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PALEONTOLOGY AND GEOLOGY OF THE BADWATER CREEK AREA, CENTRAL WYOMING

Part 10. A late Paleocene mammal fauna from the Shotgun Member of the Fort Union Formation

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A small outcrop of the Fort Union Formation along Badwater Creek at the western end of Cedar Ridge, T. 39N., R. 89W., was first noted by Tourtelot in 1953. This occurrence of Fort Union sediments was mentioned by Keefer (1961:1315; 1965a: A29) and was described as being some 1600 feet thick with the base of the section terminated by faulting and the top truncated by sediments of early Eocene age. In 1961 Keefer noted a fossil plant locality in this section, but no vertebrates were known to occur in the Shotgun Member as exposed at this locality. Gard (unpublished thesis completed in 1969), mapped the Shotgun outcrops, which extend northwest along the Cedar Ridge Fault into the SW-1/4, Sec. 9, T. 39N., R. 89W.

In 1963 fossil vertebrates of Paleocene age were first discovered along Badwater Creek just east of the Natrona-Fremont County line in the Shotgun Member (erroneously called the Shotgun Butte Member by Black and Dawson, 1966: 301, 302) of the Fort Union Formation. Using washing techniques (Black and Dawson, 1966) two to three tons of matrix from this locality have now been washed, and some four hun-

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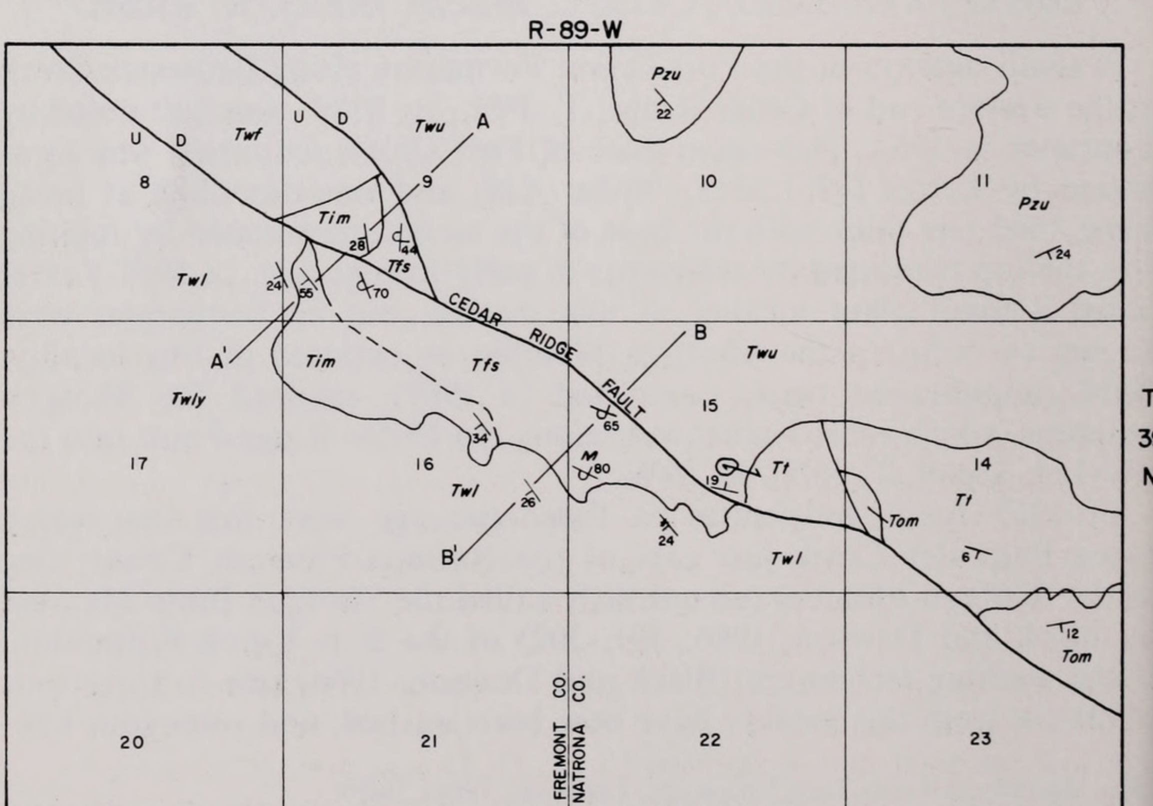
dred mammalian specimens have been recovered, together with shark teeth, osteichthyan vertebrae, crocodilian fragments, various gastropods, and pelecypods and reworked ammonite fragments.

GEOLOGY OF THE FORT UNION FORMATION

In the vicinity of the vertebrate fossil locality (SW 1/4, Sec. 15, T. 39N., R. 89W.) the overturned beds of the Shotgun Member crop out (Test-fig. 1) as a narrow band of deeply dissected siltstones, claystones, and sandstones. In the lowest 250 feet of outcrop, yellowish-gray sandstones and silty sandstones form several sharp low ridges. Other lenticular sandstones are widely scattered in the upper exposures. The siltstones and claystones are predominantly light gray to olive gray but some beds are dark reddish-brown. Weathering gives the outcrop a general grayish-orange aspect. Some of the siltstones contain limonite-filled worm burrows. Carbonized leaf fragments are common in others. These outcrops are overlain by coarse boulder conglomerates in the Lysite Member of the Wind River Formation, with about 90 degrees of angular unconformity and over 120 feet of erosional relief, but farther to the northwest the same sequence of Shotgun strata is overlain



Text-fig. 1. Sketch map showing relationships of the Shotgun Members of the Fort Union Formation (TFs) to the Indian Meadows (Tim), Tepee Trail (Tt), and Wind River (Twl, Twly and Twu) formations. Tertiary "Oligo-Miocene" and Palaeozoic undifferentiated are also indicated. The vertebrate faunal locality is indicated (M) in Section 15, T39N., R. 89W. The geology has been compiled by D. W. Riedel.

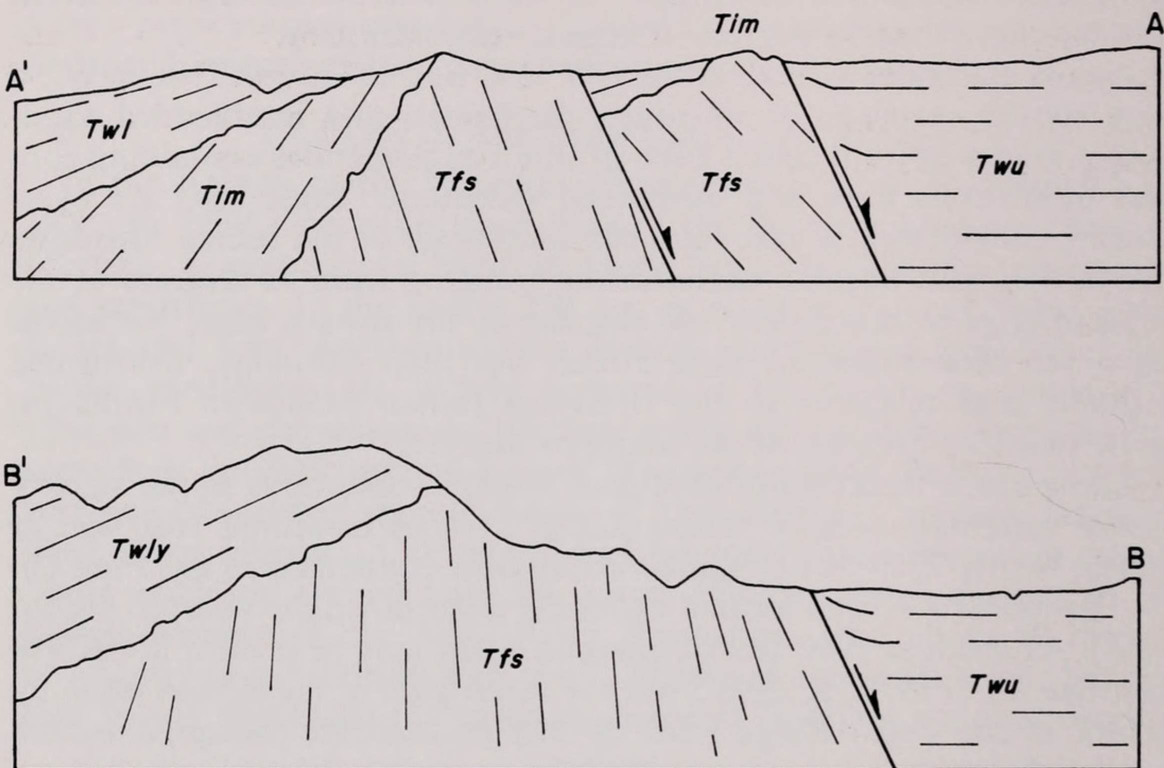
by conglomerates and mudstones of the Indian Meadows Formation with no more than 55 degrees of angular unconformity.

Across Badwater Creek, in the SW 1/4, Sec. 9, T. 39N., R. 89W., a very similar sequence of siltstones, claystones, and interbedded sandstones grades upward into a zone of thin conglomerates containing cobbles of siliceous shale and oil-stained sandstone. These beds are overlain by conglomerates and algal ball limestones of the Indian Meadows Formation with angular unconformity ranging from 55 degrees at the western edge to more than 100 degrees at the eastern edge. No fossils have yet been found in these rocks, but their lithology, overturned attitude, and relations to the overlying Indian Meadows Formation show that they are part of the Shotgun Member.

The greatest thickness of unfaulted Shotgun outcrop is in the vicinity of the vertebrate locality, where Keefer (1965a) measured 1600 feet of strata. Nearly 2300 feet of similar rocks were penetrated in the Pure Oil Co. Badwater 2-A well located about 2½ miles down dip (Keefer, 1965a, pl. 3). As much as 2000 feet of Shotgun strata may be present in the SW 1/4, Sec. 9, T. 39N., R. 89W., but the lower part of the section is cut by a fork of the Cedar Ridge Fault so that no accurate measured section can be obtained.

The complex relationships (Text-fig. 2) of the Shotgun Member to other strata in the Badwater area are largely the result of subsidence of the Wind River Basin throughout early and middle Tertiary time, and the uplift and overthrusting of the Bighorn Mountains that accompanied and followed it. The geologic history of the area has been discussed by Keefer (1965a, 1965b, and 1966), Paape (1961) and Tourtelot (1957).

During Fort Union time subsidence caused the Wind River Basin to become landlocked, or nearly so, and a large lake formed in the northeastern part. Siltstones, claystones, and sandstones of the Shotgun Member accumulated along the lake margin, interfingering with and prograding over the offshore deposits of the Waltman Shale Member. Uplift of the Bighorn Mountains may have begun in latest Paleocene or earliest Eocene time, causing erosion of Mesozoic rocks and deposition of the conglomerates in the uppermost part of the Shotgun Member. By earliest Eocene time the uplift had created localized thrust faults that upturned and overturned the beds of the Shotgun Member toward the west and southwest in the Badwater area. Rapid erosion of the Bighorn front during early Eocene time truncated the Shotgun strata and formed coarse alluvial fans of the Indian Meadows Formation. This deposition was interrupted by a great episode of thrust faulting that affected the basin margin from the Owl Creek Mountains to the Casper Arch, and further tilted the rocks in the Badwater area so that boulder conglomerates of the Lysite Member of the Wind River



Text-fig. 2. Cross-sections A-A[1] and B-B[1] shown in Text-fig. 1, illustrating the relationships of the Tertiary rock units. Abbreviations as in Text-fig. 1.

Formation overlie the Indian Meadows beds with up to 26 degrees of angular unconformity. Further erosion during Wind River time breached the Precambrian core of the Bighorn Range, changing the lithic composition of the sediments in the Wind River Formation from limestones and sandstones in the Lysite Member to sandstones and conglomerates of granite, gneiss, and schist in the Lost Cabin Member. Both subsidence and uplift had nearly ended by late Wind River time, and the uppermost clastic sediments of the Lost Cabin Member were masked and buried by fine-grained volcanic debris transported from the Absaroka region. All the younger tuffaceous strata of the late Eocene Tepee Trail, Oligocene White River, and Miocene Split Rock Formations are fine-grained and relatively thin, and are separated from Lost Cabin strata and from each other by only modest angular and erosional unconformities. The structural evolution of the Badwater area was completed in post-Miocene time by normal faulting that lowered the Bighorn Mountains and the Tertiary sediments north of the Cedar Ridge Fault relative to the Wind River Basin, placing the Split Rock Formation in contact with Lysite beds and the uppermost Wind River strata against those of the Shotgun Member.

ACKNOWLEDGEMENTS

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7801, and GB-30840X to Craig C. Black and Mary R. Dawson, and by the Institute of Museum Research of Texas Tech University. We thank Dr. Dawson for loan of the Carnegie Museum of Natural History (CM) material. All specimens are in the Carnegie Museum collection unless otherwise noted. All measurements are given in millimeters.

MAMMALIAN FAUNAL LIST

Multituberculata
- *Ptilodus* sp.
- *Ectypodus* sp. nr. *E. tardus*
- *Mesodma* sp.
- Cf. *Mesodma*
- *Microcosmodon conus*

Marsupialia
- *Peradectes protinnominatus*

Insectivora
- Leptictid sp.
- Palaeoryctid sp.
- *Aphronorus fraudator*
- *Apatemys kayi*
- Cf. *Talpavus*
- Cf. *Scenopagus*

Primates
- *Plesiadapis farisi*
- *Phenacolemur frugivorus*
- *Carpolestes* sp.

Condylarthra
- *Chriacus pelvidens*
- *Mimotricentes* sp.
- Cf. *Litomylus*
- *Phenacodaptes sabulosus*
- *Ectocion osbornianum*
- *Phenacodus* cf. *primaevus*
- *Phenacodus* sp.

Class Mammalia
Order Multituberculata
Suborder Ptilodontoidea
Family Ptilodontidae
Ptilodus Cope, 1881a
Ptilodus sp.
Figures 1-5

REFERRED SPECIMENS: P^1, 12491, 16128, 16138, 16144; P^2, 12455, 12453, 12488, 16130, 16129, 16132, 16136, 16179, 16146, 16145, 16143, 16140, 16137, 16134, 16185, 16141, 16147, 12487, 12489, 23693; P^3, 16135; P^4, 16133, 16124, 16125, 16121, 16187, 16126; M^1, 16182, 16165, 16163, 23686, 23692; M^2, 12454; P_4, 12490, 12449, 12450, 12452, 12451, 16120, 23685; M_1, 16150, 16180, 16152, 16148, 16156, 16191, 23684, 23687-23691; M_2, 16186, 16162, 16161, 16159.

DESCRIPTION: P^1 in occlusal view resembles an isosceles triangle with the apex directed anteriorly. Three cusps occur on the crown, one anteriorly and a transverse pair posteriorly. The crown of CM 16138 is wider and less nearly triangular than the other referred P^1's, and has a slight anteroexternal bulge.

The crown of P^2 has a gently sloping posterior shelf, is subquadrate in occlusal outline, and bears four cusps, one pair occurring anteriorly, and one pair posteriorly. The cusps are either pyramidal, conical, or crest-like. Variation also occurs in their size and distance from one another.

P^3 (CM 16135, AP 3.5, TR 2.1) is elongate and slightly hourglass-shaped in occlusal outline. The crown bears nine cusps in two longitudinal rows. One row consists of five cusps, and the other of four. The internal cusps are laterally compressed and joined together almost to their apices. The cusps of the external row are pyramidal and more nearly separate.

None of the five referred P^4's is complete. Four are anterior fragments, and one (CM 16121) is a posterior fragment. A composite P^4 (of CM 16121 and CM 16125) has an approximate cusp formula of 0:6:9. The anterior fragments have a small anteroexternal bulge, but do not bear any external cusps. The medial cusps, of which the second is largest and opposite the second internal cusp, are conical and separate from one another at their bases. The medial cusps are lower than the internal cusps. The anterointernal cusps are laterally compressed, become progressively higher posteriorly, and are joined to one another almost to their apices. On the posterior fragment, five internal and three medial cusps are preserved. The last medial cusp is opposite the groove between the penultimate and antepenultimate internal cusps.

The most nearly complete of the referred M^1's is CM 16165 (TR 2.1), a posterior fragment with three external, five medial, and five internal cusps. The external and medial cusps are pyramidal, with the medial cusps wider and slightly more massive than the external ones. The internal cusps are smaller and more nearly conical than those in the other rows, and progressively decrease in size posteriorly. On CM 16163, a worn anterior fragment of M^1, only the external and internal rows are preserved, each with four cusps. An approximate cusp formula of a composite M^1 (CM 16165 and CM 16163) is 10:11:8.

The cusp formula on M^2 is 1:3:4 (CM 12454; AP 3.0, TR 2.8). The crown is triangular in occlusal outline and slightly concave anteriorly. The medial cusps are large, subcrescentic, and well separated from one another. The internal cusps are small, and conical to pyramidal. The first three are close together, but well separated from the fourth.

Only one specimen of P_4 is complete (CM 12449; AP 6.4). The blade bears 12 serrations, although one or two additional ones may have been obliterated by wear. In lateral view, the crest profile is long, very low, and not symmetrical. The anterior slope is longer and more gently in-

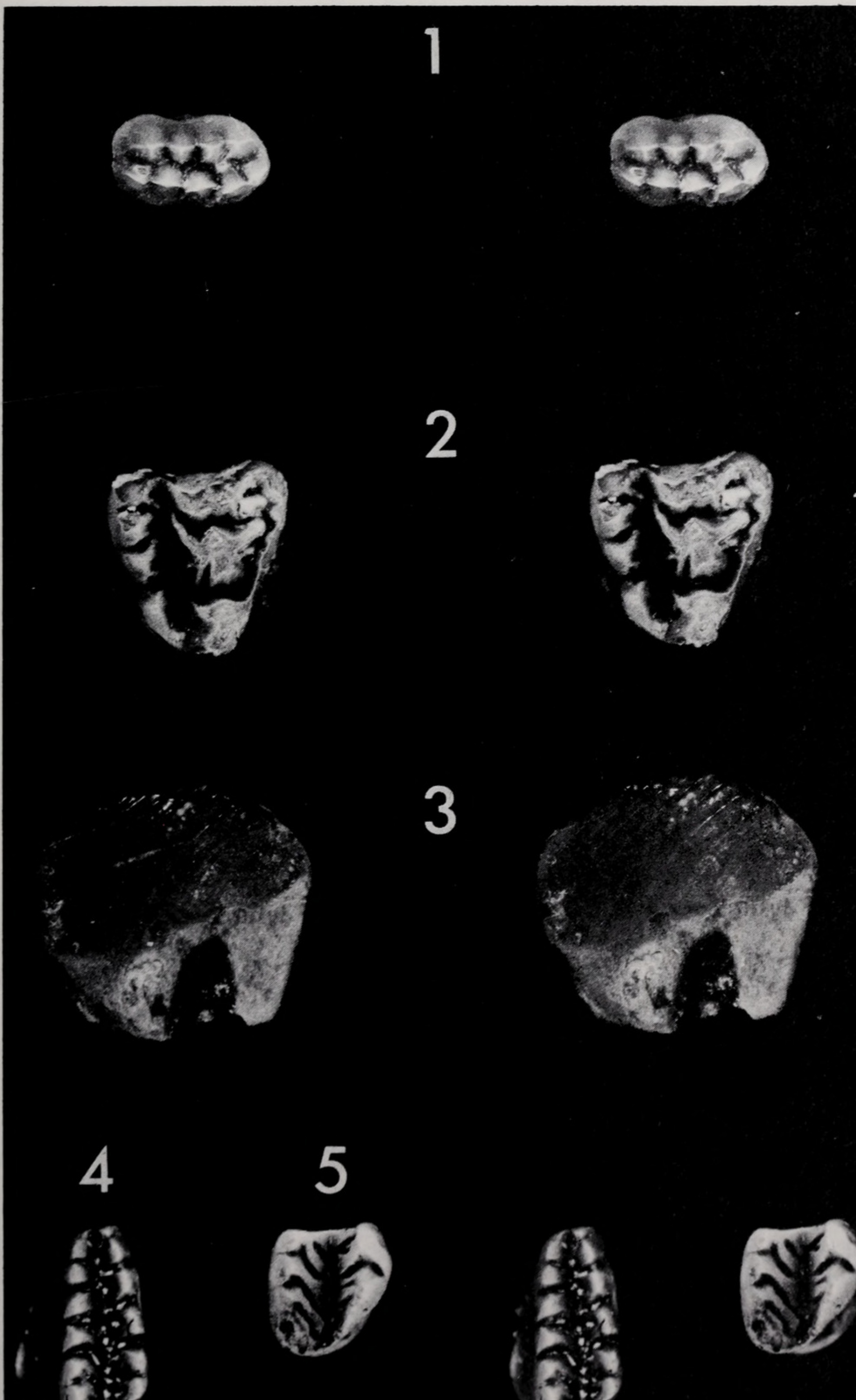


Plate 1, Figs. 1-5. *Ptilodus* sp. 1. P^3, CM 16135, occlusal view, approx. X 5. 2. M^2, CM 12454, occlusal view, approx. X 7. 3. P_4, CM 12449, external view, approx. X 5. 4. M_1, CM 16191, occlusal view, approx. X 7. 5. M_2, CM 16162, occlusal view, approx. X 7.

clined than the posterior slope. The sixth serration is highest on the blade. The distance from the top of the anterobasal concavity to the first serration is more than one-third of the length of the crown. The first ridge originates from the base of the first serration, and posteroventrally directed ridges are absent.

The cusp formula of M_1 is 6:5 (CM 16191; AP 3.3, TR 1.6). Anteriorly the crown narrows only slightly, so that the lateral borders of the crown are essentially parallel. The cusps of the external row progressively increase in size posteriorly. The first four are pyramidal, the fifth is subcrescentic, and the sixth, which appears to be formed by the union of two cusps, is the longest cusp on the crown. The cusps of the internal row are higher and more laterally compressed than the external cusps. The first four internal cusps are well separated from one another, whereas the fourth and fifth are united along most of their height. Two accessory cuspules occur on M_1, one anterior to the first external cusp, and a larger one anterior to the first internal cusp.

The cusp formula of M_2 is 4:2 (range, AP 2.0-2.2; TR 1.9-2.0). The external cusps are joined and subequal in size, but are demarcated medially by three deep grooves. The internal cusps, of which the first is largest and tallest on the crown, are more nearly separate. A single groove occurs on the medial face of the first internal cusp, and two are present on that of the second.

COMMENTS: Except for P^3 (CM 16135), all teeth described here are like *Ptilodus* in size and crown morphology. P^3, with 9 cusps arranged in two longitudinal rows, more nearly resembles that of *Prochetodon cavus.* The maximum number of cusps known for P^3 of *Ptilodus* is 7, which occurs on only one specimen of *P. montanus* (Simpson, 1937). In addition, P^3 of *Ptilodus* is invariably narrower than P^2. CM 16135 is much wider than the isolated P^2's described here. The remaining teeth resemble *Ptilodus* and differ from *Prochetodon* as follows: four cusps on P^2 instead of three; slightly wider P^4, which is straight in lateral aspect instead of concave; and absence of a deep groove on the anterior slope of P^4. Molars of *Prochetodon* have never been described. However, apart from M_1, the molars referred here do not differ significantly from those of *Ptilodus wyomingensis* in size, cusp formula, and crown morphology. The 6:5 cusp formula for M_1 is slightly higher than the 6:4 formula recorded for *P. wyomingensis.* P^4, in lacking a third row of cusps and a pronounced anteroexternal bulge, closely resembles that of *P. wyomingensis,* but is slightly narrower than the latter. The narrowness of P^4, the relatively higher cusp formula of M_1, and the curious *Prochetodon*-like structure of P^3 suggest that the species of *Ptilodus* represented by these isolated teeth is more advanced than *P. wyomingensis* and perhaps was derived from the latter.

Family Ectypodontidae

Ectypodus Matthew and Granger, 1921

Ectypodus sp. near *E. tardus* (Jepsen, 1930b)

Figures 6-10

REFERRED SPECIMENS: P^4, 16175; M^1, 23694; M^2, 16167, 16177, 16181, 23695, P_4, 16119, 16176, 23696-23699; M_1, 16178.

DESCRIPTION: The cusp formula of P^4 is 2:6 (CM 16175, AP 2.5). The internal crest is moderately high in lateral profile, with straight anterior and posterior slopes. The last cusp is highest on the blade, and a tiny posterobasal cuspule is present. The first external cusp is small and occurs opposite the first internal cusp. The second external cusp, conical and larger than the first, is situated opposite the second internal cusp.

The M^1 cusp formula is 9:11:8 (CM 23694, AP 3.9, TR 1.8). In lateral aspect the crown is slightly concave. The internal row begins anteriorly at the level of the fourth medial cusp and is approximately two-thirds of the length of the tooth. The cusps in all three rows are pyramidal, but those of the medial row are broader at the base.

M^2 is triangular in occlusal outline and has a cusp formula of 1:3:3 (range, AP 2.0, TR 2.1). In both the medial and internal rows the first two cusps are appressed, and the third nearly separate. The medial and internal cusps are subcrescentic, with the former relatively larger and extremely broad at the base. The second medial cusp is highest on the crown. On CM 16181 the first internal cusp bears a small bump on its anterior face.

Both the complete referred P_4's have 11 serrations (CM 16119, AP 3.0; CM 16176, AP 2.9). In lateral aspect, the anterior profile of the blade is short, high, and sharply convex. The posterior slope is relatively longer, much lower, and nearly straight. The fourth serration is highest on the crown. Although the posterolabial surface of the blade is quite worn on both specimens, a single posteroventrally directed groove can be discerned originating from between the ultimate and penultimate serrations.

The cusp formula of M_1 is 7:5 (CM 16178, AP 2.8, TR 1.3). In occlusal view, the two rows of cusps diverge posteriorly. The external cusps, worn well below the height of the internal cusps, become progressively longer anteriorly from the sixth cusp. In the internal row the cusps are pyramidal, the first and second cusps, as well as the fourth and fifth, are appressed, and the third cusp is the largest on the crown. The largest intercusp valley occurs between the third and fourth internal cusps.

COMMENTS: The high anterior and low posterior profile of P_4 is characteristic of *Ectypodus* and *Mimetodon*. P_4 of *Mimetodon* bears three posteroventrally directed grooves on the posterolabial part of the blade.

P_4 referred here bears only one. In its lateral profile, number of serrations, and size, P_4 closely agrees with that of *Ectypodus tardus,* known from the Eocene of Colorado (McKenna, 1960) and Wyoming (Jepsen, 1930b), and with *E. powelli,* known from a number of Tiffanian localities in Montana and Wyoming.

P^4, with a cusp formula of 2:6, a moderately high blade, and ultimate internal cusp highest, agrees only with that of *Ectypodus,* among known Tertiary ectypodontids, and especially with *E. tardus.* P^4 of *E. powelli* has not been described. M^1 and M_1 referred here are significantly larger than those of *E. tardus* and *E. powelli,* but are closer in cusp formula (M^1, 9:11:8; M_1, 7:5) to the former (M^1, 8:9:6; M_1, 7-8:4). Whereas the larger size and cusp formulae of the molars imply morphologic distinction from *E. tardus,* affinity to this species is inferred from the extreme similarity of P^4 and P_4 to those of *E. tardus.* The Badwater Paleocene species of *Ectypodus* is clearly closely related to *E. tardus,* and may have been near, or part of, its ancestral lineage.

Mesodma Jepsen, 1940
Mesodma sp.
Figures 11-14

REFERRED SPECIMENS: P^4, 23702, 16122, 16183; M^1, 16164; M^2, 16160; 16189, 23700; M_1, 23701, 16154, 16155, 16157, 16188.

DESCRIPTION: The cusp formula of P^4 is 3:6 (CM 16122, AP 1.9). In occlusal aspect, the crown is essentially rectangular, has a narrow anteroexternal bulge and is slightly constricted medially. The internal crest is straight and runs posteroexternally from the anterointernal corner of the crown. In lateral view, the blade profile is extremely low. The anterior and posterior slopes are straight, the latter very short. The ultimate internal cusp, when unworn, is the highest point of the blade. Posterobasal cuspules are not present. The three external cusps are conical, become progressively larger posteriorly, and occur opposite the first three internal cusps, respectively.

The cusp formula of the only referred M^1 of *Mesodma* sp. is 8:10:6 (CM 16164, AP 2.4, TR 1.2). In the external row, the anterior cusps are subconical and the posterior ones pyramidal. The penultimate cusp is largest. Similarly, and anterior medial cusps are small, low and subcrescentic, whereas posteriorly the cusps are larger, taller, and fully crescentic. The ultimate medial cusp is the highest on the crown. The internal row provides approximately two-thirds of the internal border of the crown and originates anteriorly at the level of the fourth medial cusp. The first two and last internal cusps are small and conical; the third, fourth, and fifth cusps are much larger and pyramidal.

The cusp formula of M^2 is 1:3:3 (range AP 1.1-1.2, TR 1.1-1.2). In

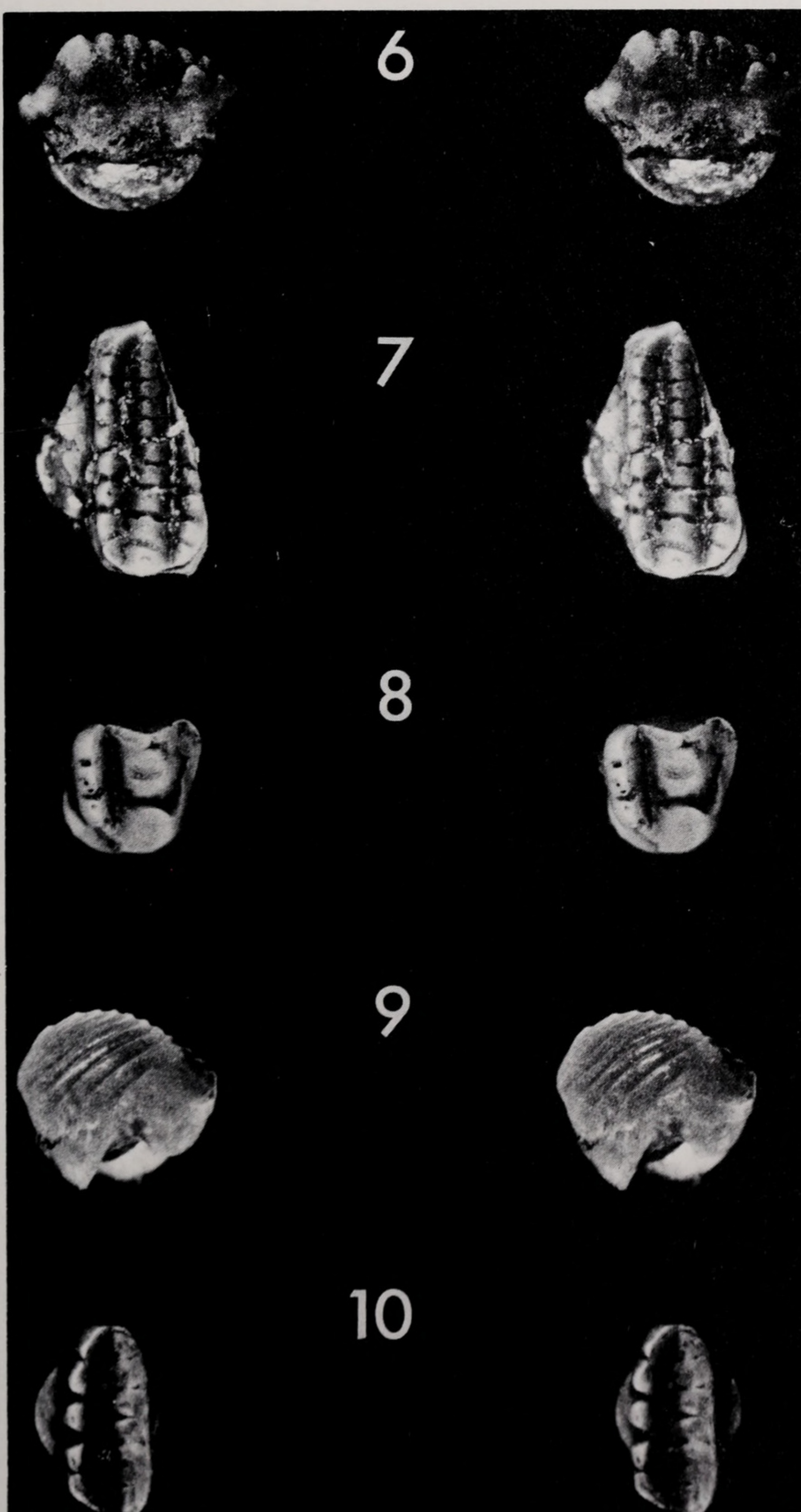


Plate 2. Figs. 6-10. *Ectypodus* sp. nr. *E. tardus*. 6. P^4, CM 16165, external view, approx. X 10. 7. M^1, CM 23694, occlusal view, approx. X 7. 8. M^2, CM 16177, occlusal view, approx. X 7. 9. P_4, CM 16176, external view, approx. X 7. 10. M_1, CM 16178, occlusal view, approx. X 7.

occlusal aspect the crown is wider than long and concave anteriorly. A relatively wide cingulum connects the single small external cusp to the last medial cusp. The medial cusps, of which the first two are appressed, are subcrescentic, and progressively increase in height posteriorly. The internal cusps, slightly lower than the medial ones, are pyramidal and gradually become smaller posteriorly.

The cusp formula on M_1 is 7:4-5 (range AP 2.1-2.3, TR 0.9). Anteriorly, in occlusal view, the crown narrows only slightly, and the two rows of cusps are essentially parallel. Posteriorly, the last internal cusp occurs opposite the penultimate external cusp so that the cingulum joining the last cusp of each row is oriented extremely obliquely. In the external row the first cusp is smallest and conical, the second to fourth are subcrescentic, the fifth and sixth cusps are crescentic, and the last cusp is short and crest-like. The internal cusps are larger and taller than the medial ones, and pyramidal in shape.

COMMENTS: The *Mesodma*-like features of P^4 described here are: cusp formula, 3:6; internal blade of extremely low profile, with straight short posterior slope, and ultimate cusp highest. The molars are referred to *Mesodma* sp. on the basis of size association with P^4, and their similarity in cusp formulae and crown morphology to *Mesodma* sp. F, known from the Cypress Hills Tiffanian of Alberta (Krishtalka, 1973); Gidley Quarry, Montana; and Shotgun Local fauna, Wyoming (R. E. Sloan, personal communication).

Cf. *Mesodma*
Figure 15

REFERRED SPECIMEN: P^4, 16118.

DESCRIPTION: CM 16118 (AP 3.5, approx.), a left P^4, is intermediate in size between P^4 of *Ptilodus* sp., and *Ectypodus* sp., near *E. tardus*. The cusp formula is 1:7. The posterior part of the base of the tooth below the last internal cusp is broken away, but the posterior slope appears to have been straight and short. The anterior slope of the blade is straight and very low in lateral profile, with the ultimate cusp highest on the blade. The internal cusps are large, well-defined, and increase in size posteriorly. The external cusp, large and pyramidal, occurs opposite the second and third internal cusps. A tiny bump is situated anterior to the external cusp, but is not large enough to be included in the cusp formula.

COMMENTS: Features of this large, isolated P^4 that imply affinity with *Mesodma* include the very low profile of the internal crest, the straight anterior and posterior slopes, a relatively low cusp formula, and the relative height of the last internal cusp (highest on the blade). The last two features are also characteristic of P^4 of *Ectypodus,* although the lateral profile of the internal crest on P^4 of *Ectypodus* is considerably higher than that of *Mesodma* and CM 16118. Only two Paleocene species of *Mesodma* are known: *M. ambigua,* from the Mantua Lentil, Polecat Bench Formation, Wyoming, and *Mesodma* sp. P (including *Mesodma* sp. described in this paper) from Tiffanian localities in Alberta, Montana, and Wyoming. CM 16118 is much larger than P^4 of *Mesodma* sp. P. P^4 is unknown in *M. ambigua.* If CM 16118 indeed represents a large species of *Mesodma,* it is the first such record for the Late Paleocene.

Suborder Taeniolabidoidea
Family Eucosmodontidae
Microcosmodon Jepsen, 1930a
Microcosmodon conus Jepsen, 1930a
Figures 16-20

REFERRED SPECIMENS: M^1, 16149, 23703; M^2, 16168; P_4, 16123; M_1, 16151, 16153, 16158, 16166; M_2, 16171.

DESCRIPTION: The cusp formula on M^1 is 7:8:8 (CM 16149; AP 2.2, TR 1.2). The internal row is a high narrow cingulum, with the individual cusps developed as crenulations along its apex. This internal ridge is one-half the length of the tooth and originates anteriorly at the level of the fifth medial cusp. The medial and external cusps are well worn but appear to have been more robust than those on M^1 of *Mesodma* sp.

The cusp formula on M^2 (CM 16168; AP 1.3, TR 1.1) is 1:3:4, and differs perhaps significantly from that of *Mesodma* sp., which is 1:3:3. In occlusal aspect, the crown is longer and less transverse than M^2 of *Mesodma* sp., and the cingulum joining the external cusp to the last medial cusp is much narrower. The medial cusp are subcrescentic, and the internal cusps form a continuous crest.

CM 16123 (AP 1.8), the only P_4 referred to *Microcosmodon conus,* is heavily worn, but 5 large, cusp-like serrations can be discerned. Characteristically, there are no ridges on the external or internal faces of the blade. In lateral outline, the blade is arcuate and appears to have been almost symmetrically so when unworn. Anteriorly, the blade only slightly overhangs the root, and a basal concavity is absent. A posterobasal crescent, convex ventrally, occurs on the labial surface of the blade. The crown does not overhang the posterior root.

The cusp formula of M_1 is 7:4 on three specimens (range AP 1.9-2.0, TR 0.9) and 6:4 on CM 16166 (AP 1.8, TR 0.9). In occlusal view, the posterior border of the crown is only moderately oblique and is much wider than the anterior edge. The two rows of cusps converge anteriorly. This condition differs from M_1 of *Mesodma* sp., on which the two rows of cusps are more nearly parallel and the posterior edge of the crown is very oblique. The external cusps are subcrescentic and the first is the smallest on the crown. The internal cusps are pyramidal and much higher than the external ones. The last internal cusp is massive

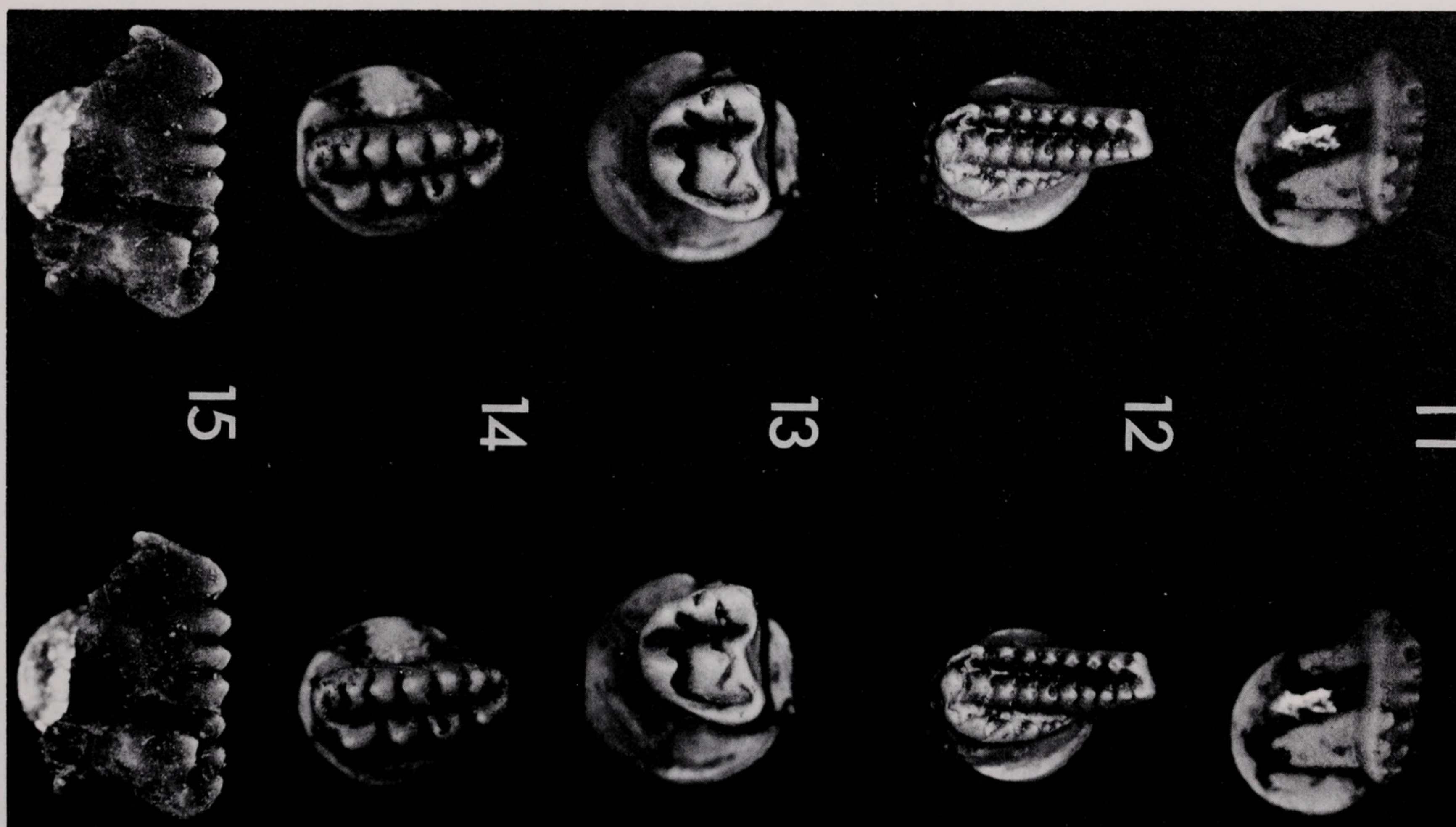


Plate 3. Figs. 11-14. *Mesodma* sp. 11. P^4, CM 16122, external view, approx. X 10. 12. M^1, CM 16164, occlusal view, approx. X 10. 13. M^2, CM 16189, occlusal view, approx. X 10. 14. M_1, CM 16155, occlusal view, approx. X 10. Fig. 15. Cf. *Mesodma*. P^4, CM 16118, external view, approx. X 10.

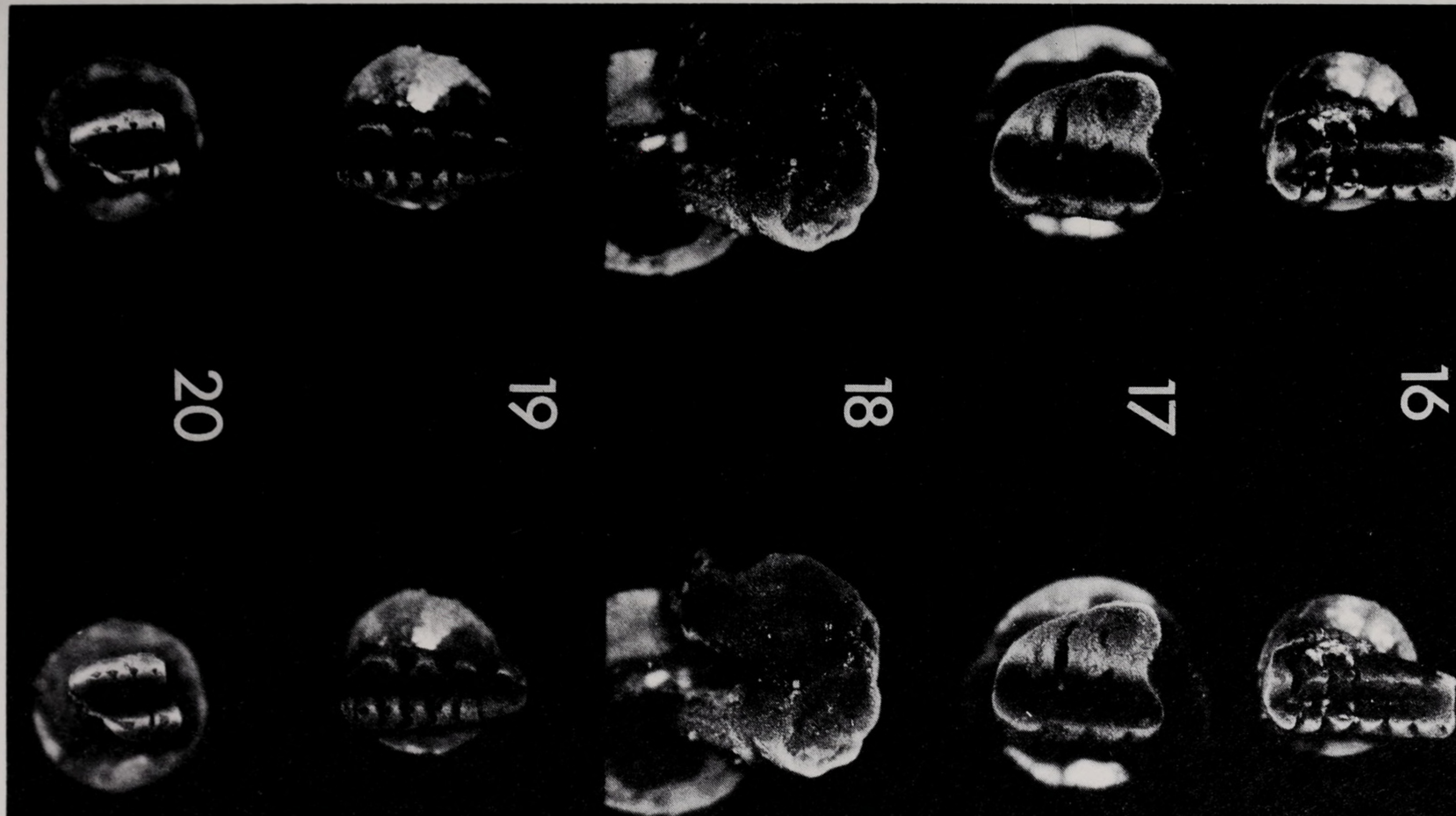


Plate 4. Figs. 16-20. *Microcosmodon conus.* 16. M^1, CM 16149, occlusal view, approx. X 10. 17. M^2, CM 16168, occlusal view, approx. X 15. 18. P_4, CM 16123, external view, approx. X 15. 19. M_1, CM 16149, occlusal view, approx. X 10. 20. M_2, CM 16171, occlusal view, approx. X 10.

and appears to be the union of two cusps.

The cusp formula on CM 16171 (AP 1.2, TR 0.9), a heavily worn M_2, is 4:2. The crown is rather elongate in occlusal outline.

COMMENTS: Among Tertiary multituberculates known to us, only *Microcosmodon* possesses a P_4 with 5 cusp-like cerrations, no anterobasal concavity, and no external and internal ridges. Although similar in outline and serration count, P_4 of *Pentacosmodon* is much larger and bears well developed labial and lingual ridges. The lower molars are referred to *M. conus* on the basis of size association with P_4 and similarity of cusp formula and crown shape to described M_1 and M_2 of *M. conus* (Jepsen, 1940). M^1, with a short internal crenulated crest and robust medial and external cusps, differs significantly from M^1 of *Mesodma* sp., and appears eucosmodontine in character. M^2 is narrower, more elongate, and has a higher cusp formula than that of *Mesodma* sp. Future recovery of associated upper and lower dentitions of *M. conus* may, however, prove the tentative referral of these isolated upper molars to *M. conus* to be incorrect.

Infraclass Metatheria
Order Marsupicarnivora
Family Didelphidae
Peradectes Matthew and Granger, 1921
Peradectes protinnominatus McKenna, 1960
Figure 21

REFERRED SPECIMENS: M^3, 23705; molar trigonids, 23706-23709.

DESCRIPTION: CM 23705, a labial fragment of M^3 (AP 1.6) bears a well-developed metacone, a paracone, and four stylar cusps. The paracone is worn well below the height of the metacone, but the size of its base implies that the metacone and paracone were subequal in height. Stylar cusp C is very weak and is the smallest of the stylar cusps. Cusp D is well developed and is slightly larger than cusp B. Cusp A is intermediate in size between cusps B and C.

On the referred trigonid fragments, the protoconid is the tallest cusp, with the metaconid higher than the paraconid.

COMMENTS: M^3 resembles *Peradectes,* and differs from *Peratherium* in possessing subequal paracone and metacone. The tiny stylar cusp C on M^3 implies affinity to the Wasatchian *Peradectes protinnominatus* rather than the Tiffanian *P. elegans,* in which cusp C is well developed. The teeth described here are larger than those of *P. pauli* (Gazin, 1956a), which is known only from the lower dentition.

Three didelphid molars from the Tiffanian of Alberta, Canada, were described by Krishtalka (1973) as *Peradectes* cf. *elegans.* However, University of Alberta No. 5760, an M^1, bears a tiny stylar cusp C and, along with the two lower molars, should be referred to *P. protinnominatus.*

Infraclass Eutheria
Order Insectivora
Family Leptictidae
Leptictid sp.
Figure 22

REFERRED SPECIMENS: M^1 or M^2, 16230, 23704.

COMMENTS: The two referred specimens are lingual fragments of upper molars that bear an anteroposteriorly compressed protoconid, a small hypocone on a wide hypoconal shelf, long protocristae, and an extremely weak anterior cingulum. Compared to known Tiffanian leptictids, the molar fragments are larger than *Diacodon pearcei* (Gazin, 1956a) and *Palaeictops septentrionalis* (Russell, L. S., 1929). As in *Palaeictops,* the protocone is high and anteroposteriorly compressed. However, these specimens cannot be assigned to *Palaeictops* with any degree of certainty until more complete material is recovered.

Family Pentacodontidae
Aphronorus Simpson, 1935
Aphronorus fraudator Simpson, 1935

REFERRED SPECIMENS: M^2, 16219, 16235; M_2, 23715 (AP 2.4; TR 1.8).

COMMENTS: The three molars referred to *Aphronorus* are much smaller than those of *A. orieli* (Gazin, 1969) but closely agree in size and morphology with M^2 and M_2 of *A. fraudator,* described by Simpson (1935, 1937) from the Torrejonian of Montana. The first occurrence of *Aphronorus* in Tiffanian deposits was reported from the Shotgun Local Fauna, Wyoming, by D. E. Russell (1967). Examination of Shotgun material and personal communication with Craig Wood, Harvard University, indicate the occurrence of both *A. fraudator* and *A. orieli* in the Shotgun fauna.

Family Palaeoryctidae
Palaeoryctid sp.
Figure 23

REFERRED SPECIMENS: M_1 or M_2, 16221, 23710-23714 (range, AP 2.3-2.7, TR 2.0).

DESCRIPTION: All but one (CM 16221) of the referred specimens are extremely worn lower molars. Discernible palaeoryctid characters are the very high trigonid, the relatively narrower and shorter talonid, and the simple, arc-shaped postcristid. On CM 16221 the paraconid is highly compressed anteroposteriorly and occurs considerably internal relative to the metaconid. The protoconid and metaconid are well devel-

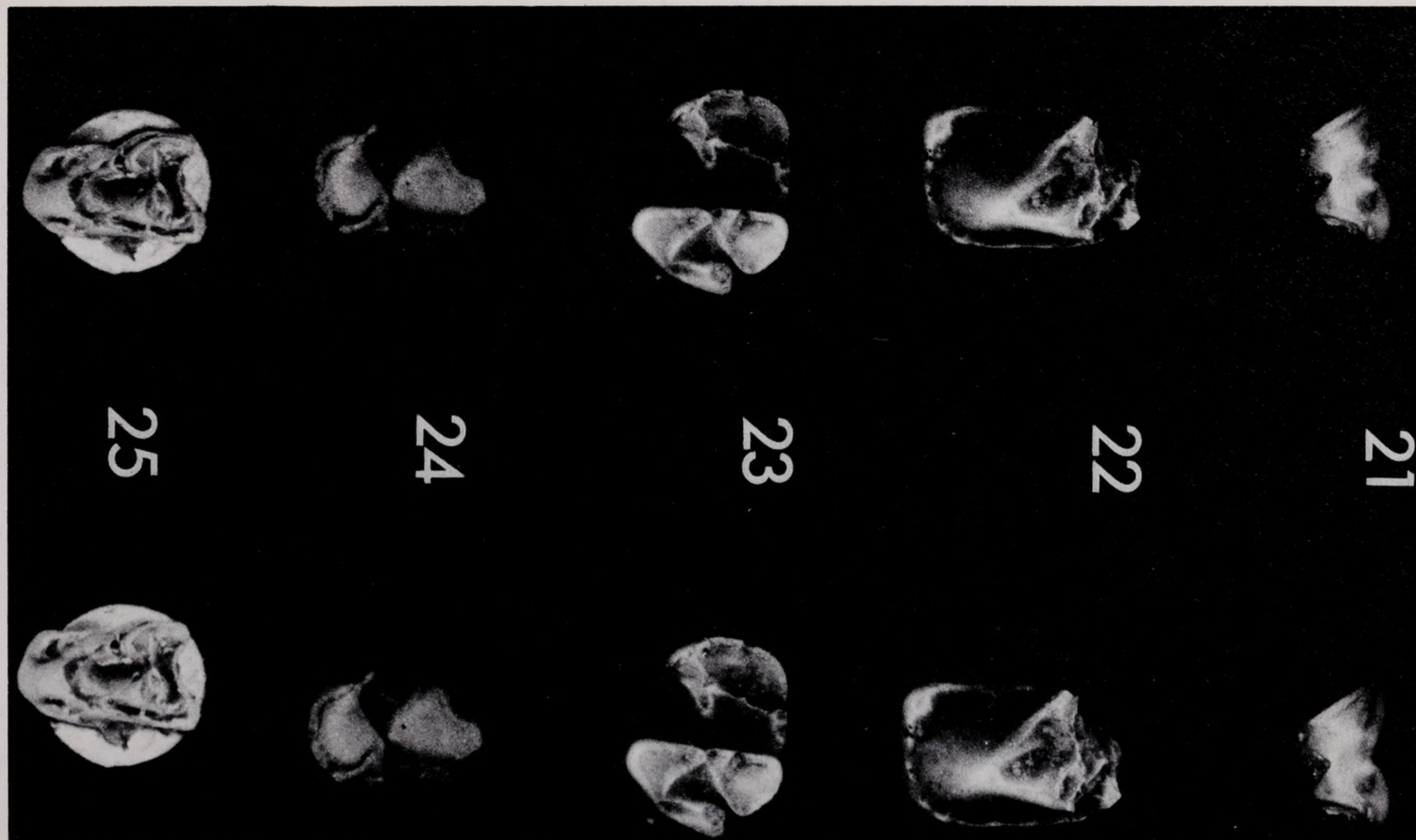


Plate 5. Fig. 21. *Peradectes protinnominatus.* External ½ of M^3, CM 23705, occlusal view, approx. X 10. Fig. 22. Leptictid sp. Internal ½ of M^1 or M^2, CM 23704, occlusal view, approx. X 10. Fig. 23. Palaeoryctid sp. M_1 or M_2, CM 23713, occlusal view, approx. X 10. Figs. 24-25. *Apatemys kayi.* 24. M_1 or M_2, CM 16218, occlusal view, approx. X 10. 25. M^2, CM 16231, occlusal view, approx. X 10.

oped, with the metaconid relatively lower, less robust, and more posterior in position. The hypoconid forms the highest point on the talonid, and the cristid obliqua is median on the posterior wall of the trigonid.

COMMENTS: These lower molars fall within the range in size of *Avunculus* Van Valen, 1966, and *Gelastops* Simpson, 1935, but cannot be assigned to either genus until more complete material is recovered. The authors follow MacIntyre (1966), Szalay (1968), and McKenna (1969) in classifying palaeoryctids as Insectivora rather than Deltatheridia (Van Valen, 1965, 1966).

Family Adapisoricidae
Talpavus Marsh, 1872
Cf. *Talpavus*
Figures 26-28

REFERRED SPECIMENS: M^1 or M^2, 16226, 16227, 23719; P_4, 23718; M_1, 12495, 23717; M_2, 23716; M_3, 16210.

DESCRIPTION: The referred upper molars are small, lingual fragments that bear a well developed protocone, a small hypocone, and distinct conules. The protocone leans anteriorly and is not anteroposteriorly compressed. The hypocone, which is on the posterior cingulum, is separate from and posterolingual to the protocone. The protocristae and conulecristae are sharp and distinct. The precingulum is narrow and terminates lingually in a tiny cuspule.

P_4 (CM 23718; AP 1.7, TR 1.1) is submolariform, with a tricuspid trigonid and a relatively wide but unbasined talonid. The three trigonid cusps are extremely worn but appear to have been well developed when complete. The talonid is shorter than and approximately three-fourths as wide as the trigonid. The hypoconid is worn flat, the hypoconulid is small and medial, and the entoconid is well developed and is the highest of the three talonid cusps. The postcristid is slightly arcuate.

The trigonid on M_1 (CM 12495; AP 1.8, TR 1.2) is narrower than the talonid. The paraconid is moderately developed and is compressed anteroposteriorly. As on P_4, the entoconid is much higher than the worn hypoconid and the hypoconulid is small and central on the postcristid.

M_3 (CM 16210; AP 1.8, TR 1.2) is extremely worn, so that the diagnostic features of the paraconid cannot be discerned. However, as on P_4 and M_1, the hypoconid is worn flat, below the height of the entoconid.

COMMENTS: The authors follow Robinson's (1968a, 1968b) classification of adapisoricid and nyctitheriid insectivores. The teeth closely resemble *Talpavus* in that the talonid on P_4 is large and unbasined, the paraconid is anteroposteriorly compressed on M_1, and the entoconid is much higher than the hypoconid on P_4, M_1, and M_3. This condition differs from that of *Leptacodon* and other nyctitheriids in which the talonid on P_4 is relatively narrow, the hypoconid on M_{1-3} is higher than the entoconid, and the hypoconulid occurs slightly lingual to the midline. Relative to *Talpavus* and the present sample, the talonid on P_4 of *Entomolestes* (Adapisoricidae) is narrower, and the paraconid on the lower molars is not as compressed anteroposteriorly.

The upper molars from Badwater are approximately one-half as large as those of *T. sullivani* (Guthrie, 1971), and are tentatively referred to cf. *Talpavus* on the basis of size association with the lower molars and their adapisoricid-like characters: the anterior leaning protocone, a distinct posterolingual hypocone, and sharply defined conules and cristae.

In comparable parts of the dentition, cf. *Talpavus* is slightly larger than the Bridger *Talpavus nitidus,* much smaller than *T. sullivani,* but close in size to *T. (Leipsanolestes) seigfriedti* (Simpson, 1928) from the Bear Creek Tiffanian of Montana. According to Simpson (1928), the paraconid on P_4 of *T. seigfriedti* is rudimentary, the talonid is narrow and simple, and the hypoconulid on $M_{1\text{-}2}$ is not definite. This condition differs from, and seems more primitive than, that described above for cf. *Talpavus.*

Scenopagus McKenna and Simpson, 1959

Cf. *Scenopagus*

Figure 29

REFERRED SPECIMEN: M^1, 16222 (AP 1.9; TR 2.6).

DESCRIPTION: The crown of CM 16222 is constricted anteroposteriorly across the conules and is considerably longer labially than lingually. The labial and lingual borders of the crown are nearly parallel and oriented obliquely posterobucally. The anterior and posterior margins of the crown are respectively convex and concave in parallel fashion along the lingual two-thirds of the tooth. The three major cusps are well developed: the paracone is tall, conical, and nearly vertical in stature; the metacone is somewhat lower, compressed labiolingually, and leans posteriorly; the protocone is large, leans anterolabially, and possesses a long lingual slope. The hypocone, quite small and conical, forms the lingual end of the narrow postcingulum. The conules are pyramidal in structure and well developed, each with distinct pre- and postconulecristae. The parastyle is a low, somewhat enlarged shelf and forms the anteriormost extension of the crown. There is no metastyle and the ectoflexus is extremely shallow. The short precingulum does not extend to the lingual margin of the crown. Both the pre- and postcingula narrow labially and terminate at the level of the conules. The paracingulum and metacingulum are broad, but do not, respectively, extend completely around the base of the paracone and metacone. The postmetacrista is straight in occlusal view, and runs directly posterolabially, with no flexure. There is no preparacrista.

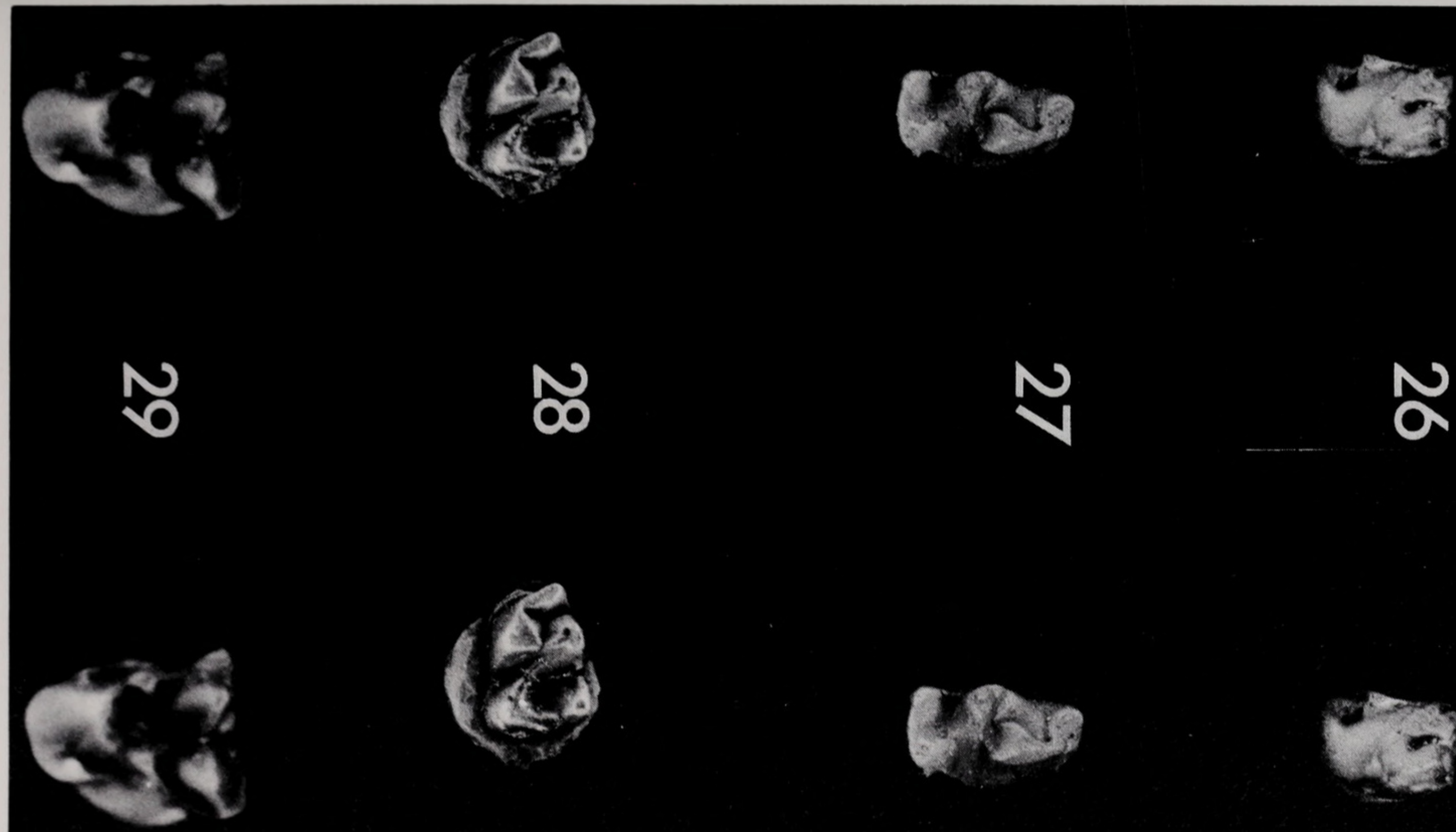


Plate 6. Figs. 26-28. Cf. *Talpavus*. 26. M^1 or M^2, CM 16226, occlusal view, approx. X 10. 27. P_4, CM 23718, occlusal view, approx. X 10. 28. M_1, CM 12495, occlusal view, approx. X 10. Fig. 29. Cf. *Scenopagus*. M^1, CM 16222, occlusal view, approx. X 10.

COMMENTS: This upper first molar is of the adapisoricid-nyctitheriid-type in crown shape and cusp morphology. Among early Tertiary adapisoricids and nyctitheriids (including *Leptacodon*) known to us, CM 16222 most closely resembles M^1 of *Scenopagus* (McKenna and Simpson, 1959), previously known only from Eocene horizons. The absence of a distinct metastyle, and the small hypocone and postcingulum on CM 16222 obviates referral of this molar to a known species of *Scenopagus,* all of which possess a large metastyle, and a large hypocone at the lingual end of a broad postcingulum. In all other characters, CM 16222 and M^1 of *Scenopagus* are very similar: significantly, a shallow ectoflexus, a flaring parastylar salient, absence of a preparacrista, hypocone separate from the protocone, and a labiolingually compressed metacone that is drawn posterolabially into a high postmetacrista. These shared characters suggest that this latest Paleocene species of cf. *Scenopagus,* represented by CM 16222, may have been temporally and morphologically close to the ancestry of the earliest known Eocene species of *Scenopagus* (from the Lost Cabin), with enlargement on the upper molars of the hypocone, metastyle, and postcingulum developing in these lineages by Eocene time.

Among other known adapisoricids and nyctitheriids, CM 16222 only superficially resembles M^1 of *Leptacodon tener* and *Talpavus.* Comparison of CM 16222 with McKenna's (1963) reconstruction of the type of *L. tener* revealed the following differences: a greater degree of crown constriction across the conules on CM 16222, a much shallower ectoflexus, a posterolabial (in contrast to a posterolingual) orientation of the lingual margin of the crown, a straight (rather than flexed) postmetacrista, a slightly more conical metacone, and narrower, shorter anterior and posterior cingula. Upper molars of Eocene *Talpavus* (Guthrie, 1971; and CM 12397, partial left maxilla with M^{1-3}, Willwood Fm., Big Horn Basin, Wyo.) and *Entomolestes* (Guthrie, 1971) differ from CM 16222 (and upper molars of *Scenopagus*) in possessing a weaker, lower postmetacrista, a distinct preparacrista, and a conical, uncompressed metacone. Finally, CM 16222 is distinct from the fragmentary upper molars assigned in this paper to cf. *Talpavus* in its larger size, smaller hypocone, and in the posterolabial, instead of posterolingual, orientation of the lingual margin of the crown.

Family Apatemyidae

Apatemys Marsh, 1872

Apatemys kayi (Simpson, 1929)

Figures 24-25

REFERRED SPECIMENS: M^2, 16231; M_1 or M_2, 16218.

DESCRIPTION: The M^2 (CM 16231, AP 1.3; TR 2.0) is quadrate in occlusal outline, quite transverse, and slightly constricted anteroposteriorly at the level of the conules. The ectoflexus is deep and symmetrically concave, producing distinct metastylar and parastylar salients. The protocone occurs anterior to the midline, and its base forms the lingual extent of the crown. The lingual border of the tooth, from the base of the protocone to that of the hypocone, is oriented obliquely posterobucally. The hypocone is large and conical, and is situated directly posterior to the protocone. A moderately broad stylar shelf occurs between the labial edge of the crown and the well-developed, conical paracone and metacone. The paracone is taller than the metacone, broader at the base, and slightly more labial in position. Although they are badly worn, the conules appear to have been subequal in size, with the paraconule situated more lingual than the metaconule. Both the paracingulum and metacingulum are broad. The paracingulum extends to the parastyle, whereas the metacingulum terminates lingual to the metastyle. A high and broad postmetacrista runs from the posterior side of the metacone to the metastyle. The anterior and posterior cingula are narrow and do not extend labially beyond the level of the conules.

The referred lower molar (AP 1.9, TR 1.2) possesses the characteristic lingual apatemyid curve, and a squared trigonid with an anterolabial cusp. The trigonid is low, and narrower than the talonid. The protoconid and metaconid are subequal with the metaconid more posterior. The paracristid extends directly anteriorly from the protoconid to a tiny, ridge-like anterolabial cusp, which in turn is joined to the anterolingual paraconid by a lateral cristid. The paraconid occurs substantially medial relative to the metaconid. The hypoconid is small and the entoconid and hypoconulid are broken away. The cristid obliqua is medial on the posterior wall of the trigonid, and the talonid basin is not symmetrical, but slopes to its deepest point at the posterolingual part of the base of the metaconid.

COMMENTS: Among known Paleocene and Eocene apatemyids, the molars described here closely resemble *Apatemys* in the corresponding parts of the dentition. In contrast to *Labidolemur* (Matthew and Granger, 1921) and *Jepsenella* (Simpson, 1940), M^2 (CM 16231) possesses a hypocone, well developed conules, a larger metastyle, and a more quadrate occlusal outline, and CM 16218 (M_1 or M_2) has a much lower trigonid (McKenna, 1963; West, 1972). Both molars agree in size with *A. kayi,* known from the Tiffanian Bear Creek fauna, Montana.

Except for the Late Eocene *A. uintensis,* West (1973) recently synonymized all of the other known species of *Apatemys* as *A. bellus,* and considered the high coefficients of variation for the resultant sample of *A. bellus* as a corollary of the great temporal and geographic range of the species. We believe that these high C.V. values (generally between 10-20) warrant continued separation of the species of *Apatemys* until more evidence for their synonymy is found.

Order Primates
Suborder Plesiadapoidea
Family Plesiadapidae
Plesiadapis Gervais, 1877
Plesiadapis farisi Dorr, 1952

REFERRED SPECIMENS: I, 16273, 16286; P^3, 16243, 16245, 16268, 16277, 16272, 23720; P^4, 12472, 16251, 16242, 16204, 16246, 23721; M^{1-2}, 16194; M^1, 12484-12486, 12480, 16193, 16197, 16207, 16253, 16283, 16266, 23722, 23723; M^2, 23724, 16203, 16255, 16198, 16199; M^3, 16275, 12479, 23725-23732; P_3, 16284; P_4, 16249, 16248, 23733, 23734; M_{1-2}, 12471; M_1, 23735, 12481-12483, 16285, 16267, 16265, 16247; M_2, 12459, 16256, 16270, 12469, 12470, 16254, 16206; M_3, 16250, 16281, 16252, 16282, 12477, 12478, 23736, 23740; fragments of molars and premolars, 23741.

MEASUREMENTS: P^3, AP 2.2-2.7, TR 2.8-3.3; P^4, AP 2.4-3.0, TR 3.9-4.1; M^1, AP 3.2-3.5, TR 4.3-4.7; M^2, AP 3.5-3.8. TR 5.2-5.8; M^3, AP 3.2-3.7, TR 4.5-5.4; P_3, AP 2.4, TR 2.2; P_4, AP 2.5-2.8, TR 2.4; M_1, AP 3.0-3.6, TR 2.7-3.1; M_2, AP 3.3-3.8, TR 3.0-3.5; M_3, AP 5.0-5.3, TR 2.9-3.5.

COMMENTS: A detailed treatment of the isolated teeth of *P. farisi* from Badwater is unnecessary, as this species has been adequately described by Dorr (1952, 1958). The diagnostic features of the isolated teeth are as follows: P^{3-4} are transverse, bear a distinct and elongate paraconule, and confluent paracone and smaller metacone. On M^{1-3} the hypocone is not a distinct cusp, and the mesostyle is a weak ridge. P_4 is simple, with no metaconid or paraconid. The trigonid is slightly narrower than the talonid on M_{1-2}, and the labial walls of the protoconid do not exhibit the exaggerated slope characteristic of *P. jepseni* and *P. anceps* (Gazin, 1956a; 1956b). On M_3 the posterior lobe of the talonid is nearly as broad as the anterior lobe.

In contrast to *P. farisi* and the teeth described here, P_4 in *P. dubius* and *P. rubeyi* bears an incipient metaconid, P^4 in *P. cookei* and P^3 in *P. anceps* and *P. fodinatus* lack a paraconule, and P^{3-4} in *P. gidleyi* are less transverse, with the paraconule slightly weaker and less distinct.

Family Paromomyidae
Phenacolemur Matthew, 1915
Phenacolemur frugivorus (Matthew and Granger, 1921)

REFERRED SPECIMENS: P^4, 16288; M^1, 16259, 23742-23744; M^1 or M^2, 16293-16295, 16287; M^2, 16260, 12499, 12497; M^3, 16274, 16278, 16261; P_4, 16289; M_1, 12498, 16264, 16296, 16292, 16290, 23745, 23746; M_2, 16262, 16291, 16269, 16257, 16258, 16271, 23747; M_3, 16263, 16297, 23748, 23750.

MEASUREMENTS: P^4, AP 1.9, TR 2.3; M^1, AP 1.9-2.0, TR 2.8-2.9; M^2, AP 1.7-1.9, TR 2.6-3.0; M^3, AP 1.7-2.3, TR, 1.9-2.3; P_4, AP 1.6, TR 1.0; M_1, AP 1.8-2.1, TR 1.4-2.0; M_2, AP 1.8-2.1, TR 1.5-1.8; M_3, AP 2.6-2.7, TR 1.4-1.7.

COMMENTS: The isolated teeth closely agree in size and morphology with *P. frugivorus,* well known from Tiffanian localities in Wyoming, Colorado, Montana, and Alberta (Simpson, 1955; Krishtalka, 1973). *P. frugivorus,* including these specimens from Badwater, is smaller than other Tiffanian and Wasatchian species of *Phenacolemur,* and possesses simpler, less robust fourth premolars and a smaller hypoconal shelf on M^{1-2}. Although the molars of *P. frugivorus* and *P. mcgrewi* (Robinson, 1968c) from the Late Eocene of Badwater, are very close morphologically, the difference in size between M^1 and M^2 of *P. frugivorus* is not as great as in *P. mcgrewi.* The ratio of average length of M^1:M^2 and M_1:M_2 for *P. mcgrewi* is 1.66 and 1.50, respectively. That for *P. frugivorus* from Badwater is 1.1 and 1.0, respectively.

Family Carpolestidae
Carpolestes Simpson, 1928
Carpolestes sp.

REFERRED SPECIMEN: P^4, 16170.

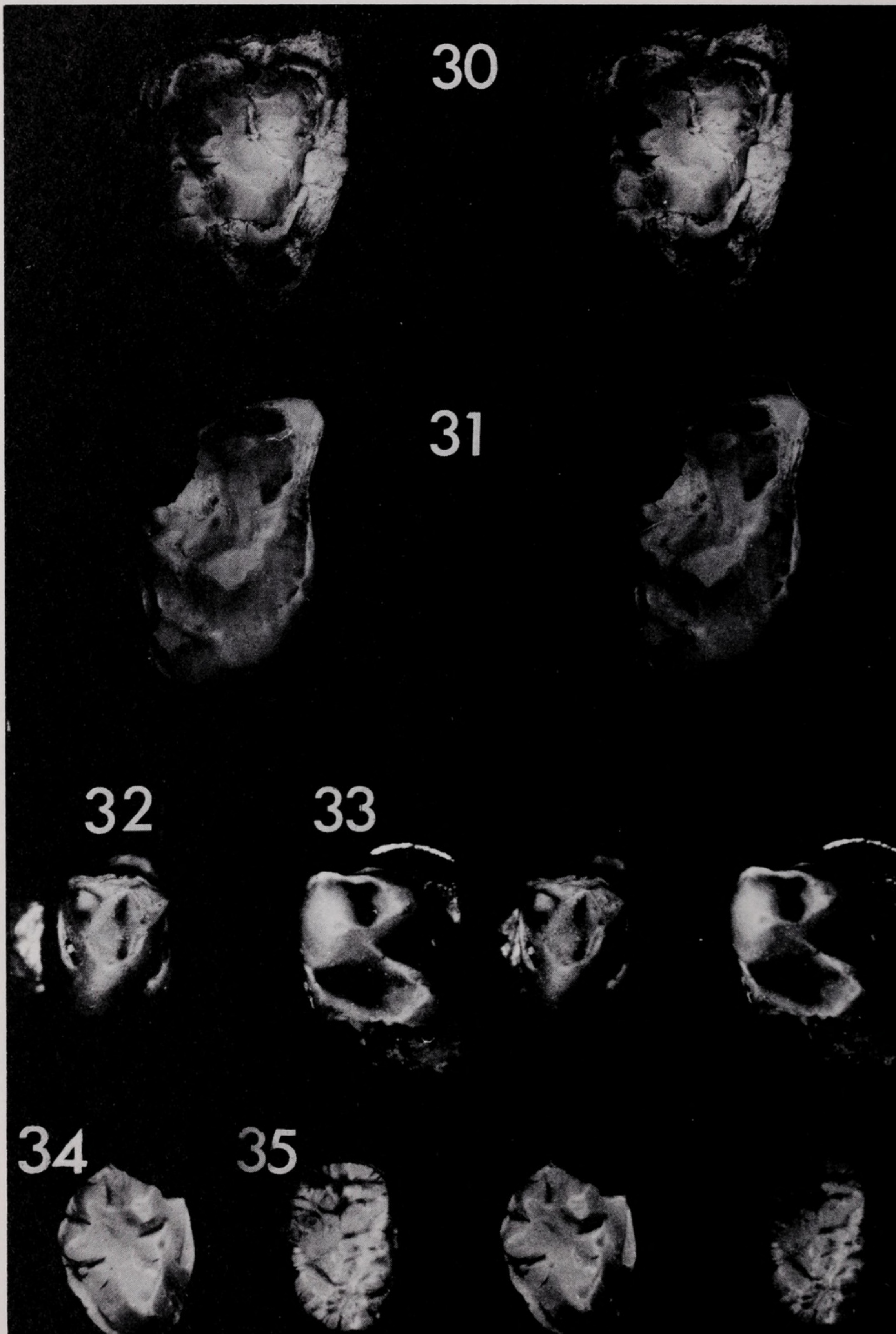
DESCRIPTION: CM 16170 is a labial fragment of a carpolestid P^4 (AP 1.6). Six small cusps, subequal in height, are joined along the labial edge of the crown. The largest intercusp valley occurs between the second and third anterior cusps. The median ridge is preserved on CM 16170 but is well worn. It extends across the length of the crown internal to the labial cusps, and terminates anteriorly in a small cuspule. A round wear facet, which occurs anteriorly near the broken lingual margin of the crown, corresponds to the cuspule on the anterior cingulum of known carpolestid P^4's.

COMMENT: CM 16170 closely resembles P^4 of both *Carpodaptes* and *Carpolestes.* However, it agrees with *Carpolestes* and differs from *Carpodaptes* in that the labial row of cusps is not arcuate in lateral view, and is nearly straight rather than lingually convex in occlusal aspect.

Among described species of *Carpolestes,* P^4 is known only in *C. dubius* (Jepsen, 1930a) where it is much longer than CM 16170. The fragment may represent P^4 of *C. nigridens* (Simpson, 1928) or *C. aquilae* (Simpson, 1929), the known dentitions of which are smaller than in *C. dubius.*

Order Condylarthra
Family Arctocyonidae
Chriacus Cope, 1883
Chriacus pelvidens (Cope, 1881b)
Figures 30-31

REFERRED SPECIMENS: M^1, 16240; M^2, 23751.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DESCRIPTION: In occlusal view, CM 16240, an M^1 (AP 7.7, TR 8.5) is nearly quadrate, with a slightly concave posterior margin and a shallow ectoflexus. The cingulum is continuous around the edge of the crown and bears a large hypocone posterior to the protocone, a small parastyle and a comparatively weaker metastyle. The protocone is large, broad at the base, and occurs anterolingually. The metacone and paracone are subequal, conical, and bunodont, and the conules are well developed.

On M^2, CM 23751 (AP approximately 7.0, TR 8.3), the metacone and the posterolabial corner of the crown are broken away. Relative to M^1, M^2 is slightly shorter, the anterior margin of the crown is gently concave, the cingulum is not continuous lingual to the protocone, and hypocone is more lingual in position.

COMMENTS: These teeth are larger than those of *C. truncatus,* but agree closely in size and crown morphology with *C. pelvidens,* known from both Torrejonian and Tiffanian horizons.

Mimotricentes Simpson, 1937
Mimotricentes sp.
Figures 36-40

REFERRED SPECIMENS: M^1, 12492, 16239; M^2 12457, 12456, 23752, 23753; M^3, 16205; M_1, 12458, 23754; M_2, 23755-23757.

DESCRIPTION: M^1 is quadrate in occlusal view. The protocone is large and crescentic, the paracone and metacone are subequal and conical, and the hypocone is large and bunodont and does not extend lingually beyond the protocone. The metaconule is much larger than the paraconule and lacks a premetaconulecrista. Both paraconulecristae are absent. The parastyle is stronger than the metastyle and juts anteriorly beyond the margin of the precingulum. The cingulum is continuous around the protocone on CM 16239 (AP 6.3, TR 6.5), but is discontinuous on CM 12492 (AP 6.3, TR 6.7). The ectocingulum is incomplete at the ectoflexus in both specimens. Accessory cuspules occur on the postcingulum at the labial and lingual margins of the base of the hypocone.

On M^2 (CM 12457; AP 6.9, TR 8.1) the crown is more transverse than on M^1, the hypocone and conules are weaker, the parastyle is stronger, the ectoflexus is shallower, and the ectocingulum is continuous labially.

Plate 7. Figs. 30-31. *Chriacus pelvidens.* 30. M^1, CM 16240, occlusal view, approx. X 3. 31. M^2, CM 23751, occlusal view, approx. X3. Figs. 32-33. Cf. *Litomylus.* 32. M^1 or M^2, CM 16224, occlusal view, approx. X 10. 33. M_1 or M_2, CM 23763, occlusal view, approx. X 10. Figs. 34-35. *Phenocodus* sp. 34. M^3, CM 23783, occlusal view, approx. X 3. 35. M_3, CM 16200, occlusal view, approx. X 2.

The parastylar area is broken away on CM 16205, the single referred M^3. Relative to M^1 and M^2, the paracone is larger and higher than the metacone on M^3, the paraconule is much stronger than the metaconule, and the hypocone is absent.

The specimens referred to M_1 and M_2 are isolated trigonid fragments. The trigonid cusps are large, conical, and bunodont, with subequal protoconid and metaconid and smaller paraconid. On M_1 the paraconid is somewhat anteroposteriorly compressed and joined to the protoconid by a strong paracristid. On M_2 the paraconid is more nearly conical and more posteromedial in position. The paracristid is weaker on M_2 than on M_1 and the metaconid is less posterior relative to the protoconid. The enamel on all the referred molars is rugose.

COMMENTS: Van Valen and Sloan (1965) referred all species of *Tricentes* (except the type species, *T. crassicolidens*) to *Mimotricentes*. The specimens described here are larger in comparable parts of the dentition than *M. fremontensis* and *M. subtrigonus*, but are close in size to *M. latidens* and *M. angustidens*, of which only the lower dentitions have been adequately described and figured (Simpson, 1937). The characters that distinguish these two species (relative widths of talonid and trigonid on M_1 and M_2) are not discernible on these fragmentary lower molars.

Family Hyopsodontidae
Cf. *Litomylus* Simpson, 1935
Figures 32-33

REFERRED SPECIMENS: M^1 or M^2, 16224, 16228, 23758-23761; M_1 or M_2, 23762, 23763.

DESCRIPTION: All the referred upper molars are lingual fragments. The protocone is crescentic, sharp, and anterolingual in position. The conules, preserved on CM 16224, are well defined, with sharp pre- and postconulecristae. The precingulum is very short, and ends lingually just buccal to the base of the protocone. The postcingulum is well developed and ridge-like, and curls anterolingually toward the base of the protocone. The hypocone is tiny, and is formed by the expansion of the lingual end of the postcingulum. A weak groove occurs between the hypocone and protocone on the posterolingual face of the latter. In occlusal view the crown of the upper molar fragments is essentially rectangular, with a straight lingual margin, and anterior and posterior borders that converge labially.

The two lower molars thought to pertain here are also fragmentary, with the trigonid and part of the talonid preserved on CM 23763. The protoconid and metaconid are conical, but the metaconid is taller and broader at the base. Significantly, the paraconid is extremely reduced and merely forms the lingual end of a small, ridge-like paracristid,

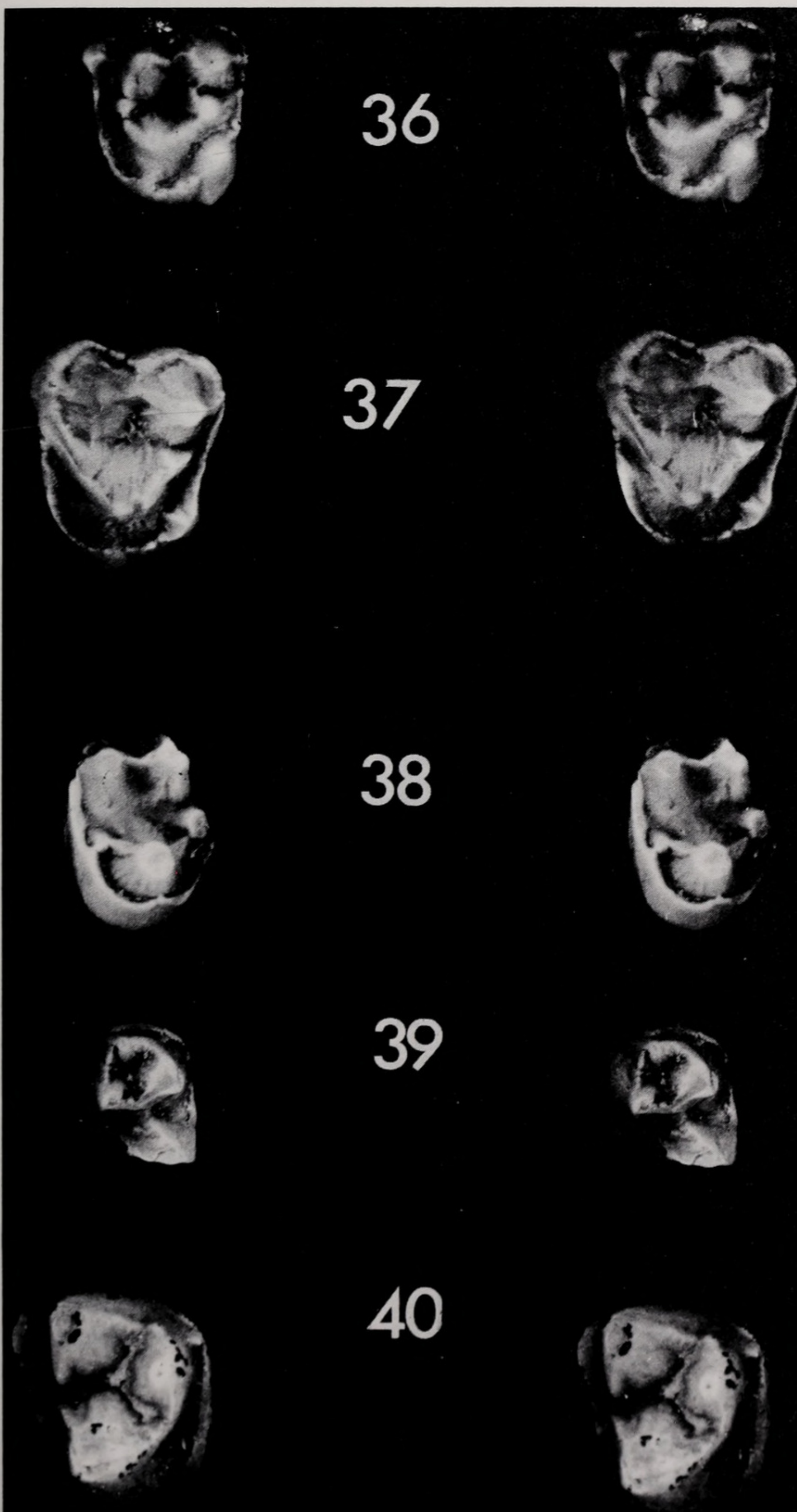

Plate 8. Figs. 36–40. *Mimotricentes* sp. 36. M^1, CM 12492, occlusal view, approx. X 3. 37. M^2, CM 12457, occlusal view, approx. X 3. 38. M^3, CM 16205, occlusal view, approx. X 3. 39. M_1, CM 12458, occlusal view, approx. X 3. 40. M_2, CM 23755, occlusal view, approx. X 5.

which extends between the anterior part of the base of the protoconid and metaconid.

COMMENTS: The fragments of the upper molars are *Litomylus*-like in the slight medial constriction of the crown, the sharp crescentic structure of the protocone and conules, and the occurrence of a tiny hypocone on a narrow postcingulum. The partial lower molars resemble *Litomylus* in the extreme reduction of the paraconid and the straight, short ridge-like nature of the paracristid. However, the referred material is considerably smaller in comparable parts of the dentition than known species of *Litomylus* and is too fragmentary to be definitely assigned to that genus.

Phenacodaptes Jepsen, 1930a

Phenacodaptes sabulosus Jepsen, 1930a

REFERRED SPECIMENS: M^2, 16201, 23764-23766; M_2, 16276; M_3, 23767.

COMMENTS: The referred upper and lower molars closely resemble those of *P. sabulosus,* described by Jepsen (1930a) and Gazin (1959). Comparison of the Badwater material with casts of Princeton University Nos. 17591 and 14398 (partial upper and lower dentitions, respectively, of *P. sabulosus* from Silver Coulee) revealed no significant differences in size or crown morphology.

Family Phenacodontidae

Ectocion Cope, 1882

Ectocion osbornianum Cope, 1882

REFERRED SPECIMENS: M^1 or M^2, 23778, 23779, 23780; M^3, 16209; M_1, 23781.

DESCRIPTION: On the referred upper first or second molars, all of which are lingual fragments, the crown narrows internally and has a long lingual slope. The protocone and hypocone are large and bunodont and occur at the anterolingual and posterolingual corns of the rectangular crown. The conules are well developed, with the metaconule slightly anterior relative to the hypocone. On M^3 the hypocone is absent, the paracone is about twice as large as the metacone, the conules are strong, and a well developed mesostyle is present.

CM 23781, an M_1 trigonid, bears subequal and bunodont protoconid and metaconid. Although the paraconid is not a definite cusp, the paracristid is strong, and characteristically slopes ventrolingually towards (while being separate from) the anterior part of the base of the metaconid. A distinct metastylid occurs on the posterolingual slope of the metaconid.

COMMENTS: West (1971) considered *Gidleyina* to be congeneric with *Ectocion.* The rectangular occlusal outline of the partial upper molars differs from the subquadrate condition of M^1 and M^2 of *Phenacodus* and species previously referred to *Gidleyina,* but resembles *Ectocion* *sensu stricto* in this respect. The molars from Badwater are larger than molars of *E. parvus,* but they do not differ significantly from *E. osbornianum,* which is known from Late Tiffanian and Wasatchian deposits of Wyoming and Colorado, and from the Late Tiffanian of Alberta.

Phenacodus Cope, 1873
Phenacodus cf. *primaevus*

REFERRED SPECIMENS: M^2, 12475; M^3, 23782; molar fragments, 23768-23777.

COMMENTS: Two species of *Phenacodus* are represented in the collection. Although the material is fragmentary, the molars show a distinct size bimodality. The larger fragments are closest in size to *P. primaevus,* which is known from Tiffanian and Wasatchian horizons. A well developed mesostyle occurs on CM 12475, a partial M^2, and the metaconule is large and only slightly internal relative to the metacone. On CM 23782, a fragment of M^3, the metaconule occurs significantly more posterior relative to the metacone, than on M^2.

Phenacodus sp.
Figures 34-35

REFERRED SPECIMENS: M^3, 23783; M_3, 16200.

COMMENTS: The smaller species of *Phenacodus* is represented by a complete lower and partial upper third molar. M_3 (CM 16200; AP 10.3, TR 7.3) and M^3 are within the size range of *P. almiensis* (Gazin, 1942) and *P. ?bisonensis* (Gazin, 1956a) but cannot be assigned to either species until more complete material is recovered.

AGE OF THE FAUNA

Of the 22 species in the Badwater fauna, two *(Peradectes protinnominatus* and cf. *Scenopagus)* were previously known only from the Eocene, two *(Ectocion osbornianum* and *Phenacodus primaevus)* occur in late Paleocene and early Eocene rocks, and three *(Ptilodus* sp., *Ectypodus* sp. nr. *E. tardus,* and *cf. Talpavus)* possess dental features that seem to imply a late Paleocene or early Eocene stage of development. The remaining 15 species are either known only from late Paleocene deposits, or are undoubtedly of late Paleocene aspect in tooth morphology. The presence of many Paleocene, together with a number of Eocene, forms in the Badwater fauna suggests that the Badwater locality represents a previously unsampled latest Tiffanian facies. The assemblage compares most closely, although only in part, with the late Tiffanian faunas from Silver Coulee, Dell Creek, and Clark Fork, and provides the earliest known record of *Peradectes protinnominatus* and possibly *Scenopagus. Ectypodus* sp. nr. *E. tardus,* cf. *Talpavus* and cf. *Scenopagus* appear to be intermediate between late Paleocene and early Eocene members of those lineages. *Ptilodus* sp. is more advanced than *P. montanus* and *P. wyomingensis* and seems to parallel the late Tiffanian *Prochetodon* in the development of P^3. *Microcosmodon conus* and *Mesodma* sp., as well as the primates *Plesiadapis farisi, Phenacolemur frugivorus,* and *Carpolestes* sp. are reliable indicators of a late Paleocene age. Apart from *Ectocion osbornianum* and *Phenacodus* cf. *P. primaevus,* which occur in both late Tiffanian and Wasatchian deposits, the Badwater condylarths correspond to those recovered from other latest Paleocene localities.

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