

# *American Museum* **Novitates**

---

PUBLISHED BY THE AMERICAN MUSEUM OF NATURAL HISTORY  
CENTRAL PARK WEST AT 79TH STREET, NEW YORK 24, N.Y.

---

NUMBER 2024

NOVEMBER 29, 1960

---

## A Continental Paleocene Vertebrate Fauna from California

BY MALCOLM C. MCKENNA

### INTRODUCTION

The oldest continental Cenozoic fossil mammal, fish, crocodilian, and chelonian remains known from California, or for that matter from anywhere in the United States west of Utah, have been collected near the town of Inyokern from a small number of localities in Paleocene sediments in the El Paso Mountains. This range lies between the Garlock fault and the southern Sierra Nevada. A few fragmentary specimens have been recovered from poor outcrops of the Goler formation (Dibblee, 1952, p. 19), a sequence of conglomeratic clays, sands, and gravels approximately 6500 feet thick. Outcrops of the Goler formation lie mainly within the Saltdale quadrangle (Corps of Engineers, United States Army, topographic map, 1943, 1:62,500), but a few outcrops and probably the main subsurface extent of the formation are within the Inyokern quadrangle (Corps of Engineers, United States Army, topographic map, 1943, 1:62,500). The Goler formation also has been traced eastward from the Saltdale quadrangle into sections 35 and 36, T. 28 S., R. 39 E., and sections 30, 31, and 32, T. 28 S., R. 40 E., Randsburg quadrangle, by C. D. Hulin (1925, geologic map, Randsburg quadrangle). These outcrops in the Randsburg quadrangle lie north of the Garlock fault, but they and various outcrops south of the fault in the vicinity of Red Mountain, the Lava Mountains, and Summit Diggings were referred by Hulin to the Rosamond series of Hershey (1902). Hulin's referred Rosamond outcrops north of the Garlock fault belong to the Goler formation (Dibblee, 1952, p. 19).

Prior to 1955 the Goler formation was considered to be possibly Eocene (*sensu lato*) in age by F. H. Knowlton (statement printed by Fairbanks, 1896, p. 68, and reprinted by Smith, 1900, p. 456). Knowlton based his age estimate on three small fragmentary specimens representing two species of fossil plants. These were recovered at a locality low in member 2 from clay immediately above an impure coal seam which occurs approximately 1 mile northeast of Gerbracht Camp in the Saltdale quadrangle. The geologic map of California issued by the State Mining Bureau in 1916 mapped the Goler and Ricardo formations as one unit (Mohave formation as described by H. W. Fairbanks and named by J. H. Smith) and labeled the unit "Miocene" in spite of the previously published paleobotanical evidence for an early Cenozoic date. The geologic map of California issued by the California Division of Mines in 1938 separated the Goler and Ricardo formations on the basis of previously unpublished mapping by Hulin (Dibblee, 1952, p. 10), showing both formations in considerably greater detail than on the previous state geologic map, but the Goler formation was placed in the category of undivided Miocene non-marine sediments. The paleobotanical evidence continued to be discounted. Hulin's (1925) referred Rosamond series in the Lava Mountain-Red Mountain area in the Randsburg quadrangle was also placed in the undivided Miocene, and his referred Rosamond series was extended westward, north of the Garlock fault, from the Randsburg quadrangle into both the present Saltdale and Inyokern quadrangles.

The Rosamond "series" has a complicated nomenclatural history which need not be discussed here, but sediments referred to the Rosamond "series" in the first half of this century have generally been regarded as Miocene on the basis of mammalian faunas recovered from badlands in the Barstow Syncline, the bone-bearing sediments ("Barstow formation" of Merriam, 1915, 1919, *not* Hershey, 1902) themselves merely being referred to the Rosamond "series." Reference of the Goler formation to the Miocene on the 1938 state geologic map of California thus depended on the inferences that: (1) the Barstow faunas are Miocene; (2) the Barstow faunas date Rosamond sediments; (3) Hulin's sediments in the Randsburg quadrangle south of the Garlock fault are referable to the Rosamond, of which the type section is in the Elizabeth Lake quadrangle; (4) Hulin's sediments north of the Garlock fault in the Randsburg quadrangle, which are continuous with the Goler formation in the adjacent Saltdale quadrangle, are referable to Hulin's referred Rosamond sediments south of the Garlock fault; and (5) paleobotanical evidence for an early Cenozoic age for part or

all of the Goler formation was unreliable.

However doubtful Knowlton's original evidence for Eocene (including Paleocene) age may have been, confirmation of his estimate was provided by Axelrod (1949, p. 1935). Representatives of five genera of plants (*Anemia*, *Anona*, *Myrica*, *Persea*, *Parathesis*) from Knowlton's locality led Axelrod to state that an Eocene (*sensu lato*) age was clearly demonstrated.

T. W. Dibblee, Jr., published a study of the geology of the Saltdale quadrangle in 1952, separating the Goler formation from Hulin's referred Rosamond south of the Garlock fault and discussing its age. Dibblee's abstract (p. 8) stated that the Goler formation is probably Miocene in age. In his discussion of the geologic history of the Saltdale quadrangle he stated (p. 41) that the events of the Cretaceous-Eocene left no record in the region. In most of his paper, however, Dibblee estimated the age of the Goler formation as late Eocene to Miocene, generally with late Miocene as the upper limit, though his geological map gave the age as Eocene to lower Miocene. Member 2, in the lower part of which occurs the locality from which Knowlton's and Axelrod's fossil plant remains were collected, tentatively was stated to range from Oligocene or Miocene to possibly upper Miocene (p. 25). Clearly, lithologic similarities and known regional geologic relations suggested a Miocene age to Dibblee for member 2. But the finding of fossil plants of Eocene aspect low in member 2, *the upper member*, did force consideration of a possible pre-Miocene age, such as Oligocene (p. 25), for at least these beds. Member 1, which underlies member 2, was placed anywhere from Eocene to Miocene, again mainly on the basis of certain lithologic similarities (e.g., p. 23).

The Trona sheet of the geologic map of California, issued in uncolored form in 1955, placed the Goler formation in the category of Oligocene non-marine sediments on the map itself, but on the explanatory chart that accompanies the map one of Dibblee's statements giving the age as Eocene to lower Miocene was cited as the published source for the allocation.

Dibblee (1952, p. 25) stated that "the only vertebrate fossil obtained from the Goler formation is a turtle of indeterminable age. It was found about a mile north of Holland Camp, in Goler Gulch." This specimen and a mammal tooth found about a mile northeast of the original fossil plant locality were collected for Chester Stock of the California Institute of Technology shortly before his untimely death in 1950. Both of these specimens were accidentally lost prior to 1952.

Identifiable fossil vertebrates were not recovered from the Goler

formation until December, 1954, despite several intensive prospecting efforts. At that time a mammalian jaw fragment containing one tooth was collected at a locality in Laudate Canyon, high in member 2, about 5000 feet above the base of the type section of the formation in Goler Gulch. This specimen was shown to be a Paleocene anisonchine condylarth jaw in a short note by the author (McKenna, 1955). The discovery of Paleocene fossils high in the upper member of the Goler formation established beyond question that at least this part of the Goler formation was of Paleocene age, probably early or middle Paleocene, and that stratigraphically lower sediments were of approximately the same age or older.

Prospecting has been intermittently continued from 1955 to the present, but identifiable specimens are extremely rare. Approximately one man-week of prospecting per identifiable mammalian specimen has been required. The total available collection from the Goler formation now consists of five identifiable mammal teeth and a scattering of other vertebrate remains, collected by R. H. Tedford, L. R. Kent, B. D. Combs, and the writer. Four of the mammal teeth were found in Laudate Canyon, about 5000 feet above the base of the formation. A fifth tooth was recovered some 3400 feet lower in the section, or approximately 1600 feet above the base of the type section. This second locality is at approximately the level that yielded the plant remains discussed by Knowlton and by Axelrod. Most of the prominent exposures of the Goler formation have now been thoroughly prospected.

I would particularly like to thank Messrs. Lester R. Kent, Burton D. Combs, and Richard H. Tedford for their patient help in the field. Mr. Leigh Van Valen read the manuscript and generously made available certain observations on anisonchine molar morphology. Dr. D. E. Savage, University of California, permitted the loan of the Laudate specimens. Dr. G. L. Jepsen, Princeton University, made available certain specimens of *Neoliotomus*. Figures 1 and 2 were drawn by Mr. Howard Hamman. Figures 3 and 4 were prepared by Mr. Chester Tarka.

Abbreviations are used to indicate the catalogued specimens, and the localities, of various institutions; the former are listed with the abbreviation "No." between the initials of the institution and the number:

A.M.N.H., the American Museum of Natural History

C.N.H.M., Chicago Natural History Museum

P.U., Princeton University

U.C.M.P., University of California Museum of Paleontology, Berkeley

## LAUDATE LOCAL FAUNA: UPPER FAUNULE

## CLASS REPTILIA

## ORDER CHELONIA

SPECIMEN: U.C.M.P. No. 55403, a poorly preserved tibia.

LOCALITY: U.C.M.P. V-5251, progressive grid coordinates 1,314,000–1,396,900, Saltdale quadrangle, California, Corps of Engineers, United States Army, topographic map, 1943; member 2, Goler formation. The specimen was taken from gypsiferous carbonaceous shales interbedded with sandstone about 200 feet stratigraphically below the local contact of member 2 of the Goler formation with the unconformably overlying Ricardo formation. The locality is stratigraphically at approximately the same level as U.C.M.P. V-5352 and V-5870, across the valley to the east.

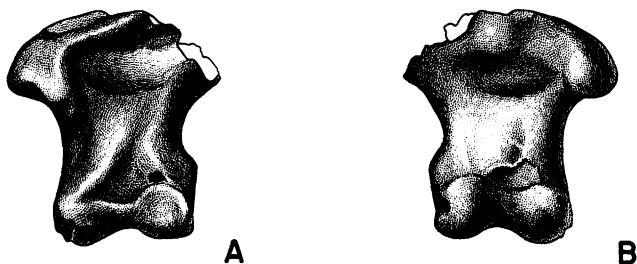


FIG. 1. ?Chelonian phalanx; upper faunule, Laudate local fauna, Goler formation, Paleocene of California; U.C.M.P. No. 55401. A. Ventral view. B. Dorsal view.  $\times 1$ .

DISCUSSION: The specimen is of little interest other than to demonstrate the occurrence of vertebrate fossils in this part of the formation. Chelonian bone fragments also occur at U.C.M.P. V-5252 and various other localities throughout the section.

## ? ORDER CHELONIA

## Figure 1

SPECIMEN: U.C.M.P. No. 55401, a nearly complete phalanx.

LOCALITY: U.C.M.P. V-5252, site 1. Several hundred yards northeast of and at the same stratigraphic level as U.C.M.P. V-5252, site 3, the progressive grid coordinates of which are 1,318,250–1,398,300, Inyokern quadrangle, California, Corps of Engineers, United States Army, 1943; member 2, Goler formation. The locality is on a siltstone slope, 5 feet beneath a conglomerate cliff, close to the Ricardo contact, high on the north wall of Laudate Canyon. The conglomerate bears bone.

DESCRIPTION: A highly sculptured phalanx with an expanded proximal end. Muscle scars and tuberosities abundant.

DISCUSSION: This specimen is apparently a phalangeal element of some reptile adapted to powerful digging. Various attempts to identify the bone more accurately have all met with failure. It does not appear to be mammalian nor does it appear to be a reptilian or large avian quadrate bone.

#### ORDER CROCODILIA

SPECIMEN: U.C.M.P. No. 55402, an isolated tooth.

LOCALITY: U.C.M.P. V-5252, site 3 (= U.C.M.P. V-5502). Progressive grid coordinates 1,318,250–1,398,300, Inyokern quadrangle, California, Corps of Engineers, United States Army, 1943; member 2, Goler formation.

DISCUSSION: This specimen was found in 1952. Crocodilians are common in early Cenozoic sediments in the United States, but are uncommon thereafter. The finding of a vertebrate fossil that confirmed the paleobotanical dating of the Goler formation as early Cenozoic led to continued prospecting in the Goler formation and the eventual discovery of fossil mammals at the same locality in 1954 and subsequently.

#### CLASS MAMMALIA

##### ORDER MULTITUBERCULATA COPE, 1884

##### FAMILY PTILODONTIDAE GREGORY AND SIMPSON, 1926

##### SUBFAMILY EUCOSMODONTINAE JEPSEN, 1940

Cf. *Neoliotomus* sp.

#### Figure 2

SPECIMENS: U.C.M.P. No. 49490, a nearly unworn lower left incisor crown (fig. 2A–C) and U.C.M.P. No. 55399, a lower right incisor root with the posterior part of the enamel still intact (fig. 2D, E).

LOCALITY: U.C.M.P. V-5870, progressive grid coordinates 1,318,300–1,398,300, approximately 50 yards east of and at the same stratigraphic level as U.C.M.P. V-5252, site 3 (= U.C.M.P. V-5502), Inyokern quadrangle, California, Corps of Engineers, United States Army, 1943; member 2, Goler formation. Both specimens were collected from a south-facing exposure of gray-green silty clay similar to that at U.C.M.P. V-5252, site 3.

DESCRIPTION: Very large, compressed, eucosmodontine, multituberculate incisors the size of those of *Eucosmodon molestus* and *Neolio-*

*tomus*. Crown with enamel-covered tip in early wear. Depth of incisor, 6.5 mm. (U.C.M.P. No. 49490, at posterior end of specimen) to 6.9 mm. (U.C.M.P. No. 55399, at anterior end of specimen). Width of incisor, 2.2 mm. The labial enamel band extends more than halfway across the labial surface of U.C.M.P. No. 49490, but less than halfway across the labial surface of U.C.M.P. No. 55399; on the labial surface of the middle of the tooth the average extent of enamel must have been similar to that of *Eucosmodon jepseni* (A.M.N.H. Nos. 35494 and 35495), *Neo-*

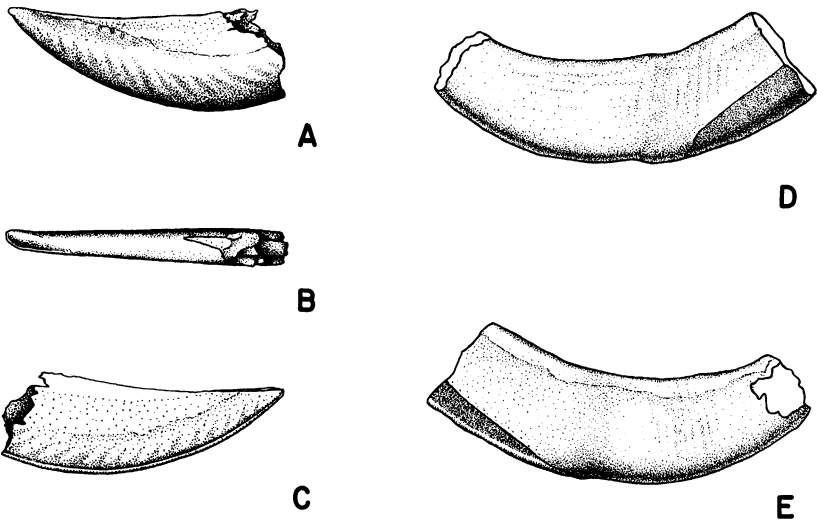


FIG. 2. Cf. *Neoliotomus* sp. A, B, C. Labial, dorsal, and lingual views of a nearly unworn lower left incisor crown, U.C.M.P. No. 49490. D, E. Labial and lingual views of a right lower incisor root with the posterior part of the enamel still intact, U.C.M.P. No. 55399. Upper faunule, Laudate local fauna, Goler formation, Paleocene of California. All  $\times 2$ .

*liotomus* (e.g., A.M.N.H. No. 16783 or P.U. No. 16145), and a Cernay-sian left lower incisor in the Depéret collection, Université de Lyon (Granger and Simpson, 1929, p. 662, fig. 40). The labial enamel band possesses a ridged, slightly beaded, dorsal border for about 12 mm. posterior to the tip. For about a third of this distance the ridged border of the enamel projects slightly above the somewhat worn enamel and dentine between itself and the opposite enamel wall, thus forming a chisel-like structure. For the posterior two-thirds of the distance the ridged dorsal border of the labial enamel wall sinks below the dorsal border of the tooth, and the enamel thins. Finally, the ridge continues in dentine, whereas the dorsal border of the labial enamel band drops about

1.5 mm. to continue in a long sweeping curve to the end of the band.

The lingual surface of the tooth is nearly flat. The lingual enamel band extends approximately one-third of the way across the tooth. At the unworn tip of the crown the lingual enamel may be seen under ultraviolet light to extend onto the dorsal surface of the tooth as a thin, easily destroyed sheet which is continuous with the enamel of the labial band. All along the ventral border of the lingual enamel band there is a slightly raised lip, as in various other eucosmodontine multituberculates.

The crown enamel possesses extremely faint longitudinal striations (not illustrated) that approximately parallel the dorsal curvature of the tooth. Similar faint striations may be seen on *Neoliotomus* incisors. Incisors of *Eucosmodon americanus* (A.M.N.H. No. 3028), *E. teilhardi* (A.M.N.H. No. 16023), *E. jepseni* (A.M.N.H. Nos. 35494, 35495), and *E. molestus* (A.M.N.H. No. 17063) show about half a dozen somewhat stronger longitudinal striations, though none of these striations reaches the fluted stage to be seen in *Taeniolabis* (Granger and Simpson, 1929, p. 605).

Both the crown and the root possess waves of growth bands which slant diagonally across the tooth. On the crown the growth bands make an angle of nearly 40 degrees with the curving tooth axis, but towards the proximal end of the root the growth bands are at right angles to the axis. Fifteen of these bands are visible on U.C.M.P. No. 49490. U.C.M.P. No. 55399, a specimen that is broken anteriorly at about the same position as U.C.M.P. No. 49490 is posteriorly, shows a crowding together and great proliferation of growth bands. Over 150 minor bands have been counted in the area between the end of the enamel and the end of the root. In addition to the minor bands, which appear to be serially homologous with the more widely spaced bands of the crown tip, there are several irregularly spaced major bands which seem to represent some major growth cycle superposed on the cycles represented by the minor bands. As in *Taeniolabis* (Granger and Simpson, 1929, pp. 604–605) and *Eucosmodon* (Jepsen, 1940, p. 277), it appears that while the crown was worn shorter the incisors grew by the addition of dentine at the root end of the tooth, offsetting to some extent the effects of attrition, but that this growth eventually slowed and then ceased.

DISCUSSION: Eucosmodontine multituberculates are not well known, nor are their relationships to other multituberculates well understood, but their distinctive incisors and usually rather low plagiaulacoid shearing teeth are easy enough to identify. As Jepsen has pointed out



(1940, p. 278), the lower incisors are similar to those of rodents, except that there are differences in dental histology and there is no characteristic rodent "twist."

The Laudate eucosmodontine incisors resemble incisors of *Eucosmodon* itself in a number of details, but are slightly larger than incisors of the largest species of the genus, *Eucosmodon molestus* (A.M.N.H. No. 17063, "neotype" of that species). The radius of curvature of the Laudate specimens is virtually the same as in *Eucosmodon molestus* and very slightly less than in *Neoliotomus*.

*Eucosmodon americanus primus*, from the lower fossiliferous horizon in the New Mexico Puercan, possesses a much smaller tooth, with a smaller radius of curvature. The same may be said of *Eucosmodon gratus* from the Mantua in Wyoming. An incisor accompanying A.M.N.H. No. 3028, type of *Eucosmodon americanus americanus*, from the upper fossiliferous horizon in the New Mexican Puercan, is larger than any of the other Puercan eucosmodontines,<sup>1</sup> but was probably only about two-thirds of the size of the Laudate specimens. The radius of incisor curvature is also somewhat smaller in that subspecies.

Among Torrejonian *Eucosmodon* incisors, those of *Eucosmodon jepseni* (A.M.N.H. Nos. 35494, 35495 = *E. sparsus*) show a greater dorsal extent of the labial enamel band than those of *E. teilhardi* or *E. molestus*, but *E. jepseni* possesses small incisors, with a smaller radius of curvature than that of the Laudate specimens. The same may be said of P.U. No. 14471, an unnamed Rock Bench specimen of which the incisor is unusually uncompressed (Jepsen, 1940, p. 295). Thus, among the known specimens of *Eucosmodon* incisors, those of the large *E. molestus* resemble the Laudate eucosmodontine incisors the most. The incisors of *E. molestus*, however, differ slightly in size, degree of compression, longitudinal enamel striation, and dorsal extent

---

<sup>1</sup> A.M.N.H. No. 3030, an edentulous, large, Puercan, lower jaw referred by Cope (1888, p. 307) to *Eucosmodon molestus*, a Torrejonian species, possesses an incisor the cross section of which is reniform as is that of *Taeniolabis*. Cope (1888, pp. 307, 308, and 361, pl. 5, fig. 11) and Granger and Simpson (1929, pp. 650-651) interpreted two prominent alveoli as those of a large, lower, shearing blade. Examination of the root occupying the posterior of the two alveoli under powerful ultraviolet light reveals that enamel is present across the posterior face of the root. For this reason it cannot be claimed that the anterior alveolus housed a single-rooted *Taeniolabis*- or *Catopsalis*-like premolar and that the posterior alveolus housed the anterior root of M<sub>1</sub>. A.M.N.H. No. 3030 therefore combines eucosmodontine with taeniolabidid characters. The affinities of this unnamed Puercan genus and species remain as puzzling as ever.

of the enamel bands. In all these features the incisors of *Neoliotomus* approach the Laudate incisors more closely.

Tiffanian members of the Eucosmodontinae are at present known with certainty at only two<sup>1</sup> localities, Plateau Valley, Colorado, and Polecat Bench, northwestern Wyoming. *Neoliotomus* has been stated to occur "in Plateau Valley" by Jepsen (1940, p. 327). Two specimens from the Debeque formation in the collections of the Chicago Natural History Museum (C.N.H.M. Nos. P16082, P27034), a "P<sub>4</sub>" and an incisor fragment, are possibly referable to *Neoliotomus* (W. D. Turnbull, personal communication, February 5, 1960). Neither *Neoliotomus* nor *Eucosmodon* has been reported from the Tiffanian of Polecat Bench. The described Tiffanian eucosmodontines from there, *Pentacosmodon* and *Microcosmodon*, are minute and somewhat *Prionessus*- or *taeniolabidid*-like. Neither genus is significantly similar to the Laudate specimens in known incisor structure.

American Clarkforkian eucosmodontines are almost unknown, only a few fragments having been collected (Jepsen, 1940, p. 324).

European Cernaysian eucosmodontines, approximately contemporaneous with the American Clarkforkian specimens, are somewhat better known, but associated incisors and upper and lower premolars are lacking. Several taxa may be represented. *Liotomus* Cope, 1884 (lectotype of *L. marshi*, Granger and Simpson, 1929, p. 661, fig. 39C), and a lower incisor questionably referred to *Liotomus* (*ibid.*, p. 662, fig. 4) have been figured. Both specimens resemble teeth of *Neoliotomus conventus*, though the incisor is considerably smaller, resembling incisors of *Eucosmodon jepseni* more closely. Whether *Liotomus* is a senior synonym of *Neoliotomus* cannot yet be decided, but it seems clear enough that the same general kind of eucosmodontine multituberculate was present on both sides of the Atlantic Ocean at the close of the Paleocene.

Wasatchian eucosmodontines are known from two species of the genus *Neoliotomus*. The first species to be described, *Neoliotomus ultimus* (Granger and Simpson, 1928, p. 2), was originally referred to *Eucosmodon*, but the type of the genus, *N. conventus* Jepsen, 1930, was shown to possess "P<sub>3</sub>" (Jepsen, 1930, pp. 122, 131, pl. 4, figs. 3 and 4). Jepsen stated that the dental formula was the same in the two spe-

<sup>1</sup> *Eucosmodon* was reported by Russell (1929, p. 166) from locality 7E, Elbow River, Calgary, Alberta. The age of this locality may be Tiffanian (Russell, 1958, p. 98, for nearby locality 2E), but the matter is open to question. Jepsen (1940, p. 295) mentioned a large undescribed Tiffanian multituberculate at Polecat Bench, but did not state that it is a eucosmodontine.

cies, the alveolus of "P<sub>3</sub>" not having been observed when *N. ultimus* was described. The presence of "P<sub>3</sub>" in *Neoliotomus* removes from the ancestry of *Neoliotomus* all species of *Eucosmodon* in which this part of the jaw is known. In fact, among described Paleocene eucosmodontines only *Microcosmodon conus* is known to possess "P<sub>3</sub>," and in that species its presence is variable (Jepsen, 1940, p. 319). *Microcosmodon*, however, is certainly not ancestral to *Neoliotomus*.

The time of separation of the lineages that led respectively to *Eucosmodon* (without "P<sub>3</sub>") and *Neoliotomus* (with "P<sub>3</sub>") is still unknown. The European genus *Liotomus*, though a Paleocene multituberculate and almost certainly a eucosmodontine, is almost contemporaneous with American *Neoliotomus*. *Liotomus* is too poorly known to permit the conclusion that it represents the stock from which the latter arose rather than *vice versa*. Undescribed *Neoliotomus*-like teeth from the Tiffanian of the Debeque formation, Colorado, suggest that the time of separation was at least pre-Tiffanian. It is probable that *Neoliotomus*-like multituberculates have a long Paleocene history which is quite separate from that of other members of the Eucosmodontinae.

The Laudate eucosmodontine incisors are almost indistinguishable from incisors of *Neoliotomus*. Isolated specimens of the latter are present in both the American Museum of Natural History and the Princeton collections, but reference to the correct species is not yet possible. The principal special similarities of the Laudate specimens with incisors of *Neoliotomus* are as follows:

1. The Laudate incisors are only slightly smaller and more tightly curved than A.M.N.H. Nos. 16782 and 16783 and various Princeton incisor fragments labeled P.U. No. 16145. Although similar to incisors of *Eucosmodon molestus* in curvature, the Laudate incisors are larger and more compressed (maximum/minimum ratio, approximately 3.0, if no lateral crushing be assumed).
2. The enamel bands in *Neoliotomus* and the Laudate specimens extend farther across the incisor both lingually and labially than in other eucosmodontines. (Incisors of *Eucosmodon jepseni* approach the condition seen in *Neoliotomus* in this one regard. The referred *Liotomus* incisor appears to do so also.)
3. Longitudinal enamel striation is at a minimum.

At present, therefore, U.C.M.P. Nos. 49490 and 55399 may be regarded as more similar to incisors of *Neoliotomus* than to those of any other known multituberculate. Because the ultimate ancestry of *Neoliotomus* in the Paleocene is otherwise unknown, it is not possible to state that the Laudate incisors actually represent *Neoliotomus*. The available material is simply not adequate to permit such a conclusion. The Laudate multituberculates therefore indicate only a Wasatchian

or Paleocene age for the containing Goler sediments. No more refined age determination based solely on the multituberculate evidence can be made at present.

ORDER CONDYLARTHRA COPE, 1881

FAMILY PERIPTYCHIDAE COPE, 1882

SUBFAMILY ANISONCHINAE OSBORN AND EARLE, 1895

Unnamed Genus and Species

Figure 3

SPECIMENS: U.C.M.P. No. 44761, fragmentary left mandible bearing  $M_3$ , and U.C.M.P. No. 49487, fragmentary right  $M_3$  of a different individual. Both specimens were found several years apart at the same spot.

LOCALITY: U.C.M.P. V-5252, site 3 (= U.C.M.P. V-5502), progressive grid coordinates 1,318,250–1,398,300, altitude approximately 3600 feet above mean sea level, Inyokern quadrangle, California, Corps of Engineers, United States Army, 1943; member 2, Goler formation. The specimens were found on brownish, reddish, and greenish siltstones interbedded with channel sandstones and conglomerate, north wall of Laudate Canyon, a short, westward-draining tributary of the main northward-trending drainage east of Black Mountain. A small stone reservoir which generally contains water lies near the end of the dirt road that enters Laudate Canyon. U.C.M.P. V-5252, site 3, is visible from the reservoir. Bone fragments are fairly common at the site. Crocodile and chelonian bone fragments almost always can be found on each new visit after the winter rains.

REVISED DESCRIPTION: Size of jaw and  $M_3$  as in *Conacodon entoconus*, somewhat larger than in *Hemithlaeus* or *Anisonchus sectorius*; depth of jaw below  $M_3$ , 16.0 mm.; length of  $M_3$ , estimated, 6.0 mm.; width of  $M_3$  trigonid, 4.4 mm.; width of  $M_3$  talonid, 4.0 mm. Mandible with small "alveolar torus" on labial side, as in some specimens of *Anisonchus gillianus*, *Anisonchus sectorius*, and *Conacodon cophater*. Maseteric fossa extends beneath  $M_3$ . Crown cusps somewhat crowded together, and lingual enamel forming essentially one high face somewhat like that of *Haploconus*. The lingual enamel extends somewhat farther down the roots than that of the labial side of the tooth. Paraconid present, but consisting of a low tubercle closely appressed to the anterior and anterolingual faces of the protoconid. (McKenna, 1955, p. 514, stated that the paraconid was absent. U.C.M.P. No. 49487 possesses the cusp. What was taken for the broken anterior spur of the protoconid of U.C.M.P. No. 44761 is now recognized as being the

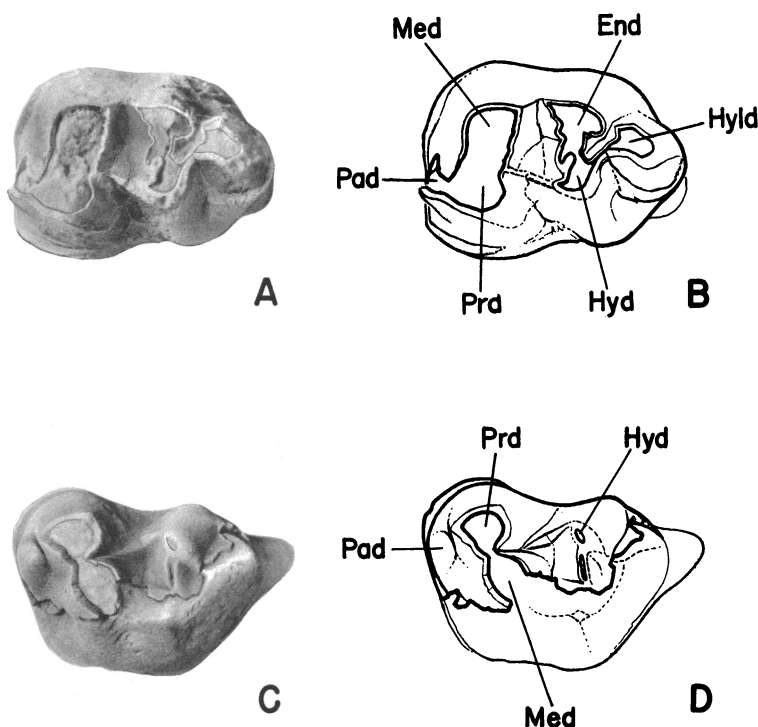


FIG. 3. Unnamed genus and species of anisonchine condylarths. A, B. Retouched photograph and interpretation of the left  $M_3$  of U.C.M.P. No. 44761. C, D. Retouched photograph and interpretation of U.C.M.P. No. 49487, fragmentary right  $M_3$  of a different individual. Upper faunule, Laudate local fauna, Goler formation, Paleocene of California. Symbols: End, entoconid; Hyd, hypoconid; Hyld, hypoconulid; Med, metaconid; Pad, paraconid; Prd, protoconid. All  $\times 6$ .

broken base of the paraconid in that specimen.) There is no paralophid running from the anterior crest of the protoconid across the anterior side of the trigonid to a lingually placed distinct paraconid such as that of some specimens of *Conacodon entoconus*, or to a centrally placed paraconid such as that of *Anisonchus gillianus*, *Hemithlaeus*, or most specimens of *Conacodon entoconus* and *Conacodon cophater*. *Haploconus* and some specimens of *Conacodon entoconus* (e.g., A.M.N.H. Nos. 3473, 16423) lack the paraconid altogether. In most specimens of *Conacodon* and in some specimens of *Hemithlaeus* (e.g., A.M.N.H. No. 3611, type of *H. kowalevskianus compressus* Matthew, 1937, and A.M.N.H. No. 3590) the paraconid is vestigial but separated

from the protoconid by at least a small paralophid. The structure of the paraconid in the Laudate anisonchine is approached in *Anisonchus sectorius*, which has almost no paralophid in contrast to *Anisonchus gillianus*. The protoconid is triangular in cross section near the apex and is appressed to the metaconid. Near the apices of the protoconid and metaconid a broad anterior gutter and a sharp posterior notch separate the cusps. The protoconid evidently stood higher than the metaconid. The metaconid lies posterolingual to the protoconid, is a smaller and lower cusp than the latter, and possesses a sharp postero-lingual ridge which joins a ridge from the entoconid in a sharp notch at the lingual border of the talonid basin. The hypoconid possesses three crests: the anterior crest (crista obliqua) is notched and connects to the middle of the posterior trigonid wall below the notch separating the metaconid and protoconid; a second crest connects to the base of the entoconid; the third crest connects to the anterolabial corner of the hypoconulid. The second crest is quite rare in both species of *Conacodon* but is frequently well developed in *Hemithlaeus* and developed to a lesser extent in *Anisonchus*. The entoconid is about the same size as the hypoconid or perhaps is somewhat smaller. It is set rather far forward, contrasting with the condition in *Hemithlaeus*. It possesses an anterior crest which connects to the metaconid. The hypoconulid projects to the rear. A subsidiary talonid basin is present between the hypoconulid and the second hypoconid crest. Such a structure occurs in *Haploconus* and sometimes in *Anisonchus gillianus* (e.g., A.M.N.H. No. 16470), but rarely in *Anisonchus sectorius*. A cingulum is present from the labial face of the protoconid across the anterior face of the trigonid beneath the paraconid, terminating at the anterolingual corner of the metaconid base. This character is essentially as in *Hemithlaeus*, *Haploconus*, and *Anisonchus*, rather than as in *Conacodon entoconus* or *C. cophater*. A second cingulum runs anterolabial from the posterior base of the hypoconulid. It rises to a small cuspule at the posterior base of the hypoconid. There is a trace of a cingulum between the hypoconid and protoconid bases. The complete absence of a lingual cingulum reminds one of *Anisonchus sectorius* or *Haploconus* rather than *Conacodon*, but *Anisonchus gillianus* and *Hemithlaeus* bridge the gap. The roots are massive, the posterior root being the larger of the two.

DISCUSSION: The Laudate anisonchine possesses an  $M_3$  which can easily be separated from that of all known anisonchine genera and species but which is nevertheless clearly an anisonchine tooth. In view of the difficulty of separating lower molars of such forms as *Hemith-*

*laeus kowalevskianus* and *Conacodon entoconus*, despite the fact that their upper dentitions demonstrate that these are distinct genera, the distinctive nature of the Laudate anisonchine would probably be more pronounced were additional features of the dentition known. The closest similarities seem to lie with *Anisonchus sectorius*, *Conacodon entoconus*, and *Haploconus*, rather than with the relatively less specialized *Hemithlaeus* and *Anisonchus gillianus*. There is no similarity to *Coriphagus*.

## LAUDATE LOCAL FAUNA: LOWER FAUNULE

### CLASS OSTEICHTHYES

SPECIMEN: An uncatalogued fossil fish tail.

LOCALITY: The locality is stratigraphically about 430 feet above the contact of member 2 of the Goler formation with the unconformably underlying buried hill of Permian metasediments and metavolcanics, or approximately 1900 feet above the base of the Goler formation at its type section. The locality is slightly higher in member 2 than U.C.M.P. V-5871 and the locality from which Knowlton's and Axelrod's fossil plants were taken. The fish tail was found in a concretion in arkosic channel sandstone interbedded with greenish and reddish brown siltstones and shales.

DISCUSSION: The specimen yields no important information other than the occurrence of a fossil vertebrate in this part of member 2.

### CLASS MAMMALIA

#### ORDER CONDYLARTHRA COPE, 1881

? FAMILY HYOPSODONTIDAE LYDEKKER, 1889

? SUBFAMILY MIOCLAENINAE MATTHEW, 1937

Unnamed Genus and Species cf. *Mioclaenus* sp.

#### Figure 4

SPECIMEN: U.C.M.P. No. 49489, approximately one-half of an upper left molar.

LOCALITY: U.C.M.P. V-5871, progressive grid coordinates 1,319,100-1,395,350, east bank of one of the forks of Goler Gulch, approximately 1900 yards north-northeast of Holland Camp, Saltdale quadrangle, California, Corps of Engineers, United States Army, 1943; member 2, Goler formation. The specimen was found on a poor and steep exposure of green mudstone, approximately 3400 feet stratigraphically below U.C.M.P. V-5252, site 3 (= U.C.M.P. V-5502), and U.C.M.P. V-5870, if no faults be assumed.

**DESCRIPTION:** Length of ectoloph, approximately 6.2 mm. Molar crown bunodont, cusps low and rounded. Paracone marginal, connected to parastyle and mesostyle by prominent arcuate crests. Metacone marginal, but morphology obscured by breakage. Crest from metacone to mesostyle arcuate, forming a convex slope facing the trigon basin and separated from the metacone by a gully. Protoconule large, rounded, with spur connecting to the anterolingual base of the paracone; the main mass of the protoconule projects into the valley between the anterior cingulum and the rest of the tooth. Protocone

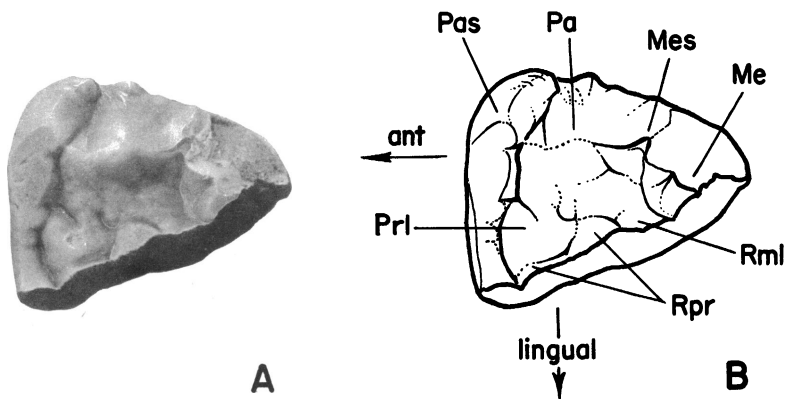


FIG. 4. Unnamed genus and species cf. *Mioclaenus* sp., U.C.M.P. No. 49489, approximately one-half of an upper left molar. Lower faunule, Laudate local fauna, Goler formation, Paleocene of California. A, B. Retouched photograph and interpretation of occlusal surface. Symbols: Me, metacone; Mes, mesostyle; Pa, paracone; Pas, parastyle; Prl, protoconule; Rml, ridges from metaconule; Rpr, ridges from protocone. Both  $\times 6$ .

unknown other than from traces of subsidiary ridges: the labial ridge to the trigon basin is represented posterolabial to the protoconule, and the ridge to the protoconule is indicated by a small area of enamel lingual to the protoconule. Metaconule unknown other than from a trace of the anterobuccal ridge into the trigon basin. Anterior cingulum heavy and broad, especially at the labial end. When unworn, the anterior cingulum bore several large cuspules, two anterior to the protoconule, a large one just lingual to the parastyle, and, of course, the parastyle itself. The parastyle is quite large and is supported by a strong rib on the ectoloph. The rib is crenulated at its dorsal end. The mesostyle is damaged but can be seen to be strongly ribbed. Nothing can be said about the metastyle. There is no labial cingulum, this struc-



ture being adumbrated by a few tiny cusps at the appropriate position. The largest of these cusps forms a sharp projection at the labial base of the paracone.

DISCUSSION: This tooth represents a condylarth of one of three families: Phenacodontidae, Didolodontidae, Hyopsodontidae. The closest similarities that I have been able to find are with teeth of *Gidleyina*, *Didolodus*, and *Mioclaenus*. Similarity to *Mioclaenus* is the greatest of these, and the only one that need be seriously considered at present.

A large collection of *Mioclaenus turgidus* teeth and jaws in the American Museum of Natural History demonstrates a great variety of morphology for this Torrejonian species. *Mioclaenus* teeth wear away the details of the cusp pattern rather early in the adult animal's life, so that it is necessary to make comparisons with young individuals only. A.M.N.H. Nos. 3135 (type), 3163, 16625, and 17080 were selected for comparison.

*Mioclaenus turgidus* agrees with U.C.M.P. No. 49489 in size, in the possession of low, bunodont cusps, a strong and cuspidate anterior cingulum with a large parastyle, a mesostyle (of a somewhat different pattern, however), a large protoconule with a small ridge to the paracone and a large one directed anterolabially towards the anterior cingulum, and a variable labial cingulum which may consist of only a row of cusps, one of the largest of which occurs at the labial base of the paracone.

In several characters, however, U.C.M.P. No. 49489 differs significantly from specimens of *Mioclaenus turgidus*. The parastyle and metastyle are strongly ribbed, and these ribs extend well down the labial face of the ectoloph. The mesostyle does not consist of a double cusp, part of which is associated with a labial cingulum. The protoconule is relatively more prominent. In all likelihood, U.C.M.P. No. 49489 represents a previously undescribed genus of condylarth closely related to *Mioclaenus*. The poorly preserved nature of the specimen does not permit a more detailed statement.

#### AGE OF THE LAUDATE LOCAL FAUNA

The Laudate local fauna comprises two faunules separated by approximately 3400 feet of rapidly accumulated continental sediments of the upper member of the Goler formation (Dibblee, 1952, p. 19). The lower member of the Goler formation has not yielded fossils. Several reptiles and two mammalian taxa represented by two specimens each are represented in the upper faunule. Lower vertebrate remains and a fifth mammalian specimen represent the lower faunule. There

is no evidence that the two faunules of member 2 differ significantly in age, but the available evidence is not sufficient to settle the question.

In addition to the stratigraphically almost useless reptiles, the upper faunule is represented by an anisonchine condylarth and a eucosmodontine multituberculate. Anisonchine condylarths have been found in Puercan (approximately early Paleocene) and Torrejonian (approximately middle Paleocene) sediments over a wide area in the United States, but the subfamily is unknown anywhere else or at any other time. The Anisonchinae are placed in the family Periptychidae, of which the other subfamily, the Periptychinae, is made up of large condylarths that range almost throughout the American Paleocene. The Laudate anisonchine bears special resemblances to *Conacodon* and to *Haploconus* and *Anisonchus sectorius*. The former is known only from the Puercan, and the two latter forms are Torrejonian, though *Haploconus* has been reported to occur in Puercan sediments. The Laudate anisonchine is probably a distinct genus, however, and its exact relationships to *Conacodon*, *Anisonchus sectorius*, and *Haploconus* are not yet known. For this reason, on the basis of these specimens alone, it is still not possible to give a more accurate age determination than my original estimate (1955, pp. 514-515).

The eucosmodontine multituberculate present in the upper faunule belongs to a group unknown before Tiffanian (approximately late Paleocene) time, but it has been pointed out that members of the *Neoliotomus*-like group of eucosmodontines (with "P<sub>3</sub>") probably had a long Paleocene history prior to their first previously recognized appearance in the record in the Tiffanian. Therefore, although *Neoliotomus*-like multituberculates are at present known only from Tiffanian to Wasatchian (approximately early Eocene) sediments, their occurrence in middle and perhaps even early Paleocene sediments is to be expected.

The single mammalian specimen from the lower faunule provides little chronologic information. It resembles a Torrejonian genus, but the importance of this is not known.

The age of the Laudate local fauna, the oldest known continental Cenozoic occurrence of fossil vertebrates in California, may be stated to be Paleocene without question. When all available evidence is taken into account, it does not seem very likely that the remains are of late Paleocene age. Tentatively, Torrejonian (approximately middle Paleocene) age is postulated as slightly more likely than Puercan age. The upper member (member 2) of the Goler formation may thus be regarded as Paleocene and tentatively Torrejonian in age. The age of

the lower member (member 1) of the Goler formation is probably Paleocene as well, but could be older.

The occurrence of Paleocene vertebrates in California provides the oldest known Cenozoic vertebrate fauna from that state and the first occurrence of Paleocene mammals west of the thrust belt that occupied the eastern Great Basin during Laramide times. During the Paleocene the continental divide was essentially co-extensive with this thrust belt for a long distance. To what extent Paleocene mammals were affected by the feature is not known, but it is significant that of the three *Laudate* genera two are not known east of the Paleocene continental divide and the third may indicate an area in which the genus was present before its dispersal to the east of the divide. When better known, therefore, the *Laudate* local fauna may provide valuable evidence concerning Paleocene faunal diversity in North America. Detailed knowledge of such diversity is one of the prerequisites to an understanding of the origin of the Paleocene faunas of South America and Mongolia.

## REFERENCES

AXELROD, DANIEL I.

1949. Eocene and Oligocene formations in the western Great Basin. *Bull. Geol. Soc. Amer.*, vol. 60, no. 12, pt. 2, pp. 1935-1936.

COPE, EDWARD DRINKER

1881. A new type of *Perissodactyla*. *Amer. Nat.*, vol. 15, pp. 1017-1018.  
1882. The *Periptychidae*. *Ibid.*, vol. 16, pp. 832-833.  
1884. The Tertiary *Marsupialia*. *Ibid.*, vol. 18, pp. 686-697, figs. 1-9.  
1888. Synopsis of the vertebrate fauna of the Puerco series. *Trans. Amer. Phil. Soc.*, new ser., vol. 16, pt. 2, pp. 298-361, pls. 4, 5.

DIBBLEE, T. W., JR.

1952. Geology of the Saltdale quadrangle, California. *Bull. California Div. Mines*, no. 160, pp. 7-43, figs. 1-5, pls. 1-11.

FAIRBANKS, H. W.

1896. Notes on the geology of eastern California. *Amer. Geol.*, vol. 17, pp. 63-74, pl. 3.

GRANGER, WALTER, AND GEORGE GAYLORD SIMPSON

1928. Multituberculates in the Wasatch formation. *Amer. Mus. Novitates*, no. 312, 4 pp., figs. 1, 2.  
1929. A revision of the Tertiary Multituberculata. *Bull. Amer. Mus. Nat. Hist.*, vol. 56, pp. 601-676, figs. 1-43.

GREGORY, WILLIAM K., AND GEORGE GAYLORD SIMPSON

1926. Cretaceous mammal skulls from Mongolia. *Amer. Mus. Novitates*, no. 225, 20 pp., figs. 1-19.

HERSHEY, OSCAR H.

1902. Some Tertiary formations of southern California. *Amer. Geol.*, vol. 29, pp. 349-372.

## HULIN, CARLTON D.

1925. Geology and ore deposits of the Randsburg quadrangle, California. Bull. California State Min. Bur., no. 95, pp. 1-152, figs. 1-8, pls. 1-31.

## JEPSEN, GLENN L.

1930. New vertebrate fossils from the lower Eocene of the Bighorn Basin, Wyoming. Proc. Amer. Phil. Soc., vol. 69, no. 4, pp. 117-131, pls. 1-4.
1940. Paleocene faunas of the Polecat Bench formation, Park County, Wyoming. Part I. *Ibid.*, vol. 83, no. 2, pp. 217-340, figs. 1-22, pls. 1-5.

## LYDEKKER, RICHARD

1889. Palaeozoology-Vertebrata. In Nicholson, Henry Alleyne, and Richard Lydekker, A manual of palaeontology. Third edition. Edinburgh and London, William Blackwood and Sons, vol. 2, pt. 3, pp. 889-1474.

## MCKENNA, MALCOLM C.

1955. Paleocene mammal, Goler formation, Mojave Desert, California. Bull. Amer. Assoc. Petrol. Geol., vol. 39, no. 4, pp. 512-515, fig. 1.

## MATTHEW, WILLIAM DILLER

1937. Paleocene faunas of the San Juan Basin, New Mexico. Trans. Amer. Phil. Soc., new ser., vol. 30, pp. i-viii, 1-510, figs. 1-85, pls. 1-65.

## MERRIAM, JOHN C.

1915. Extinct faunas of the Mohave Desert, their significance in a study of the origin and evolution of life in America. Pop. Sci. Monthly, vol. 86, pp. 245-264, figs. 1-11.
1919. Tertiary mammalian faunas of the Mohave Desert. Univ. California Publ. Geol., vol. 2, no. 5, pp. 437a-437e, 438-585, figs. 1-253.

## OSBORN, HENRY FAIRFIELD, AND CHARLES EARLE

1895. Fossil mammals of the Puerco beds. Collection of 1892. Bull. Amer. Mus. Nat. Hist., vol. 7, pp. 1-70, figs. 1-21.

## RUSSELL, LORIS S.

1929. Paleocene vertebrates from Alberta. Amer. Jour. Sci., vol. 17, pp. 162-178, figs. 1-5.
1958. Paleocene mammal teeth from Alberta. Bull. Natl. Mus. Canada, no. 147, pp. 96-103, pl. 1.

## SMITH, JAMES H.

1900. The Eocene of North America west of the 100th meridian (Greenwich). Jour. Geol., vol. 8, pp. 444-471.