pu3 local faunas in the San Juan Basin, was the sister group of *P. carinidens*. On the basis of what is currently known of the diversity of species of *Periptychus*, this hypothesis implies a ghost lineage of *P. carinidens* stretching back to the beginning of Pu2 or earlier and challenges its usefulness as a marker of the beginning of the Torrejonian.

Neither *T. taoensis* nor *P. carinidens* has been recovered from the Farrand Channel and Horsethief Canyon localities. Lofgren et al. (2004) identify *Oxytomodon*, a member of the Horsethief Canyon local fauna, among the index fossils of To1 and note the first appearance of *Paromomys* in the To1 interval zone. As discussed in the systematic paleontology section the species of *Paromomys* recorded in the Dragon fauna might well be *P. farrandi. Anisonchus, Chriacus,* and *Mimotricentes*, which are members of both northern local faunas, are characteristic genera of the To1 interval zone (Lofgren et al., 2004). At the species level, *Mimotricentes subtrigonus* makes its first appearance in To1 local faunas to the south. On the basis of these first occurrences and co-occurrences in the Dragon fauna, we follow Lofgren et al. (2004) and refer the Farrand Channel and Horsethief Canyon local faunas to the To1 interval zone.

In addition to the Farrand Channel and Horsethief Canyon local faunas, only three other occurrences of To1 mammals have been described in areas north of Dragon Canyon. Simpson (1937) described mammals from three localities (9, 65, and 78) stratigraphically very low in the Lebo Formation in the Crazy Mountains Basin, south central Montana. None yielded large collections of mammals. Neither *Periptychus carinidens*–or any other species of *Periptychus*–nor *Paromomys* was reported from these localities. Sloan (1987) suggested that they were of To1 age, and this suggestion has been followed by later workers (Hartman and Krause, 1993; Lofgren et al., 2004).

Another possible To1 local fauna is known from the School Well locality in southeastern Montana (Hunter et al., 1997). The small collection includes records of *Ptilodus montanus, Litaletes* cf. *L. mantiensis, Periptychus* sp., and *Paromomys maturus.* The record of *Periptychus* sp. is based on the distal half of either a p3 or p4. It suggests that the absence of *P. carinidens* in the collections from the sites in the Crazy Mountain Basin and the Farrand Channel and Horsethief Canyon localities might be a product of taphonomy or collecting biases and not from being outside the paleobiogeographic range of the species. The record of *Paromomys maturus* is based on two isolated lower molars, which are larger than any lower molars referred to *P. farrandi.* Similar to the localities in the Crazy Mountains Basin, the magnetostratigraphy of the School Well locality has yet to be reported.

Hunter (1999) described three mammalian teeth from the Brown Ranch locality in the upper part of the Ludlow Formation in southwestern North Dakota. Two are premolars of *Conoryctella* cf. *C. dragonensis*, which suggests a To1 age. The third is a lower molariform identified as *Dissacus* sp. This genus makes its first appearance in To2 local faunas in other areas.

In summary, the Farrand Channel and Horsethief Canyon local faunas are known from relatively small samples, which very likely do not fully document their taxonomic diversity and limit the refinement of the identification of their constituents. Similarity in composition of the two local faunas and a provisional interpretation of the lithostratigraphy of the bracketing coals are the bases for the working hypothesis that these local faunas are approximately contemporaneous and their ages fall within the same interval zone.

The Farrand Channel local fauna is preserved in strata deposited during Chron 28r. The younger Dragon local fauna, which provides the typification of the To1 interval zone, is preserved in sediments deposited during Chron 28n. With the exception of the Pu3 Wagonroad localities that appear to straddle the Chron 29n/Chron 28r boundary, the Pu3 interval zone is typified on local faunas found in sediments deposited during Chron 29n.

The beginning of the To1 (*Periptychus carinidens/Protoselene opisthacus*) interval zone was defined on the basis of the first appearance of *P. carinidens* (Lofgren et al., 2004). *Periptychus carinidens* has yet to be reported from the Dragon local fauna (Cifelli et al., 1999). Except for the record of *Periptychus* sp. in the School Well local fauna, the genus is unknown in the other northern local faunas attributed to the To1 interval zone by Lofgren et al. (2004). Assignment of the Farrand Channel and Horsethief Canyon local faunas to the To1 interval zone is based on other taxa, particularly but not exclusively on *Paromomys farrandi* and *Mimotricentes subtrigonus.*

The Farrand Channel and Horsethief Canyon local faunas add to the limited documentation of paleobiogeographic diversity of To1 interval zone faunas. This diversity might be the product of distinct northern and southern provinces or reflect latitudinal gradient of change in composition (Lofgren et al., 2005). Based on his analysis of the faunas of the San Juan Basin, Williamson (1999) suggested that the marked increase in diversity across the Puercan-Torrejonian boundary might well be the result of differences in sampling. Until the current analyses of the Pu2-Pu3 Garbani Channel and Purgatory Hill local faunas of northeastern Montana are completed, the applicability of this suggestion to northern faunas cannot be tested.

Similarly, after discussing the paleontological records in the San Juan and Hanna basins, Woodburne (2006:250) commented, “It is to be hoped that the Puercan-Torrejonian boundary can be refined in other places.” Fossil localities in the valley of Hell Creek and adjacent areas of Garfield and McCone counties provide a lithostratigraphically controlled sequence of local faunas extending from the Lancian to the Torrejonian NALMAs (Clemens, 2002; Wilson, 2005; and references cited therein). Both magnetostratigraphic analysis of this sequence and radiometric age determinations add to understanding of the tempo of faunal change. Here we present the first comprehensive study of two To1 local faunas in this area. Completion of a parallel taxonomic review of the Pu2-Pu3 Garbani Channel and Purgatory Hill local faunas should provide documentation of the Puercan-Torrejonian boundary in another place.

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We thank Rick Farrand who discovered the mammal producing localities in the Farrand Channel and Harley Garbani who found both the remarkable specimen of *Polyodon tuberculata* in the Farrand Channel and the Horsethief Canyon localities. The contributions of other members of the UCMP 1973 through 1976 field parties who helped with the collection and screenwashing of matrix from these localities are greatly appreciated. Thanks to the Bliss and Engdahl families who gave us the opportunity to work on their ranches and supported our field work in many different ways. Thanks also to T. E. Williamson who provided data from his study of *Goniacodon levisanus*. Financial and other support for the field and laboratory research was provided by National Science Foundation grant BMS 75-21017 and the University of California Museum of Paleontology. We also acknowledge the help received from M. B. Goodwin and P. A. Holroyd of the University of California Museum of Paleontology and K. Will, who gave us access to imaging equipment in the Essig Museum of Entomology, University of California. J. D. Archibald and D. L. Lofgren provided very helpful reviews of our manuscript. Three talented scientific illustrators figured specimens described in this study: Noel Sivivanzanti, Figs. 3, 4, and 12; Karen Klitz, Figs. 5-7; and Jude Swales, Figs. 8-11. This is University of California Museum of Paleontology Contribution 1988.

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