# A TERTIARY MAMMALIAN FAUNA
# FROM THE AVAWATZ MOUNTAINS, CALIFORNIA

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DESCRIPTION OF FAUNA

# INTRODUCTION

The Tertiary mammal occurrence in the Avawatz Mountains, discovered in 1932 by H. W. Nickerson of Yucca Grove, California, was first reported to the Los Angeles County Museum. W. M. Strong, sent out by the Museum to make a preliminary survey in the area, assembled a small collection. All of the material was so scrappy, however, that interest subsided. Subsequently, in 1935, in the course of their archeological field studies, Mr. and Mrs. William H. Campbell of Twenty-nine Palms rediscovered the fossiliferous locality on the south flank of the Avawatz Mountains. Very kindly drawing the attention of Mr. E. L. Furlong to their find, Mr. and Mrs. Campbell accompanied Mr. Furlong to the locality. During this first visit most of the material now in the collections of the California Institute of Technology was acquired. Since then several brief collecting trips have been made to the area.

The significance of the discovery of fossil vertebrate material in the Avawatz Mountains becomes at once apparent when it is considered that herein lies a clue to the dating of at least some of the tremendous diastrophic activity which has occurred in the western portion of the Great Basin during later Tertiary time. This point will be further discussed below under the heading Geologic Relations.

Our sincerest thanks are due to Mr. and Mrs. W. H. Campbell of Twenty-nine Palms for their wholehearted cooperation in securing the collection. To Dr. Chester Stock for his continued interest, invaluable counsel, and constructive criticism, the author is deeply indebted. With gratitude, the guidance and advice of Messrs. E. L. Furlong who assembled the bulk of the collection, R. W. Wilson who studied and described the Avawatz rodents, and J. R. Schultz is acknowledged. J. F. Dougherty, A. B. Drescher, and G. A. Rynearson ably assisted in the collecting of material. For their courtesy, cooperation, and helpful suggestions the author is greatly obligated to the staff of the University of California, especially to J. T. Gregory, R. A. Stirton and V. L. VanderHoof. The illustrations were executed by John L. Ridgeway.

## LOCATION

The fossil material in the collection from the Avawatz Mountains was found at C. I. T. Coll. Vert. Paleo. Localities 264 and 267. The localities lie on the southeasternmost flank of the Avawatz Mountains, ten miles by road northwesterly from the town of Silver Lake on the Tonopah and Tidewater Railroad. To reach the localities, drive on the Power Line Road westward 2.6 miles from the Silver Lake Power Station. In the low pass, leave the Power Line Road and bear right to follow the Cave Spring Road for 2.8 miles.

At the signposts in the flat, turn right and proceed northwesterly for 4.5 miles up into the wash which dissects the fossil-bearing strata.

## RESUMÉ OF GEOLOGIC RELATIONS

In the geologic literature, no reference has been made to the Tertiary sediments exposed at the southeast end of the Avawatz Mountains. It is not within the scope of this paper to present a detailed account of the stratigraphical and structural relationships of these sediments. A brief areal survey has, however, brought out a few major facts.

Stratigraphy. As in many other localities in the Mohave Desert, the rocks of the southeastern portion of the Avawatz Mountains may be divided into three groups: the basement complex of metamorphic and plutonic rocks, the superjacent series of sedimentary rocks, and the alluvium. (Baker 1911, Baker 1912.) The basement complex outcrops only on the high central portions of the range. Lapping far up onto the range, and even forming some of the high peaks and ridges, occur the sedimentaries. An alluvium, which is at present being vigorously dissected, lies on the lower slopes across the beveled edges of the older sedimentaries. Out from the mountains, alluvium is accumulating on the great fans and in the playas.

The Basement Complex of Metamorphic and Plutonic Rocks. No attempt was made to unravel the complexities of the basement which comprises the core of the Avawatz Mountains. It was noted, however, that there were outcrops of formations which were potential sources for most of the rock types seen in the boulders of the Tertiary conglomerates. These include quartzite, dolomite, marble, schist, gneiss, granite, and several types of darker igneous rocks, including one coarse-grained gabbro, which is composed principally of hornblende. All of these rocks are in small lithologic units intimately intruding, including, and overlying each other.

The Overlying Series of Sedimentary Rocks. Unfortunately any attempt to correlate stratigraphically the Tertiary sediments of the Avawatz Mountain area with those of other parts of the Mohave Desert Region meets with considerable difficulty. As J. C. Merriam points out (Merriam 1919), after a critical review of the literature, the use of O. H. Hershey's term Rosamond (Hershey 1902) -- construed to include all of the Cenozoic deposits of the Mohave Desert on the assumption that they represent one great period of accumulation -- is both confusing and unjustified. If the Barstow and Ricardo formations as described by C. L. Baker and J. C. Merriam (op. cit.) may be taken as fair examples, the conclusion appears reasonable that the areas of deposition of Tertiary sediments in the Mohave Desert region were generally local in extent and not necessarily correlative or even partially so. Pursuing this thesis then, Merriam defends the use of separate and local formational names for the different Tertiary series to be found in the Mohave Desert. Following this precedent, the name Avawatz Formation is proposed to include the Tertiary series which lies immediately to the south and west of the eastern end of the Avawatz Mountains. Unfortunately the lack of a map on an adequate scale prevented anything more than the most cursory survey of these Tertiary sediments. In crude fashion the Tertiary sediments may be divided into four members: a coarse conglomerate (Fanglomerate), green and brown clays (Lake Beds), a resistant breccia, and arkosic sands and tuffs (Fluviatile deposits). The lower member or Fanglomerate varies considerably in thickness, pinching out to the east and broadening to the west. Its thickness directly north of the fossil localities must be well over 1000 feet, while to the west it must attain a thickness of several thousands of feet. These deposits are characteristically extremely coarse and some of the boulders in this conglomerate material are as large as five or six feet across. Sandy lenses and layers are almost completely absent except near the upper limit of the member where it grades into the overlying fine-grained sediments. From the nature of the rock types present, it appears evident that the source for most of this material was the Avawatz Basement Complex. For the most part, the character of the fanglomerate is heterogeneous. Several remarkably persistent layers exist, however, which -- for some thirty to fifty feet in thickness and several miles along the outcrop -- consist throughout of one rock type. One of these layers, composed of light-colored granite boulders and matrix, is remarkably well displayed, dipping off the mountain mass. There are a few other layers of individual rock types, some predominately red colored while others are predominately green. The degree of cementation of the material is not especially strong, except near the surface where caliche has been recently deposited.

Above a transition zone of intercalated clays, sands and coarse and fine conglomerates occurs the middle member of the Tertiary series. It consists dominantly of green, gray green and brown green to brown fine sands and clays, the finer material making up the bulk of the member, while the more arenaceous zones occur for the most part near the upper and lower limits of the member. Ripplemarks indicative of standing water were observed in parts of this member. The origin of this member is one of deposition of sediments partly on flood plains and partly in playa lakes.

Overlying the clay member and in conformity with it occurs a series of coarse breccias, generally self-cementing and very resistant to erosion. The breccias consist of extremely angular blocky fragments, some of which are several feet across. Generally the lower part of the breccia is made up of a fine to medium grained, gray green igneous rock, while gray dolomite or pure white limestone and marble form the upper part. A most remarkable feature is constancy and uniformity of rock type composing these two separate parts of the breccia. Extremely little commingling of rock types occurs. The aggregate thickness of these breccias varies from place to place, ranging from perhaps a few tens to a few hundreds of feet. These breccias probably represent a fanglomeratic type of deposit.

The uppermost member of the Tertiary formations has been considered in detail. Characterized by the predominance of arenaceous sediments over those of an argillaceous or tuffaceous nature, this member is the only one which has been found to contain fossil material. Very striking in appearance are several persistent layers a few feet thick of pure white volcanic ash, occurring in the lower part of the member. These vary from fissile shales made up of paper-thin laminae to massive beds so highly indurated as to break with conchoidal fracture. Other beds which have been employed as markers include several of punky gray volcanic ash, each a few feet in thickness. The upper part of this member lenses gradually into a pebbly conglomerate and finally into a coarse conglomerate. While some of this material was deposited in still water, as indicated by occasional layers showing oscillation ripplemarks, the bulk of it was laid down under flood plain conditions.

Quaternary. Resting with pronounced angular unconformity upon the Tertiary conglomerate is a coarse conglomerate which is believed to be Quaternary in age. Whether it is Pleistocene or Recent has not been ascertained. This younger conglomerate has itself been subjected to diastrophic movements which in one place at least have tilted the member as much as $22^{\circ}$.

All of the formations discussed above are now being vigorously eroded, while out on the fans and playas, alluviation is proceeding at a rapid rate.

## Detailed stratigraphy of the fossiliferous fluviatile beds of the Avawatz formation

| | | |
|---|---|---|
| | 60' | Fine to coarse conglomerate resting with angular unconformity upon the underlying beds |
| 976' | | |
| | 160' | Sand layers and pebble conglomerates at the base. Pebble lenses are thicker, more frequent in occurrence and with larger pebbles in upper levels, finally becoming coarse conglomerate |
| 816' | | |
| | 4' | Punky gray ash |
| 812' | | |
| | 76' | Brownish gray alternating coarse and fine fluviatiles, becoming sandy and gravelly towards the top |
| 736' | | |
| | 3' | Punky gray ash. "Marker bed" in the structure section. |
| 733' | | |
| | 150' | Soft to hard gray sandy fluviatiles, occasional gravels and brick-red pebbles. Fossil mastodon 30' below "marker". |
| 583' | | |
| | 6' | Punky gray ash, capped by hard sandstone. Highly fossiliferous. Remains of Antilocapridae, Camelidae, Equidae and Rodentia. |
| 577' | | |
| | 306' | Fluviatiles, mostly greenish-gray sands with a few green-gray clays. Some of the sands are light-gray micaceous arkoses. Fossils first appear here at about 450' above the base of section. |
| 271' | | |
| | 64' | Sandy fluviatiles, soft to hard, overlying a very thin white volcanic ash. |
| 207' | | |
| | 29' | Greenish-gray punky shale |
| 178' | | |
| | 2' | Hard white volcanic ash |
| 176' | | |
| | 70' | Soft poorly bedded gray punky clays. Occasional sand layers. One bed of gray ash near the base. |
| 106' | | |
| | 39' | Gray ash passing upward into a zone of brownish sandstone and gray ash. |
| 68' | | |
| | 1' | Hard brown sandstone |
| 67' | | |
| | 34' | Light gray ash, crossbedded to finely bedded to laminated. A few sandy layers. Occasional layers containing rounded fragments of white volcanic ash. |
| 33' | | |
| | 27' | Greenish-gray clays to gray sands, soft, shows no bedding. |
| 6' | | |
| | 6' | Greenish to yellowish brown sands and gravel beds. Small pebbles of limestone. |
| 0' | | |
| | | Coarse conglomerate, mostly limestone fragments, some gneisses, etc. |

Structure. An adequate structural picture of the Tertiary sediments of the Avawatz Mountain locality can be obtained only with detailed mapping. Unfortunately in the absence of a sufficiently detailed topographical map, such work could not be carried out. In general terms, the dominant structure consists of a series of broadly to closely folded anticlines and synclines. The axes of the folds trend from N45°W to N80°W, the former being nearer the mountain front and more nearly in parallel alignment with it. These structures plunge to the east and to the west from a region just a few miles west of the fossil localities.

In the area studied at least three faults strike approximately E-W and have possibly a vertical position. Offset marker beds indicate that the movement along one of these breaks has been of the strike-slip type, the south side moving eastward relative to the north side, a distance of several thousand feet. Minor faults with offsets of only a few feet are found in abundance throughout the Tertiary sediments. Probably the majority of these are subordinate breaks controlled by the formation of the major structures.

The structure of the Quaternary conglomerate demonstrates two interesting facts. First, in one place, where the conglomerate overlies with angular unconformity the limb of an anticline in the Tertiary rocks, the conglomerate has been tilted up so as to dip as much as 22°, but preserves the strike of the underlying more steeply dipping anticlinal limb.

This indicates a continuation of folding along the same lines after a period of quiescence. In the second place, in the relatively undisturbed areas, the Quaternary conglomerate dips away from the main Avawatz range at angles varying from $4^{\circ}$ to $8^{\circ}$. The channels of the streams now incising these beds dip at $1.5^{\circ}$ or less. Thus, a strong indication is given that there has been a relatively recent uplift in the area centering on the main body of the Avawatz Mountains.

## OCCURRENCE AND PRESERVATION OF MATERIAL

Fossil material has been recovered so far only from the uppermost member of the Tertiary Avawatz formation. All of the fossils found in place come from a stratigraphic zone about 250 feet thick immediately underlying the gray tuff marker bed (see stratigraphic section). Bone scrap is exceedingly common throughout this zone. The identifiable material occurs in a very scattered and fragmentary manner. No complete pieces were found. Though some of the teeth and bones show rounding and water wear, many of them appear remarkably fresh and unworn. The general state of preservation is only fair. Checking has rendered many pieces very difficult to recover and prepare. This condition is believed to have been caused in part at least by the stresses set up during diastrophism. The occurrence appears to have been formed under floodplain conditions, where the vertebrate remains were stream-borne, or at any rate widely scattered before burial.

## AVAWATZ FAUNA

Carnivora
- Canid indet.
- Pseudaelurus intrepidus Leidy

Rodentia
- Perognathoides cf. P. tertius Hall
- Perognathoides (?) sp. undet.
- Dipodomyine (?) n. g. et sp.
- "Peromyscus" prob. n. sp.

Lagomorpha
- Hypolagus sp.

Proboscidea
- Trilophodon cf. simplicidens Osborn

Perissodactyla
- Pliohippus (?) sp.

Artiodactyla
- Camelidae
  - Procamelus coartatus Stirton
  - Camelid, sp. large
- Antilocapridae
  - Merycodus cf. cerroensis (Frick)

## ENVIRONMENT OF FAUNA

Of the forms which at present are known to occur in the Avawatz fauna all are typical plains-dwellers. The vegetation of the region at that time must have afforded grass and scrubby trees. Presence of the latter is indicated by occasional finds at the fossil locality of petrified wood of brushy character. To support such vegetation, the climate presumably was somewhat more humid than the present one. Perhaps, as J. C. Merriam suggests in regard to the environmental conditions of the Barstow and Ricardo faunas, the conditions prevailing contemporaneous with the Avawatz fauna resembled those now obtaining in the southern portion of the Great Valley of California.

## COMPOSITION AND EVOLUTIONARY STAGE OF THE FAUNA

The presence of Pseudaelurus intrepidus Leidy, a species based on a "well preserved specimen of lower jaw, discovered by Dr. Hayden in the sands of the Niobrara River" (Leidy 1858, Leidy 1869), unfortunately gives no true index to the age of the Avawatz fauna. Most of the recorded occurrences of Pseudaelurus are assigned to the Miocene, including Barstow (Merriam 1919), Tonopah (Stock 1934), Lower Snake Creek (Matthew 1918, Matthew 1924), and Niobrara River fauna (Leidy 1869). Two occurrences, however, from the lower Pliocene are referred to Pseudaelurus, Esmeralda (Stirton 1936) and Valentine (Stirton and McGrew 1933).

From Barstow the only material is a very poorly preserved ramal fragment about the size of the type, but heavier (Merriam 1919, pp. 469 and 471, fig. 27). The lower jaw material of the Pseudaelurus from Tonopah approximates most closely the small size of P. marshi Thorpe (Stock 1934, pp. 1051-57, pl. 130 B). From an unknown horizon in the Snake Creek comes the variety *P. intrepidus sinclairi*. Though this form is of small dimensions, falling in size between *P. Intrepidus* and *P. marshi*, it is considered advanced in stage of evolution (Matthew 1918, p. 196, fig. 6). A form said to resemble the type is reported from the Lower Snake Creek (Matthew 1924). Leidy lists his type as occurring in Bed F (Pliocene?) of the Niobrara River Sands (Leidy 1869). Thorpe reports two specimens from the Niobrara River Sands, and states that they exceed the type in size (Thorpe 1922). Both the Niobrara River and the Valentine (sensu Stirton and McGrew) contain *Pseudaelurus* (Stirton and McGrew 1933). Stirton includes *Pseudaelurus* in a check list of the Esmeralda fauna (Stirton 1936). The Valentine, (sensu Thorpe), has yielded the new species *P. marshi* Thorpe, characterized by its small size (Thorpe 1922).

An attempt to place these specimens in some sort of faunal or evolutionary sequence is beset with difficulty, for many are derived from doubtful horizons or else are unfigured. A comparison with the Barstow fragment reveals nothing beyond a general size agreement. When compared with the small form from Tonopah the Avawatz specimen appears to be slightly more advanced on the basis of a less well developed heel on $M\overline{1}$ and a smaller alveolus for $P\overline{2}$. However, these differences may have little significance.

The small canid species recorded in the faunal list does not resemble generically any later Tertiary form described in the literature and hence is valueless as an indicator of the age of the fauna.

Included in the collection from the Avawatz locality are a number of fragmentary rodent and lagomorph specimens. This assemblage consists chiefly of heteromyid rodents (pocket-mice) of which there are present two and possibly three forms. A single specimen of the cricetine, Peromyscus, and several individuals representing the extinct hare, Hypolagus, are likewise to be recorded.

The following notes on individual species are based on a preliminary study of the material which has not afforded any definite evidence in regard to age of the assemblage. An upper Miocene or lower Pliocene age is indicated, more probably the latter.

In spite of the fact that mastodont material has been reported from almost all of the fossil localities which contain a fauna comparable to that of the Avawatz Mountains, only two formations have yielded lower jaw material sufficiently well preserved to be of value in making comparisons. The more useful of these from the standpoint of correlation, namely Trilophodon ? sp. from the Ricardo (Stock 1928), resembles in general appearance the Avawatz mandible throughout, although it is very slightly larger in all its measurements. This difference in dimensions falls well within the limits of specific variation. The second occurrence is that of *T. simplicidens*, the type tooth of which was found in the lower Pliocene Bone Valley formation near Pierce, Florida. This horizon is regarded as the equivalent of the Rattlesnake by Simpson (Simpson 1933), while both Rattlesnake and Bone Valley are considered middle Pliocene by Stirton (Stirton 1936). Osborn suggests that the tooth "may be intrusive from older Miocene beds" (Osborn 1936). Since Osborn himself (Osborn 1923; Osborn 1936, p. 285) seemed doubtful as to the age to which his type *Trilophodon simplicidens* might be ascribed, a close comparison of the Avawatz mastodont with this obviously primitive form would not throw much light on the age of the Avawatz occurrence.

The Equidae, represented in the Avawatz collection by only one poorly preserved upper molar and by a few skeletal fragments, furnish little information to assist in dating the fauna. The tooth has been assigned to the genus *Pliohippus* on the basis of the extremely strong curvature of its crown and by the few features exhibited on the wearing surface. Though *Pliohippus* has been reported from a number of localities which might be referred to the upper Miocene, in general these localities contain a mixed fauna representing both upper Miocene and lower Pliocene. The exact stratigraphic position of *Pliohippus* is in doubt in these cases. For the present it is sufficient to say that if *Pliohippus* occurs in a fauna, the chances are excellent that the fauna falls within the

Pliocene. It is regrettable that the advanced stage of wear and the poor preservation of the tooth do not permit any critical study of the relationships of the Avawatz Pliohippus to other pliohippine forms.

Of the Camelidae two representatives are found in the Avawatz fauna. The larger of these is about twice the size of the smaller. Similar variation in size among Tertiary camels appears to be common to most of the faunal groups which are comparable to that of the Avawatz. For lack of material the larger camel cannot be identified even generically. The smaller form, however, has been referred specifically to Procamelus coartatus Stirton, which was described from Fish Lake Valley. Without extended explanation Stirton remarks, "This species may prove to represent a group of the genus Procamelus which is not in line with P. robustus Leidy and P. occidentalis Leidy. The Fish Lake Valley beds may upon more careful study and collecting be divided into two horizons representing upper Miocene and lower Pliocene faunas. If so, this species will likely be found in the lower beds." (Stirton 1929.) No new facts were ascertained which might further elucidate the position of P. coartatus Stirton with regard to other members of the genus.

Pending the publication by Frick of the definite stratigraphic and faunal relationships of Merycodus cerroensis (Frick) from Round Mountain, New Mexico, the Avawatz antilocaprid has been referred only tentatively to Frick's species.

In regard to the position of *Merycodus* cf. *cerroensis* (Frick) in the genus, several definite statements can be made. The material from the Avawatz, like that of Frick's type, represents a specialized form among merycodonts. This is clearly demonstrated by the extreme reduction of the premolar series with respect to the molars and by the remarkable elongation of the post-symphysial diastema. Frick refers his Round Mountain material to the "Uppermost Late Tertiary", which means presumably at least middle Pliocene. Such a determination might appear logical did we not feel certain that *Ilingoceros* and particularly *Sphenophalos* had already established themselves as the dominant antilocaprids. (Rattlesnake, Merriam, Stock and Moody 1925). Furthermore, without citing stratigraphic evidence or additional faunal evidence, is it fair to assume that this form could not be an aberrantly advanced type occurring in association with a more primitive fauna? With the discovery of further material from the Ricardo such an assumption may prove unnecessary, for in at least one Ricardo specimen (U.C. 22450, Merriam 1919, fig. 243), the only one in which molars and premolars are preserved in the same ramal fragment, there certainly exists a strong suggestion of premolar reduction comparable to that found in **M.** cf. *cerroensis* (Frick) from the Avawatz Mountains, California, and from Round Mountain, New Mexico. Hence, though the structure of the horncore remains distinct, the dentary of the Ricardo *Merycodus* with its slightly more hypsodont molars and slightly less reduced premolars may, in its general stage of development, be roughly analogous to the Avawatz form.

## RELATIONSHIPS OF FAUNA

### GREAT BASIN

In the Tertiary deposits of the Great Basin region of southeastern California and western Nevada occur several faunal groups which present an aspect similar to that of the Avawatz fauna. Examination of the faunal lists from the Barstow, Ricardo and Fish Lake Valley formations reveals the lack of comparable material. In the Barstow fauna (Merriam 1919) no forms are similar to those found in the Avawatz. *Merycodus necatus* Leidy from the Barstow exhibits characters which are decidedly more primitive than are those of *M.* cf. *cerroensis* (Frick). Greater similarity, on the other hand, exists between Ricardo (Merriam 1919, Matthew 1924, Stock and Furlong 1926, Matthew and Stirton 1930 /2 pubs./, Stirton and VanderHoof 1933) and the Avawatz faunas. *Trilophodon* ? sp. (Stock 1928) appears to be close to *T.* cf. *simplicidens* Osborn. *Pliohippus* ? sp. may be related to one of the Ricardo pliohippines. *Procamelus* sp. b (Ricardo) approaches the form of *P. coartatus* Stirton (Avawatz). The merycodonts of the two faunas, though not of the same species, represent approximately a similar stage of advancement. *Pseudaelurus* ? occurs in the Fish Lake Valley fauna (Stirton 1929, 1932, 1936), but for lack of material it cannot be compared directly with the Avawatz form. Pliohippus cf. leidyanus Osborn and Procamelus coartatus Stirton from Fish Lake Valley may well have been contemporaries of the Avawatz forms.

## PACIFIC COAST

Tertiary assemblages from the Pacific Coast Province do not offer any close comparisons with the Avawatz fauna. The Chanac (Merriam 1916, Hoots 1930, Stock 1935) fauna which has been described in the literature is very incompletely known except for the Equidae. Some undescribed material in the collections of the California Institute of Technology indicates that although the Antilocapridae from the Chanac are probably less advanced than those of the Avawatz, the Proboscidea and Equidae may be more so. The Orinda-Siesta fauna (Merriam 1913, 1917; Stock 1921; Stirton 1935), for lack of corresponding material, cannot be compared to the Avawatz fauna. The fauna from Mint Canyon (Maxson 1930, Stirton 1933) is mixed, while that from the Cuyama (Gazin 1930) is incomplete.

## GREAT PLAINS

In the Great Plains Province there are again several mixed faunas with which a comparison is difficult if not meaningless. The Santa Fe fauna of New Mexico is certainly a mixed accumulation (Frick 1933, p. 549), as is the Upper Snake Creek of Nebraska. The fauna formerly termed Valentine has now been divided into three parts by Stirton and McGrew

(Stirton and McGrew 1935). The middle of these, the Burge, is characterized by an assemblage which may prove to be roughly contemporaneous with the Avawatz fauna. In the only available list of the mammals from the Burge the forms have been determined generically but not specifically, hence critical comparison is not yet possible. The Madison Valley fauna, Montana, (Douglass 1899) appears definitely more primitive than the Avawatz. The Clarendon fauna of Texas contains no forms which can be compared with those from the California locality (Cope 1893).

## CONCLUSION

Although the fragmentary nature of the material and the almost complete absence of equid material make anything more than a suggestion of chronologic arrangement impossible, all available evidence points to a position of the Avawatz fauna close to that of the Ricardo and Fish Lake Valley. The Avawatz is perhaps slightly pre-Ricardo in age and approximately the equivalent of the Fish Lake Valley.

## Time relationship of the Avawatz fauna to certain Miocene-Pliocene vertebrate faunal horizons of western North America

| | California | | Nevada | Oregon | Nebraska |
|---|---|---|---|---|---|
| | Pacific Coast | Mohave | | | |
| Middle Pliocene | | | | Rattlesnake | |
| Lower Pliocene | Chanac | Ricardo<br>Avawatz | Fish Lake Valley | | Burge |
| Upper Miocene | | Barstow | | | |

## RICARDO

Testudinata

- Fragments, indet.

Carnivora

- Canid, small near Canis (?) vafer Leidy
- Aelurodon (?), aphobus Merriam
- Aelurodon (?), n. sp. a
- Aelurodon (?), n. sp. b
- Aelurodon or Tephrocyon, sp. c
- Aelurodon or Tephrocyon, sp. d
- Osteoborus ricardoensis Stirton and VanderHoof
- Hadrocyon mohavensis Stock and Furlong
- Mustela (?) buwaldi Merriam
- Ischyrosmilus osborni Merriam
- Felid, large
- Felid, small, not Ischyrosmilus

Rodentia

Lagomorpha

- Lepus (?), sp.

Proboscidea

- Trilophodon (?), sp.
- Tetrabelodon (?) sp.

- Perissodactyla
    - Aphelops, sp.
    - Peraceras (?), sp.
    - Hipparion mohavense Merriam
    - Hipparion mohavense callodonte Merriam
    - Hipparion, sp. a
    - Hipparion, sp. b
    - Pliohippus tantalus Merriam
    - Pliohippus fairbanksi Merriam
    - Pliohippus, sp. near mirabilis (Leidy)
- Artiodactyla
    - Merycoidodontidae
        - Metoreodon californicus (Merriam)
    - Camelidae
        - Procamelus, sp. a
        - Procamelus, sp. b
        - Pliauchenia, sp.
        - Alticamelus (?), sp.
    - Antilocapridae
        - Merycodus, near necatus Leidy
        - Merycodus furlongi (Frick)

## FISH LAKE VALLEY

Aves

- Branta esmeralda Burt

Insectivora

- Meterix latidens Hall
- Metechinus nevadensis Matthew

Chiroptera

- Mystipterus vespertilio Hall

Carnivora

- Aelurodon haydeni (Leidy)
- Pseudaelurus (?)

Rodentia

- Eucastor tortus Leidy
- Mylagaulus, sp.
- Entoptychus (?)
- Perognathoides quartus (Hall)
- Perognathoides tertius (Hall)
- Macrognathomys nanus Hall
- Peromyscus dentalis Hall

Lagomorpha

- Hypolagus cf. vetus L. Kellogg
- Sylvilagus (?)

Perissodactyla

- Hypohippus nevadensis Merriam
- Pliohippus cf. leidyanus Osborn
- Neohipparion cf. occidentalis Leidy

Artiodactyla

- Tayassuidae
  - Prosthennops crassigenis Gidley
- Camelidae
  - Procamelus, cf. gracilis Leidy
  - Procamelus coartatus Stirton
  - Procamelus, cf. robustus
  - Alticamelus, cf. priscus Matthew
- Antilocapridae
  - cf. Merycodus

## BARSTOW

Mollusca

- Anodonta (?)
- Planorbis mohavensis Hannibal
- Limnaea, sp.

Testudinata

- Testudo mohavense, n. sp.

Aves

- Buteo, sp.

Carnivora

- Canid (Canis?) sp. small
- Tephrocyon, near temerarius (Leidy)
- Aelurodon, near wheelerianus Cope
- Aelurodon, Dinocyon or Amphicyon sp.
- Machaerodont, sp. a
- Machaerodont, sp. b
- Machaerodont, sp. c
- Felid, indet.
- Pseudaelurus, sp.

Lagomorpha

- Lepus (?), sp.

Proboscidea

- Tetrabelodon(?), sp.

Perissodactyla

- Hypohippus near affinis (Leidy)
- Parahippus (?) mourningi Merriam
- Merychippus (Protohippus) intermontanus Merriam
- Merychippus calamarius stylodontus Merriam.
- Merychippus sumani Merriam
- Protohippus (?) or Pliohippus sp.

Artiodactyla

- Tayassuidae
  - Prosthennops (?), sp.
- Merycoidodontidae
  - Merycochoerus buwaldi Merriam
- Camelidae
  - Procamelus, sp. a
  - Procamelus, sp. b
  - Pliauchenia, sp.
  - Alticamelus (?) sp.
- Cervidae
  - Dromomeryx or Cervus (?) sp.
- Antilocapridae
  - Ramoceras (Paramoceras) brevicornis Frick
  - Ramoceras (Merriamoceras) coronatus (Merriam)
  - Merycodus (Paracosoryx) alticornis (Frick)
  - Meryceros joraki Frick

## BURGE

- Insectivora
    - Metechinus ?
- Rodentia
    - Mylagculus
    - Eucastor
- Carnivora
    - Aelurodon
    - Cynodesmus euthos
    - Vulpes vafer (= Leptocyon vafer)
    - Amphicyon (= Pliocyon )
- Proboscidea
    - Mastodontinae
- Perissodactyla
    - Rhinocerotidae
    - Hypohippus affinis
    - Merychippus
    - Neohipparion
    - Nannippus
    - Pliohippus
- Artiodactyla
    - Tayassuidae
        - Prosthennops
    - Merycoidodontidae
        - Metoreodon ?

Camelidae
    Alticamelus
    Procamelus
Cervidae
    Blastomeryx
    Dromomeryx
Antilocapridae
    Cosoryx furcatus Leidy
    Meryceros warreni johnsoni Frick

# DESCRIPTION OF FAUNA

## Carnivora

## Felidae

### Pseudaelurus intrepidus Leidy

A single poorly preserved left ramus represents the only diagnostic felid material from the Avawatz Mountains, (Plate V, Figs. 1 and 1a). The lower edge and the posterior portion of the ramus are missing. $P\overline{3}$, $P\overline{4}$, and $M\overline{1}$ remain, but are badly shattered. A small calcaneum and astragulus in the collection are perhaps of this species. A large felid calcaneum from the Los Angeles Museum collection of Avawatz material may represent a different species.

In size the left ramus resembles the slightly larger forms *Pseudaelurus intrepidus* Leidy (1869) and *Metailurus major* Zdansky (1924) much more closely than the smaller forms *Pseudaelurus marshi* Thorpe (1922) and *Metailurus minor* Zdansky. The anterior mental foramen is large and lies below $P\overline{2}$. Behind this opening are two small foramina, which lie beneath the posterior root of $P\overline{3}$. The masseteric fossa is deep, with its anterior end reaching forward to a point beneath the posterior root of $M\overline{1}$.

The incisors are completely missing. The canine is likewise gone, but its partly preserved alveolus attests to its large size. Following a short diastema, there appears to be a single small alveolar cup on the ramus which may represent a socket for a small single-rooted $P\overline{2}$.

Another but shorter diastema is followed by P$\overline{3}$, a large double-rooted tooth. The crown consists of a large central cusp with small anterior and posterior cuspules. Of these the anterior is the least developed. This tooth along with those described below is set slightly diagonally to the axis of the jaw.

P$\overline{4}$ is so placed that its anterior end lies just inside the posterior end of P$\overline{3}$, so that the teeth overlap about 2 mm. It is slightly larger than P$\overline{3}$, doublerooted, and with anterior and posterior cusps larger in proportion to the main cusp than are those of P$\overline{3}$. Posteriorly there is in addition a fourth very low heel-like cusp, the talonid.

M$\overline{1}$ overlaps P$\overline{4}$ on the inside by more than 3 mm. and has a position decidedly diagonal with reference to the long axis of the ramus. The sharp-pointed paraconid is separated by a broad deep notch from the protoconid or main cusp. A very small cusp on the posterior ridge of the tooth is all that is left of the metaconid. The talonid or heel, while not as greatly reduced as the metaconid, is only weakly developed. There is no indication of a second molar.

*Relationships.* In structural characters the species from the Avawatz Mountains resembles most closely Leidy's *Pseudaelurus intrepidus*. It differs from *Metailurus* of Zdansky in smaller size, in presence of three lower premolars, and in smaller amount of reduction of heel in M$\overline{1}$.

The only difference between this form and the type of *P. intrepidus* Leidy is the relatively advanced position of the anterior edge of the masseteric fossa in the former.

*Age.* Most of the recorded occurrences of *Pseudaelurus* are assigned to the Miocene, including Barstow, Tonopah, and Lower Snake Creek. The genotype described by Gervais came from Sansan (Miocene). Leidy, however, records *Pseudaelurus* from his Bed F or Pliocene and upwards. Nevertheless, the occurrence of *Pseudaelurus* in the Avawatz fauna gives that assemblage a Miocenic cast.

Measurements in millimeters

| | Avawatz | | Tonopah | | Niobrara | Valentin |
|---|---|---|---|---|---|---|
| | | #772 | #1233 | #1234 | | |
| Depth of jaw at posterior end of M$\overline{1}$ | ca. 22.5 | ca. 21.7 | 22.5 | | 22.5 | 21.7 |
| Thickness of jaw below M$\overline{1}$ | 11.0 | 9.5 | 9.5 | | | |
| Length P$\overline{3}$-M$\overline{1}$ inclusive | 42.7 | 42.5 | 38.2 | | 43.6 | 36.0 |
| Diastema bdtween C and P$\overline{3}$ | 10.0 | | 10.0 | | 14.8 | 8.6 |
| P$\overline{3}$, anteroposterior diameter | 11.0 | 10.5 | 10.3 | | 11.4 | 9.5 |
| P$\overline{3}$, transverse diameter | 5.0 | 5.3 | 4.6 | | 5.2 | 4.8 |
| P$\overline{4}$, anteroposterior diameter | 15.5 | 14.3 | 13.0 | 12.5 | 14.8 | 12.5 |
| P$\overline{4}$, transverse diameter | 6.6 | 6.8 | 5.8 | 6.0 | 7.2 | 6.0 |
| M$\overline{1}$, anteroposterior diameter | 19.6 | ca. 18.9 | 15.3 | 16.5 | 19.6 | 16.0 |
| M$\overline{1}$, transverse diameter | ca. 7.8 | ca. 7.0 | 6.6 | 6.9 | 7.9 | 7.5 |

## Canidae

### Canid, indet.

A right maxillar fragment with premolar tooth-row of a small canid has been preserved in good condition. Only a small part of the alveolar border remains. The molars, the canine and the incisors are completely absent.

The premolar tooth-row (P1-P4) resembles that of Recent *Vulpes macrotis*, for in both cases the teeth are set for apart (Plate V, Figs. 2 and 2a).

P1, a peglike single-rooted tooth, has a rounded anterior ridge convex in profile. The ridge running from the apex down to the posterior border, on the other hand, is more sharply defined and has a concave profile. Near the cingulum this concavity is more pronounced so that a slight but definite shelf is formed. Hence, an angular break in the tooth profile occurs between the posterior edge of the crown and the posterior edge of the root of the tooth. This structure resembles that of *Vulpes macrotis*, but is not quite so pronounced as it is in that form.

Though injured anteriorly, P2 is a double-rooted tooth presenting a triangular lateral aspect. Its anterior ridge is almost straight from tip to border of crown. The concavity of the posterior border and the shelving posteriorly again are not quite so strongly developed as in *Vulpes macrotis*.

P3 is considerably larger than P2 and possesses a slightly concave anterior ridge and a strongly concave posterior ridge. No extra tubercles or cusps in addition to the main cusp are present on this tooth. P3 of *Vulpes macrotis* is similar in proportions, but shows an incipient development of a posterior cusp. Also it has a very definite little tubercle halfway down the posterior ridge of the tooth.

In contrast to the anterior premolars, P4 differs distinctly from the corresponding tooth in *Vulpes macrotis*. Like this tooth in the latter, the principal cusp is the sharp-pointed paracone, while the metacone forms a long shearing blade. A small well-developed protocone is present, but does not stand so far anteriorly as does the protocone of *V. macrotis*. The tooth differs from that of *V. macrotis* in being larger, more robust, and not so compressed laterally. Also its ridges are not developed to the almost razor-edge sharpness observed in P4 of *V. macrotis*. The blade-like metacone of *V. macrotis* slopes strongly downward posteriorly, while that in the specimen from the Avawatz forms a horizontal edge. Finally, the notches separating paracone from matacone and paracone from protocone are not so strongly and sharply developed as in *V. macrotis*.

*Relationships.* The form and proportions of Canid indet. resemble fairly closely those of *Canis vafer* Leidy. In the literature the upper dentition, however, is neither discussed nor figured. Hence, any determination of the form as *vafer* is impossible.

Since all the teeth of the premolar series from the Avawatz Mountains show distinctive differences from corresponding teeth of Recent *Vulpes macrotis*, it is believed that the two forms do not belong to the same genus.

*Age*. No estimate of the age of the Avawatz fauna can be based upon this canid form with any surety at all.

**Measurements in millimeters**

| | Canid, indet. Avawatz | V. macrotis Recent | Urocyon sp. Recent |
|---|---|---|---|
| P1 - P4, total length | 32.5 | 33.0 | 26.7 |
| P1, anteroposterior diameter | 3.2 | 3.0 | 2.4 |
| P1, transverse diameter | 2.0 | 1.5 | 1.7 |
| P2, anteroposterior diameter | ca. 5.7 | 5.6 | 4.8 |
| P2, transverse diameter | 2.0 | 1.9 | 2.1 |
| P3, anteroposterior diameter | 6.5 | 6.8 | 5.2 |
| P3, transverse diameter | 2.3 | 2.1 | 2.3 |
| P4, anteroposterior diameter | 11.0 | 10.7 | 9.6 |
| P4, transverse diameter | 5.0 | 4.0 | 4.2 |

## Rodentia

### Heteromyidae

### Perognathoides cf. P. tertius (Hall)

*Perognathoides* is a pocket-mouse belonging to the subfamily Perognathinae. It is close to the living genus *Perognathus*, but is characterized by a precocious development of crown height and presence of certain features generally associated with the Dipodomyinae and the Heteromyinae. In development of crown height without attendant lengthening of the pattern-bearing portion of the tooth, presence of a X-pattern in P$\overline{4}$, small lingual style in P$\underline{4}$, and asulcate upper incisors, the Avawatz material agrees with that of the type species and that of referred species of *Perognathoides*. Teeth clearly showing the unworn pattern are available for the first time. The species represented seems to be closest to *P. tertius* of the Fish Lake Valley fauna but perhaps is new.

### Perognathoides (?) sp. undet.

A lower jaw with worn P$\overline{4}$, M$\overline{2}$, and M$\overline{3}$ is smaller than those of *P.* cf. *tertius*, and apparently pertains to a distinct species. P$\overline{4}$ is relatively shorter anteroposteriorly, but any other characters which may exist cannot be recognized in the worn dentition present. The specimen is apparently a species of *Perognathoides*, but might be a *Perognathus*.

### Dipodomyine (?) n. gen. and sp.

What is apparently a new genus of kangaroo-rats is represented by $P\overline{4}$ and $M\overline{1}$ in a fragment of ramus. A lower incisor is considered as belonging to the same individual. The cheek-teeth are very hypsodont but are not persistent in growth, a character distinguishing this genus from the Recent *Dipodomys*. Other than in this, it does not appear possible to separate the two genera. Wide enamel breaks are present in $M\overline{1}$ separating the enamel into anterior and posterior bands. The enamel of $P\overline{4}$ is complete in the present stage of wear but an examination of the tooth indicates that breaks would develop with additional attrition. Differentiation of enamel in a heteromyid species as old as lower Pliocene is rather surprising. The highly specialized Dipodomys is the only heteromyid genus with incomplete enamel bands and hot all Recent species exhibit this character. The earliest known fossil form that does is upper Pleistocene is age. *Cupidinimus*, a Pliocene genus which A. E. Wood considers to be ancestral to *Dipodomys*, not only has complete enamel bands, but is distinctly shorter crowned than the Avawatz specimen.

The progressive characters seen in the Avawatz material may raise the question as to whether the form is a heteromyid at all. The dentition of the Geomyidae (pocket-gophers) is very close in characters to that of the Heteromyidae, and species with rootless cheek-teeth and differentiated enamel are known from the upper Pliocene to Recent. A. E. Wood has postulated that at any stage of geologic time, the former family is always more advanced than the heteromyids. The new genus is about in the right stage of evolution to be a geomid but the material itself, aside from considerations of geologic age, is typically dipodomyine.

### Cricetidae

### "Peromyscus" probably n. sp.

A right ramus with $M\overline{1}$-$M\overline{2}$ represents a peromyscine form. The species is smaller than *Peromyscus longidens* from the Barstow beds, and has narrower teeth than *P. dentalis* of the Fish Lake Valley fauna. No other extinct species of "*Peromyscus*" have been described which are represented by comparable material or are of comparable geologic age, and the Avawatz species is probably new.

### Lagomorpha

### Leporidae

### Hypolagus species

Leporid specimens are extremely fragmentary, the material consisting mostly of isolated teeth and bits of limb bones. Two isolated third lower premolars record the presence of *Hypolagus*, and there is no reason for not assigning all specimens to this common and almost sole representative of the later Tertiary lagomorphs of North America. Most of the teeth indicate an animal slightly smaller than *H. vetus* from the Thousand Creek, but one upper cheek-tooth is as large or larger than any of those of H. vetus. Perhaps two species are present.

### Proboscidea

### Trilophodon cf. simplicidens Osborn

An incomplete and badly fractured mandible bearing three poorly preserved molar teeth (right $M\overline{2}$ and $M\overline{3}$; left $M\overline{2}$) represents available proboscidean material from the Avawatz Mountains (Plate V, Fig. 3). Though the posterior portion of the symphysis remains, the anterior end is lacking. The part of the symphysis which has been preserved hints of considerable elongation and of but slight downward deflection in this region. The right ramus, badly shattered, extends posteriorly only to the heel of $M\overline{3}$. The left ramus, in even worse condition, has been broken or eroded off at the middle of $M\overline{3}$. Enamel thickness amounts to about 7 mm.

Both second lower molars are in an exceedingly poor state of preservation. Both show a high degree of wear. They retain enough of their original form to demonstrate their fundamental pattern consisting of three main ridge crests. The teeth are worn below the point where they might still bear evidence of the existence of central conules in a younger stage.

Of the right $M\overline{3}$ the internal cone of the tetartolophid and the entire heel are missing. In the anterior portion of the tooth, all of the main cones have been broken off. The ridge crest formula was probably $4\frac{1}{2}$. Intercrestal conules are present. Whether or not any of the cones would wear to a trefoil pattern is doubtful. The tooth as a whole is very slender in appearance and possesses a low breadth-length ratio.

In general character the specimen is distinctive by reason of its small size and its simplicity of dental pattern. These characters are apparent in but one of all the American Trilophodonts, namely <u>Trilophodon simplicidens</u> Osborn (1936) from the Bone Valley Lower Pliocene of Florida. The Avawatz form resembles in appearance, but is slightly smaller in size than the specimen from the Ricardo referred by Stock to <u>Trilophodon</u> (?) sp. (Stock 1928).

Measurements in millimeters

| | T. cf. simplicidens Avawatz (approximate only) | T. simplicidens Bone Valley |
|---|---|---|
| Transverse across protolophid | 53 | |
| Transverse across metalophid | 57 | 60 |
| Transverse across tritolophid | 58 | 63 |
| Transverse across tetartolophid | | 52 |
| Height of tetartolophid | 37 | 35 |

## Perissodactyla

### Equidae

Horses are conspicuous because of their almost complete absence in the Avawatz fauna. These forms are represented by a few scraps. No generic determination seems possible for a complete set of lower incisors and canines (Plate V, Fig. 4) and for fragmentary distal end of a tibia. A much worn poorly preserved upper cheek-tooth is described below (Plate V, Fig. 5).

### Pliohippus ? sp.

A single poorly preserved M1 (Bode 1931) is referred tentatively to Pliohippus (Osborn 1918). The only complications in its simple crown-pattern consist of a pli protoconule and of a pli caballin. For the rest, the fossettes appear simple and large. The large, flattened-oval protocone, though only partially preserved, is obviously united to the protoloph. Strong curvature characterizes the worn crown.

Measurements in millimeters

| | |
|---|---|
| M1, anteroposterior diameter | 24.5 |
| M1, transverse diameter | ca. 23. |
| M1, crown height (measured along mesostyle) | 33.4 |

## Artiodactyla

### Camelidae

Camelid remains occur in abundance in the fauna from the Avawatz Mountains. Unfortunately, most of the material has been badly fractured and shattered, and is so fragmentary as to be of no diagnostic value. The collection includes fossil camelid remains which fall into two very distinct size ranges.

### Procamelus coartatus Stirton

Undoubtedly the material referred to this species was derived from a number of individuals. At any rate, no two fragments can be assigned to a single individual with any degree of certainty. The material consists of a fairly well-preserved palate of an adult, containing the tooth-row complete from P$\underline{2}$ to M$\underline{3}$; a partially preserved palate of a young specimen bearing Dm$\underline{3}$, Dm$\underline{4}$ and M$\underline{1}$; several poorly preserved ramal fragments, none of which carries the complete mandibular dentition; lower teeth which have been preserved include P$\overline{2}$ (roots only), P$\overline{3}$, P$\overline{4}$, M$\overline{1}$, M$\overline{2}$, M$\overline{3}$ and Dm$\overline{4}$; several ramal symphyses; distal end of a humerus; proximal end of radius and distal end of ulno-radius, proximal and distal end of femur; distal end of tibia; distal end of a cannon bone; termini of a proximal phalanx; two median phalanges.

Although the material from the Avawatz Mountains averages about one-tenth smaller in every dimension, in all other respects it approximates very closely Stirton's type specimen from the Fish Lake Valley beds, Nevada (Stirton 1929).

In a personal communication, Mr. Stirton stated that specimen U. C. 29612, provisionally referred by him to *Procamelus gracilis* Leidy, might very well be of the species *P. coartatus*. The difficulty in arriving at a definite determination lies in the fact that in making a restoration of the palate, the proper width of the roof of the mouth between the first upper premolars cannot be ascertained. If in the restoration the anterior portions of the maxillae are brought somewhat closer together, the palate might appear remarkably similar to that of the typical *P. coartatus*. In the following comparison this specimen (U. C. 29612) will be referred to as of the species *P. coartatus* Stirton.

In general appearance the palate from the Avawatz Mountains (Plate VI, Fig. 1) bears a striking resemblance to the palate in the University of California collections from Fish Lake Valley (U. C. 29608). Especially striking is the extreme constriction of the palate just anterior to $P\underline{2}$ in both cases. No other species of the genus *Procamelus* exhibits such extreme "pinching in" of the anterior portion of the palate. A palatine foramen lies just median to the posterior lobe of $M\underline{1}$.

The well-worn upper premolar teeth of the Avawatz form seem to be of proportions roughly similar to those of specimens U. C. 29608 and U. C. 29612, though in the case of the latter specimen the teeth appear to be slightly narrower in proportion to their length.

The worn upper molar teeth of the specimen from the Avawatz Mountains proportionally are definitely shorter anteroposteriorly and broader transversely than are the molars of U. C. 29612. To be sure, part of this relatively great breadth which is so striking in the illustrations may be ascribed to the difference in stage of wear of the two molar series. The importance of stage of wear in determining tooth proportions is brought out by the fact that while the crown of an unworn molar may be 1.5 times as long anteroposteriorly as it is broad, the crown of a worn molar becomes almost square. That is, the molars broaden transversely and shorten anteroposteriorly in passing in stage of wear from the crown towards the root.

In M1 of U. C. 29612 there is present a very prominent accessory lingual cusp. M1 from the Avawatz Mountains has been worn down to such a very great extent that if a comparable cusp ever was present it has now been entirely obliterated. However, in a maxillar fragment in the Avawatz collection an unworn M1 does not possess an accessory lingual cusp. The significance of this cusp in the U. C. specimen is uncertain.

A comparison of the measurements of this adult palate from the Avawatz Mountains with the corresponding measurements of the U. C. specimens from Fish Lake Valley shows the California Institute specimen to be about one-tenth smaller.

A picture of the lower dentition of the specimen from the Avawatz Mountains must be constructed from very fragmentary evidence. No clues are available concerning the general proportions of the ramus. Individual teeth or short series of teeth on scattered mandibular fragments do furnish some idea of the lower dentition.

One fragment bears very well-worn teeth, $P\overline{2}$ (roots only), $P\overline{3}$, $P\overline{4}$, $M\overline{1}$ and $M\overline{2}$ (badly shattered roots only) (Plate VI, Fig. 2). Another fragment carries $M\overline{2}$ (moderately worn) (Plate VI, Fig. 5), while $M\overline{2}$ and $M\overline{3}$ (well-worn) are present on a third fragment (Plate VI, Fig. 3). $Dm\overline{4}$, well-preserved and only moderately worn, occurs alone on another fragment (Plate VI, Fig. 4). This tooth is almost identical with a long narrow $Dm\overline{4}$ from the Ricardo (Merriam 1919, fig. 219).

Because of difference in stage of wear, the dental patterns of the lower teeth of the California Institute form cannot be compared too critically with those occurring on U. C. 19820. In general, however, they appear to be accordant. The material from the Avawatz is not so large and robust. The premolars of the Avawatz form appear to be somewhat reduced, but perhaps much of this apparent reduction should be ascribed to the advanced stage of wear which these teeth display.

Although the mandibular symphyses in the collection show some variation in size, they are all characterized by a strong constriction of the lower side of the symphysis slightly anterior to the mental foramen. The symphysis of an adult individual is very firmly fused, leaving no trace of the suture. One example bears the shattered roots of three incisors, one canine immediately posterior to the incisors, and $P\overline{1}$, double-rooted, located directly above the mental foramen (Plate VII, Fig. 3). Another symphysis of a young individual has a suture which is not yet firmly fused. Its canines are small and $P\overline{1}$ has not yet erupted.

The distal end of a humerus resembles so closely the corresponding part of a Recent llama that it might almost be said to fall within the limits of individual variation of the latter type.

The head of a radius without the ulna shows that in Procamelus the fusion of these two elements was incomplete (Plate VII, Fig. 1). Of course, this particular specimen might belong to a young individual, but the specimen is larger proportionally than the distal end of the fused radius-ulna described below. The measurements (in millimeters) of the proximal end of the radius are anteroposterior diameter 27, transverse diameter 50.

The well-preserved distal end of a radius-ulna (Plate VII, Fig. 5) shows these two bones firmly fused to almost exactly the same extent as is found in the Recent llama (Lama huanachus). The only apparent differences in the articular surfaces are caused by the development of the lunar into a more wedge-shaped bone in the llama than in Procamelus. Accordingly, on the anterior ridge, the scaphoid and cuneiform are narrowed at the expense of the lunar which is broadened in the llama. Conversely, on the posterior edge of the distal end in this element of a Recent llama, the surface for articulation of the lunar is narrowed and the surfaces for articulation of scaphoid and cuneiform are widened in comparison to the corresponding surfaces as exhibited in Procamelus.

Measurements in millimeters

| | | C.I.T. | U.C.19820 |
|---|---|---|---|
| Distal end of radius-ulna | Anteroposterior | 27 | 36-40 |
| | Transverse | 40 | 52 |
| | Shaft width | 24.6 | 34.4 |
| | Shaft thickness | 17.4 | 22.7 |

Both the proximal and the distal end of a femur are in fair state of preservation.

The proximal end corresponds very closely in size to that in the Recent llama but shows several differences. In the first place, in Procamelus the head of the femur is not set off by such a definite neck. That is, the incurve between the head and the lesser trochanter is not so deep. In the second place, the head does not rise quite so high above the trochanteric fossa. Thirdly, the depression for insertion of the ligamentum teres is much larger and deeper in *Procamelus* than in llama.

In the distal end of the femur in *Procamelus* the lateral condyle is strongly rounded out laterally, while it is flat in llama. The medial condyle of *Procamelus* is not nearly so well-developed posteriorly and medially as is that of llama.

Only the distal end of a tibia is preserved (Plate VII, Fig. 4). The articular surface for the astragalus is narrower and more deeply grooved in *Procamelus* than in llama. In the *Procamelus* tibia the medial malleolus projects slightly farther distally than does the projection of the dorsal surface of the tibia. In llama, in contrast, the medial malleolus projects much less.

The distal shaft and termination of a cannon bone cannot be identified definitely as representing a metatarsal rather than a metacarpal, but its general proportions suggest the latter (Plate VII, Fig. 6). The separation between the two bones extends slightly farther up the shaft in *Procamelus* than it does in llama. That the stage of fusion of the metapodials in *Procamelus* is advanced, however, is attested by the fact that the marrow cavities in one metapodial at any rate are fused into a single cavity only a short distance above the point of external fusion. The terminal articular surfaces are more strongly keeled in *Procamelus* than in llama. The keel in the Avawatz form is stronger than that in the

U. C. specimen from Fish Lake Valley. Also the shaft of the Avawatz form is more slender than that of the U. C. specimen. The size of the metapodial in the California Institute collection is smaller than the metapodial in the U. C. collection.

In size and proportions both the proximal and medial phalanges of Procamelus from the Avawatz fall within the range of individual variation of Recent llama (Plate VII, Fig. 2).

Measurements in millimeters

| Palate: | C.I.T. | U.C. 29608 |
|---|---|---|
| Inside width at narrowest point of palate (measured on crests of alveolar ridge) | 7 | 8 |
| Distance across palate between $P\underline{4}$'s (U. C. palate may be reconstructed too flat) | 22 | 29 |

| Dentition: | C.I.T. | | U.C. 29608 | | U.C.29612 | | | |
|---|---|---|---|---|---|---|---|---|
| $P\underline{2}$, anteroposterior | 8 | | 8.7 | | 8.7 | | | |
| transverse | 5 | | 4.5 | | 4.5 | | | |
| $P\underline{3}$, anteroposterior | 11.2 | | 12.4 | | 11.8 | | | |
| transverse | 6.8 | | 6.6 | | 6.0 | | | |
| $P\underline{4}$, anteroposterior | 11.4 | | 11.5 | | 12.0 | | | |
| transverse | 9.4 | | 9.7 | | 9.0 | | | |
| $M\underline{1}$, anteroposterior | 15.3 | base | 21.0 | crown | 17.2 | b | 21.6 | crown |
| transverse | 15.5 | | 14.2 | | 16.9 | | 14.9 | |
| $M\underline{2}$, anteroposterior | 25.2 | | 24 ? | base | 28.4 | | | |
| transverse | 17.8 | | 19 ? | | 16.4 | | | |
| $M\underline{3}$, anteroposterior | 29.8 | | | | 27.8 | | | |
| transverse | 17.7 | | | | 16.4 | | | |
| $P\underline{2}$ - $M\underline{3}$, total length | 95.8 | | | | 106.8 | | | |
| $P\underline{4}$ - mid $M\underline{2}$ | 62 | | 66 | | 70 | | | |
| Crown height $M\underline{2}$ | 12 | worn | | | 28 | unworn | | |
| Crown height $M\underline{3}$ | 16 | | | | 21 | | | |

| Mandible: | | U. C. 19820 |
|---|---|---|
| Narrowest width of the symphysis | 20.0 | 30.4 |
| Height of symphysis at same place | 15.8 | 27.2 |

| Mandibular dentition: | | C.I.T. | U.C. 19820 | P. gracilis Leidy 1869 |
|---|---|---|---|---|
| Length $P\overline{2}$ - $M\overline{1}$ inclusive | | 40 | 46.9 | |
| $P\overline{2}$, | anteroposterior | 5.2 base | 6.0 base | 7.9 |
| | transverse | 2.8 | 3.6 | 3.2 |
| $P\overline{3}$, | anteroposterior | 8.4 | 11.0 | 10.0 |
| | transverse | 4.4 | 5.0 | 4.1 |
| $P\overline{4}$, | anteroposterior | 11.2 | 13.9 | 13.2 |
| | transverse | 5.5 | 6.4 | 5.5 |
| $M\overline{1}$, | anteroposterior | 15.4 | 15.8 | |
| | transverse | 10.2 | 10.6 | |
| $M\overline{2}$, | anteroposterior | 22.5 base | 22.0 base | |
| | transverse anterior lobe | 11.0 | 12.5 | |
| | posterior lobe | 13.8 | 16.8 | |
| $M\overline{3}$, | anteroposterior | 34.0 | 40.0 base | |
| | transverse | ? | | |
| $Dm\overline{4}$, | anteroposterior | 25.5 | | |
| | transverse anterior lobe | 5.7 | | |
| | medial lobe | 6.8 | | |
| | posterior lobe | 7.2 | | |

### Camelid indet.

A portion of a large mandibular symphysis, many poorly preserved vertebrae, the iliac portion of a pelvic girdle, the distal ends of a tibia (Plate VII, Fig. 7) and metapodial, and one complete (Plate VII, Fig. 8) and one incomplete proximal phalanx indicate the presence in the fauna of a large camelid almost exactly twice the size (linear) of *P. coartatus* Stirton. The fragmentary condition of this material, which by its very nature is of little diagnostic value, precludes the possibility of making even a generic determination.

## Antilocapridae

### Merycodus cf. cerroinsis (Frick)

Merycodont remains are the most abundant fossil specimens found in the Tertiary beds of the Avawatz Mountains. While fragmental horn-cores, parts of rami and loose teeth abound, complete well-preserved specimens are rare. Small bones and terminations of the larger elements of the appendicular skeleton are well represented in the collection. However, one of the long limb bones has been preserved intact. That some of the individuals represented are quite young is attested by the fact that several of the rami bear the deciduous fourth premolar, and by the terminal epiphyses of the phalanges that are often free from the main shafts. The unworn state of the crowns of the teeth indicates that none of the rami or maxillae belonged to individuals older than young adults. In no case was a dental series found in definite association with horn-cores. Like the teeth and phalanges, however, the horn-cores probably represent mostly sub-mature to young adult individuals.

Typical specimens of the horn-cores have a long beam which branches almost evenly into two still longer tines, with a tendency to a rather wide flare and to a bending of the tips (Plate VIII, Fig. 1; also Plates IX and X). The base of each horn-core stands directly over the posterior portion of the orbit. The pedicle of the core rises perpendicularly from the frontlet, but it curves anteriorly and laterally towards the region of bifurcation. The two tines diverge at approximately 90°, one is directed anteriorly while the other projects laterally. In both of the tines a reverse curve occurs in the last 45 mm., so that the tips point upwards. The anterior tine (120 mm.) is slightly longer than the lateral tine (110mm.). When the part of the frontlet between and posterior to the horn-cores is held horizontally, a plane passed through the lower part of a pair of tines makes an angle of less than 45° with the horizontal. Also such a plane lies at an angle of about 60° to the median plane of symmetry of the skull. This latter figure is especially significant in that no specimens yet described or illustrated show such a high degree of rotation of the tines from the fore and aft position. The surface of the horn-core is grooved by shallow anastomosing nutrient canals. All parts of the horn-core, except in the proximity of the spread-out bifurcation, are round-oval to circular in cross-section.

Of the horn-cores figured in the literature, the specimens at hand resemble most closely those from Ricardo and Barstow, California, identified only generically as <u>Merycodus sp.</u> (Furlong 1927, Plate 28, U. C. Nos. 27242, 27243, 27249). Other figures which bear marked similarity in structure and proportions to the horn-corn material from the Avawatz Mountains are those of <u>Cosoryx (Subcosoryx) cerroensis</u> Frick from Round Mountain Quarry, New Mexico, (Frick 1937, Figure 38, F:A.M. Nos. 33105, 33108, 33113H, 33114, 33116). These are characterized by Frick (Frick 1937, pp. 336-338) as having a variable prong to beam ratio, but always "with tendency to rather wide flare and bending of tips." Also, "several cranial saddles indicate the presence of individuals in which the horn-cores are peculiarly rotated antero-inwardly." A horn-core from the Cedar Mountain beds of Ione Valley, Nevada, identified by Merriam as _Merycodus furcatus_ (Leidy) also exhibits the form of the specimens from the Avawatz Mountains (Merriam 1916, Fig. 44, U. C. No. 21492).

Other horn-cores in the literature identified as _M. necatus_ and _M. furcatus_ are not proportioned and curved as are the specimens at hand. When proportions of tine to beam in specimens from other localities are of the same order as those in the Avawatz horn-cores, it is seen that the beam is usually relatively stout and that the tines do not have the wide flare and strongly curved tips which are so characteristic in the material here described. This distinction applies especially in the case of the typical material from the Barstow and Ricardo beds.

Only one beam out of the twenty in the collection appears to be without a burr. It is significant that while all the other cores are relatively robust, having maximum diameters of 17 to 21 mm. below the burr, the burrless beam is delicate and has a maximum diameter of only 13.5 mm.

Most of the burrs slope more or less steeply downward from a high anterior to a low posterior position. There are no signs of internal nutrient foramina within the horn-core, hence all material for the upbuilding of the horn-core must have traveled through nutrient canals outside of the core. Such material, of course, must have been deposited on the outer surface of the horn-core to build it up. In regard to the beams which bear a burr, the burr completely seals off the nutrient canals on the surface of the beam, hence if new channels developed at all they must have passed across the outside of the burr. Moreover, if additional material were deposited on the surface of the horn-core after the formation of the burr, it might be presumed that the built-up surface of the horn-core would lap over a part of the burr. Sections do not show any such overlapping. Hence, the conclusion seems logical that with the formation of the burr, all growth of the horn-core above the burr ceased. In the light of this, the delicate beam would appear to have been the horn-core of a young individual which was not fully developed and hence had not yet sealed off the upper part of the horn-core by means of a burr.

Another more probable and completely different hypothesis as to the structure and development of the merycodont horns may be based upon a study of <u>Antilocapra americana</u>. A recent specimen in the collection of the California Institute is a skull with horn sheaths, one of which is still attached, the other loose. The exposed horn-core shows a very marked circumferential ridge or band about 2 mm. high and some 15 mm. above the orbit. This rugose area is the main point of attachment for the base of the horny sheath. If we hypothecate a similar function for the burr of merycodont forms, for structural reasons mentioned above, (i.e., that the burr is not overlapped by horn-core material, but is free to break off rather easily), the burr probably broke off annually along with the sheath. The sheath must have split to part from the forked horn-core, hence it could scarcely have been such a hard horny sheath as that of the Antilocapra americana.

In only one specimen is a frontlet preserved. The loose-knit sutures point to the youth of this individual. The fronto-parietal suture crosses the skull rather far back (10.4) behind a line drawn tangent to the posterior side of the horn-cores. This is not so far back, however, as in some of the other skulls measured. The width measured between the lateral sides of the horn-cores is 63 mm., while the width between the medial sides is but 32 mm. The frontals dome up between the horn-cores along the median line of the skull. Just anterior to this dome the frontals drop away sharply to form a shallow depression. The supraorbital foramina are set in deep hollows, antero-internal to the bases of the horn-cores. Though no orbits have been preserved complete, they appear to be characteristically large and strongly projecting.

Besides numerous loose teeth, three or four fragmentary maxillary dentitions and more than a dozen parts of rami have been preserved. A single right maxilla and a single left ramus are the only pieces which bear complete tooth rows.

Of the upper molars, M2 and M3 are clearly long-crowned teeth. M1 still retains roots which are about one-third of its length from root-tip to wearing surface. P3 and P4 are definitely hypsodont, but by no means so long-crowned as the corresponding teeth in *Antilocapra americana*. P2 shows only a slight tendency towards hypsodonty, being an almost normally rooted tooth.

Present among the Avawatz material is a portion of a maxillary tooth row containing Dp4, M1 and a partially erupted M2. Dp4 which has not yet been figured or described in the literature is a short-crowned tooth with two-lobed crown pattern, in contrast to the single crescent form of P4. The posterior lobe of Dp4 resembles a molar crescentic lobe, but is slightly more compressed anteroposteriorly and does not have such prominent styles as are to be found in a molar. The anterior lobe is asymmetric. Its crescentic pillar is strongly developed and a deep valley reaching to the cingulum lies between this crescentic pillar and the anterior very weak parastyle. This arrangement of a weak parastyle, a strong anterior crescentic pillar and a still stronger posterior lobe gives the buccal surface of the tooth crown a step-like appearance.

The ratio of length of premolar tooth-row to length of molar tooth-row indicates an amount of shortening of the premolar series greater than that found in most merycondonts. Furthermore, the entire tooth-row appears to be more compressed laterally than is common in other merycodonts. Except for this general lateral compression, the crown pattern of the upper dentition is in complete harmony with the pattern observed in all merycodonts and antilocaprids (Frick's *Antilocapridae*). On the external side the crescentic pillars are merely gently rounded ridges. The styles, in contrast, are sharply delineated ridges.

Concerning the proportions of the mandible, the lack of depth is rather striking, but certainly of no specific value, for several other forms are just as shallow, notably *M. necatus sabulonis* Matthew and Cook, (AM 14109) and *Cosoryx (Subcosoryx) cerroensis* Frick (F:A.M. Nos. 32938, 30982, 31996). A feature of greater significance is the length of the diastema between the mandibular symphysis and P$\overline{2}$. In Frick's Table VIII of "Comparative Measurements and Ratios of Merycodontini Mandibles" (Frick 1937, pp. 384-390) no form except *C. (Subcosoryx) cerroensis* Frick regularly has a postsymphysial diastema so great in comparison to the longitudinal diameter of M$\overline{3}$.

M$\overline{2}$ and M$\overline{3}$ have developed an advanced degree of hypsodonty. M$\overline{1}$ is less hypsodont, while the premolars retain rather short crowns. In general, the cheek-teeth might be said to exhibit a slightly more advanced stage of hypsodonty than that displayed in many if not in most of the figures shown by Frick. The Avawatz teeth are considerably more hypsodont than those from the Barstow, and slightly less so than those from the Ricardo as illustrated by Merriam and by Frick. The shortening in length of the premolar tooth-row in comparison to the length of the molar tooth-row is even more striking than in the case of the upper dentition. This shortening which is rivalled only by the extreme shortening found in *C. (Subcosoryx) cerroensis* Frick (see tables of measurements, Frick 1937, pp. 384-390) may be of specific value. Lateral compression, especially in the case of the premolars, is pronounced. Frick states (Frick 1937, p. 392) that the species *cerroensis* is "characterized by reduction of the premolars, particularly $P\overline{2}$ and $P\overline{3}$, and elongation and slenderness of the diastema."

The crown-pattern of the lower dentition follows closely the general merycodont-antilocaprid pattern. The molars have a strongly developed anterior parastylid which forms a very sharp ridge extending from the crown almost to the base of the tooth. The third lobe in $M\overline{3}$ is strongly developed, with a triangular to egg-shaped crown pattern, slightly flattened on the interior side, and having the larger end posterior. The crown pattern of the premolars is very simple, consisting of but three internal ribs separated by open valleys which do not reach down to the cingulum.

On the external side of the premolars just posterior to the median transverse crest lies a broad but pronounced depression extending from cingulum to crown. The antero-external side of the typical premolar is rounded and convex. Since considerable variation may occur in the crown pattern of $P\overline{4}$, that pattern may be of specific value. The variations in pattern of the transverse crests fall into three groups: (1) teeth with three simple transverse crests, (2) teeth in which an enamel infold splits the posterior crest into two small lobes, and (3) teeth in which enamel infolds split the anterior as well as the posterior crest into two lobes. Care should be taken to note the state of wear of the dentition, for the wear may be carried below the enamel infolds and in that way the splitting of the crests may be obliterated, as for example in No. 719 C.I.T., a worn specimen of *M. loxocerus* showing only three lobes.

A review of the literature reveals that where teeth have been found or described in definite association with horn-core material the following classification can be made on the basis of the structure of P$\overline{4}$.

3-lobed

| | | |
|---|---|---|
| U.C. 22507 | *M. necatus* | Barstow |
| L. A. Mus. coll. | *M. necatus* | Barstow |
| Cope (2 specimens) | *M. necatus* | Santa Fe |
| F:A.M. 31996 | C. (Subcosoryx cerroensis) | Santa Fe |
| C.I.T.(3 specimens) | *Merycodus sp.* | Avawatz Mts. |

4-lobed

| | | |
|---|---|---|
| F:A.M. 31020 | *M. coronatus* | Barstow |
| U.C. 19805 | *M. furcatus* | Cedar Mt. |

5-lobed

| | | |
|---|---|---|
| Cope (1 specimen) | *M. furcatus* | Santa Fe |
| C.I.T. 1301 | *M. loxocerus* | Tonopah |
| C.I.T. 1257 | *M. hookwayi* | Tonopah |

Also figured in the literature, but not definitely associated with horn-core material are the following:

3-lobed

| | | |
|---|---|---|
| A.M.N.H. 14109 | *M. necatus sabulonis* | Snake Creek |

5-lobed

| | | |
|---|---|---|
| Leidy type | *M. necatus* | Bijou Hill |
| Leidy 1869 | *M. necatus* | Niobrara |
| A. M. 20530 | *M. necatus sabulonis* | Sioux Co., Neb. |
| C.I.T. 60 | *Merycodus sp.* | Cuyama |

It should be noted that $P\overline{4}$ of the original type for the genus *Merycodus* and for the species *necatus* was described as a five-lobed form. It is the writer's belief that if topotype horn-core be ultimately found at Bijou Hill, it will not resemble what is now designated as characteristic *M. necatus* horn-core material.

With few exceptions, all of the members of the cervid family of horned ruminants illustrated by Frick have a five-lobed $P\overline{4}$. The exceptions are a few of the genera in the *Blastomeryx* division (*Parablastomeryx* and *Pseudoparablastomeryx*). Other groups which have complex or five-lobed crown-patterns in $P\overline{4}$ include Division Antilocaprini of the Antilocapridae Frick, and Family Bovidae Frick. In general, members of the families Protoceratidae, Hypertragulidae and Camelidae have simple crown-patterns for $P\overline{4}$, but some of them have split crests forming as many as four lobes.

Whether or not the simple three-lobed pattern is a basic type the writer is unprepared to state. If this is the fundamental pattern, it means that there has been parallel development in at least six different families to attain the complex five-lobed form. On the other hand, all of these forms may have sprung from a common ancestor with a five-lobed $P\overline{4}$. Simplification of the tooth-pattern in conjunction with the reduction of the premolars would then readily account for the four- and three-lobed forms which have been described.

Several of the mandibles in which M$\overline{2}$ is just erupting still retain the Dp$\overline{4}$. This milk tooth is short-crowned and consists of three major lobes with simple molar-form crown-pattern. Of these crescentic lobes the anterior is the smallest, being about one-half the size of the posterior lobes.

The material representing the appendicular skeleton is very fragmentary at best. The various phalangeal elements and extremities of the longer limb bones which have been preserved resemble very closely the corresponding parts in *Antilocapra americana*. Measurements indicate that the form from the Avawatz Mountains is slightly larger than *M. osborni* from Pawnee Creek, Nebraska (Matthew 1904) and *M.* near *necatus* from Ricardo, California. On the other hand, another series of specimens from the Ricardo and *M. necatus* from the Barstow formations slightly surpass the Avawatz material in size.

The single antilocaprid species from the Avawatz Mountains has been referred to *Merycodus* cf. *cerroensis* (Frick). In a recent publication (Frick 1937) the status of the genus *Merycodus* is questioned. Frick declares (p. 276, line 10), "The genotypic species, *Merycodus necatus* Leidy (1854), was based on fragmental and indefinitely characterized teeth from the Bijou Hills and remains indeterminate." He further states, "The Merycodontini are divided between three main -- *Ramoceros* n.g., *Cosoryx* Leidy and *Meryceros* n.g. --

and several minor groups......It is impossible as yet to determine which of these groups is represented by the lost type of Merycodus Leidy." Yet in at least three citations (pp. 292, 315 and 334), Frick expresses his conviction that Merycodus may "prove to be synonymous with" Cosoryx, and on two occasions (pp. 345 and 408) definitely refers to Cosoryx some material which was originally identified as belonging to the genus Merycodus. Not once does Frick suggest that material previously referred to Merycodus might actually belong to one of the major or minor groups of the Merycodontini other than Cosoryx.

Furthermore, Frick properly may be scored for his lack of judgment in handling the type genus as set up by Leidy. To be sure, the original type was very inadequately characterized in Leidy's description of material from Bijou Hill (Leidy 1854). A few years later, however, the same author without the slightest hesitation refers some excellent material from the Niobrara back to his original type (Leidy 1869). This material, more complete than the original type, Leidy described and illustrated in detail. It is to this later description that subsequent authors have turned again and again for the type species of the genus. Thus, though never formally defined as such, the material referred by Leidy in 1869 to the genus Merycodus is essentially the hypotype[1] of the genus.

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[1] Hypotype - a described or figured specimen, used in publication in extending or correcting the knowledge of a previously defined species. D. L. Frizzell, 1933.

A minor argument proposed by Frick in favor of dropping the genus Merycodus consists in the fact that at present the type material cannot be located. Obviously, the temporary misplacement or even the complete loss of a type specimen cannot render a genus invalid, though, indeed, it may make comparisons with the type somewhat more difficult. It must be borne in mind that "a generic category can have, in the final analysis, only a single type, which is a species, and not, as many have thought, a specimen;" (Schenk and McMasters 1936). It is important to recognize that the species, being intangible, is not lost and hence the genus Merycodus cannot be discarded. The only loss is the type specimen for the species. To rectify this, a neotype -- providing that more material can be located at Bijou Hill -- or a neoholotype[2] from another locality should be set up. It is the contention of the author that the material described by Leidy in 1869 fulfills just such a category.

While the above arguments for the retention of the genus Merycodus are acedemic at best, there exists one most potent practical factor in favor of retaining that generic name, namely, the weight of precedent and past usage. Only confusion of the literature can result from the substitution of Cosoryx for Merycodus.

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[2] Neoholotype - a new holotype selected by a subsequent worker in the event of loss of the original material. D. L. Frizzell, 1933.

Since the development of a long diastema and reduction of the premolars, both upper and lower, are regarded as progressive characters, the merycodont from the Avawatz Mountains must be reckoned as an advanced form. Its development of hypsodonty has reached also an advanced stage, being considerably more than that of the Barstow and Cuyama and slightly less than that of the Ricardo types. The value of the form of $P\overline{4}$ as an indicator of stage of advancement is uncertain. In position of the fronto-parietal suture, relatively close behind the horn-core pedicles, the Avawatz merycodont is definitely not so advanced as either the Barstow or the Ricardo form. Horn-cores similar to the Avawatz material have been found in both Ricardo and Barstow deposits (horizons unknown).

With all due consideration then to these determinative characters, the conclusion is reached that the merycodont from the Avawatz Mountains represents a species considerably more advanced than those from the Barstow and Cuyama and slightly less advanced than that from the Ricardo. In every way the form appears to be almost identical with *Merycodus cerroensis* (Frick) from Round Mountain Quarry, New Mexico.

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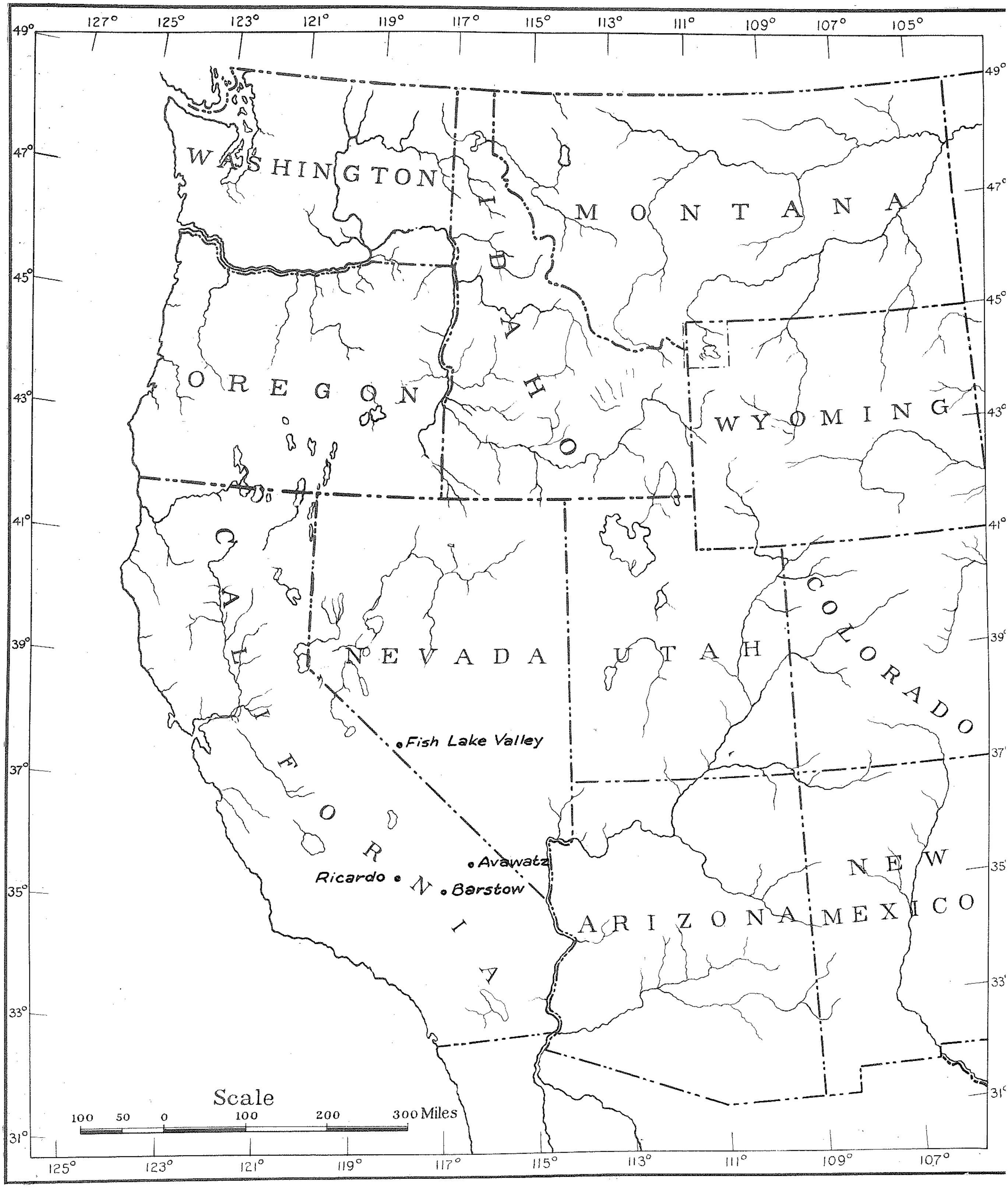
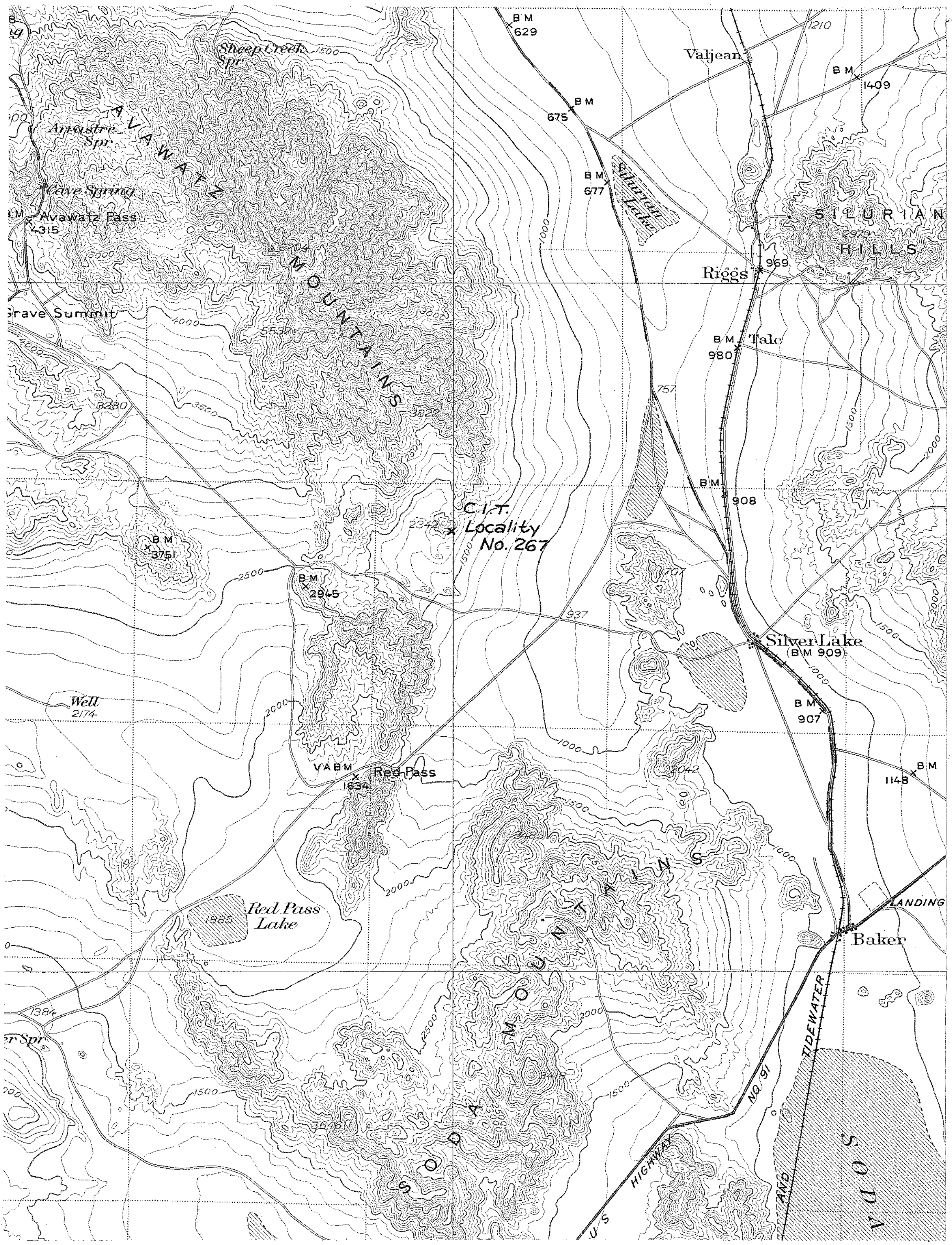
Plate I



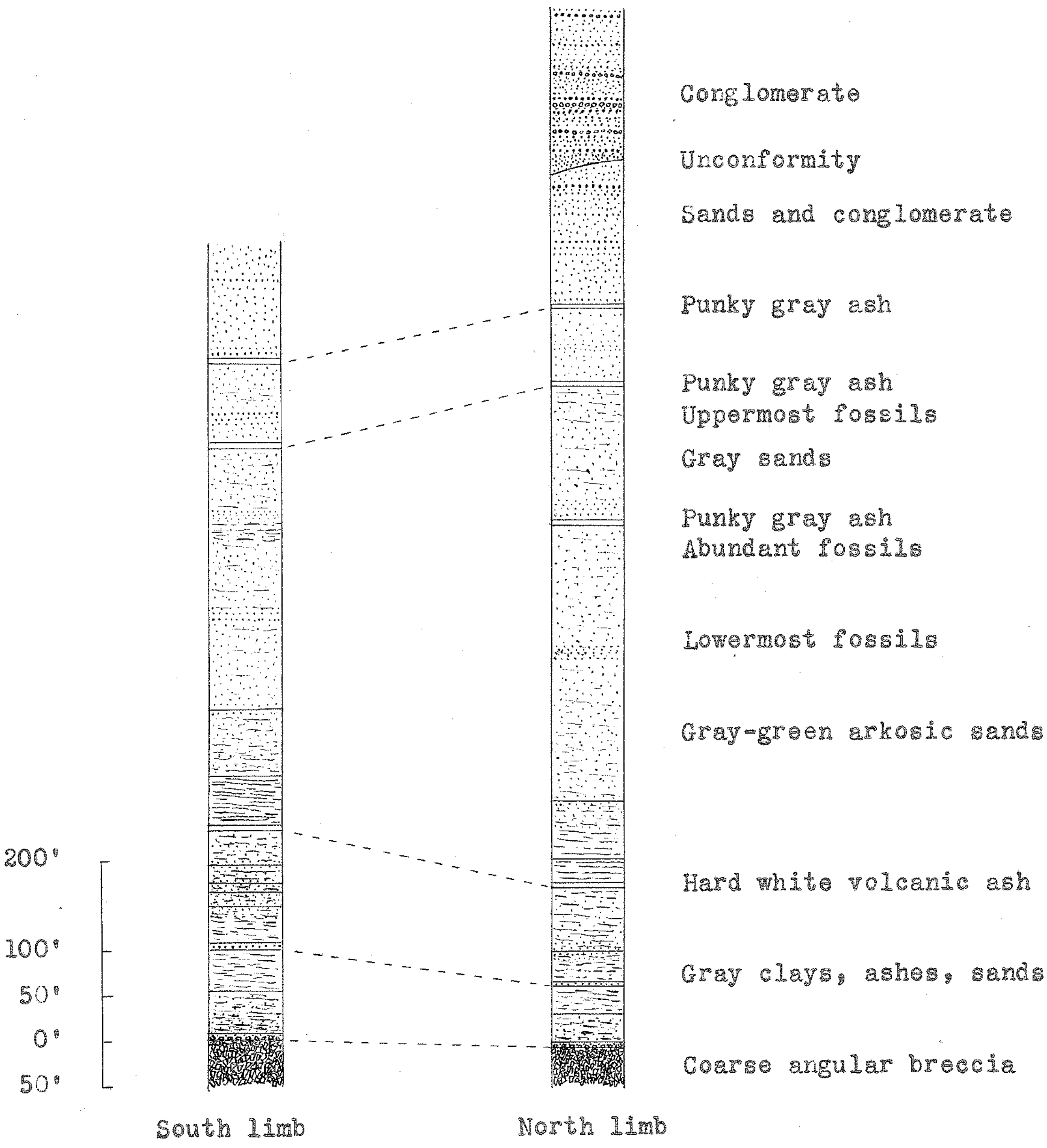
Location of upper Miocene and lower Pliocene vertebrate fossil localities of the western United States.

Plate II



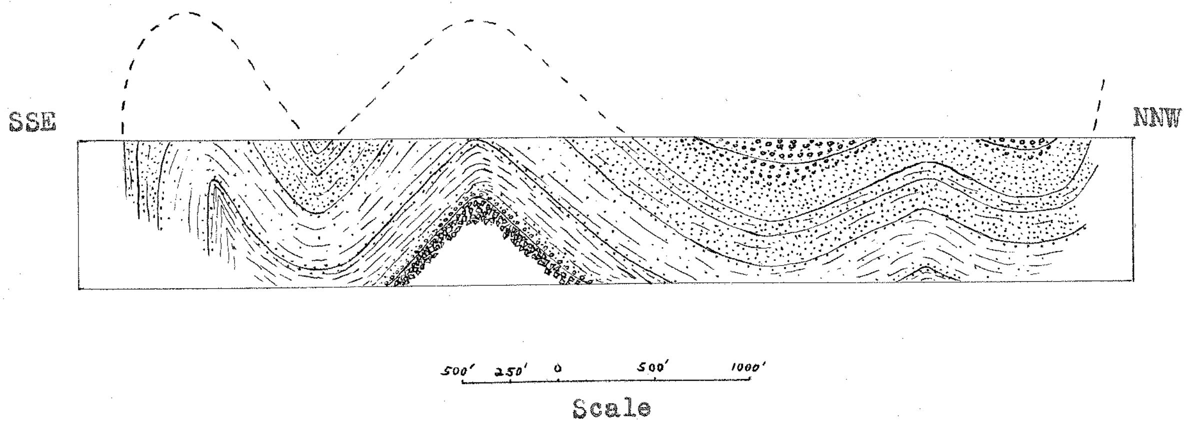
Southeastern portion of the U. S. Geological Survey Avawatz Mountains Quadrangle showing the location of the California Institute vertebrate fossil locality in the Avawatz Mountains.
Scale 1:250,000, contour interval 100 feet.

Plate III



Stratigraphic sections of the south and north limbs of the main anticline which passes through the fossil locality.

Plate IV



Section taken at N 20° W through the fossiliferous portion of the closely folded Avawatz formation. (Note: Since the structures here trend E-W, the actual folding of the sediments is even more acute than the apparent folding shown in the section.)

## PLATE V

Fig. 1 - *Pseudaelurus intrepidus* Leidy. No. 2309, left ramus, lateral view. x1.

Fig. 1a - *Pseudaelurus intrepidus* Leidy. No. 2309, left ramus, occlusal view. x1.

Fig. 2 - Canid, indet. No. 2308, right maxillary dentition, lateral view. x1.

Fig. 2a - Canid, indet. No. 2308, right maxillary dentition, occlusal view. x1.

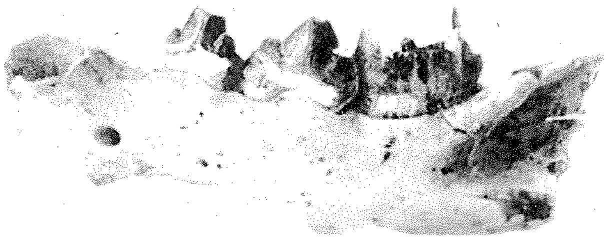
Fig. 3 - *Trilophodon* cf. *simplicidens* Osborn. No. 1984, mandible, occlusal view. x$\frac{1}{4}$.

Fig. 4 - *Pliohippus* (?) sp. No. 2313, lower incisors and canines, occlusal view. x1.

Fig. 5 - *Pliohippus* (?) sp. No. 2312, $M\underline{1}$, occlusal view. x1.

Plate V

$1^a$



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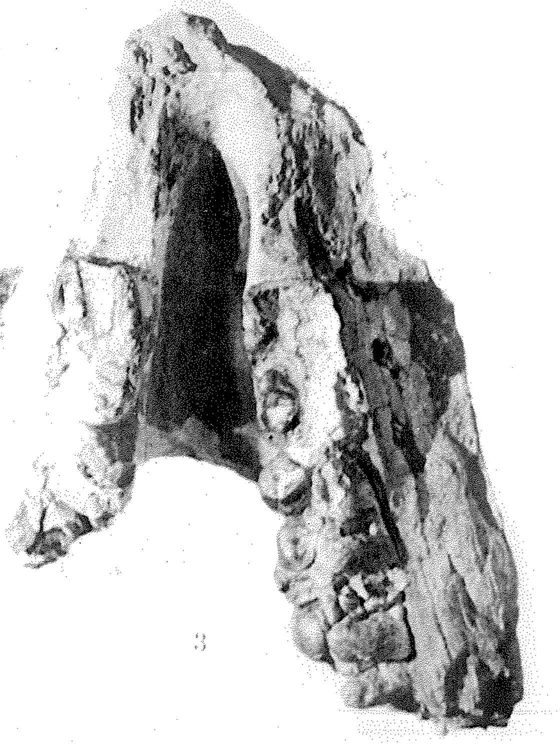

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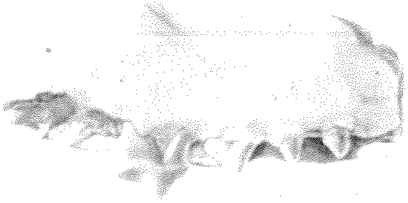

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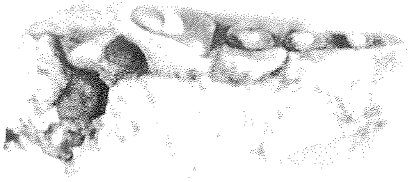


$2^a$

4

5

## PLATE VI

Fig. 1 - *Procamelus coartatus* Stirton. No. 1989, palate with dentition, occlusal view. x1.

Fig. 2 - *Procamelus coartatus* Stirton. No. 2316, right ramus, $P\overline{3}$ - $M\overline{2}$, lateral view. x1.

Fig. 3 - *Procamelus coartatus* Stirton. No. 2318, right ramus, $M\overline{2}$ - $M\overline{3}$, lateral view. x1.

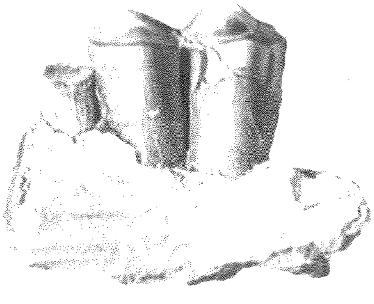
Fig. 4 - *Procamelus coartatus* Stirton. No. 2319, $Dm\overline{4}$, lateral view. x1.

Fig. 5 - *Procamelus coartatus* Stirton. No. 2317, $M\overline{2}$, lateral view. x1.

Fig. 6 - *Merycodus* cf. *cerroensis* (Frick). No. 1995, right maxillary dentition, $P\underline{2}$ - $M\underline{3}$, lateral view. x2.

Fig. 6a - *Merycodus* cf. *cerroensis* (Frick). No. 1995, right maxillary dentition, $P\underline{2}$ - $M\underline{3}$, occlusal view. x2.

6



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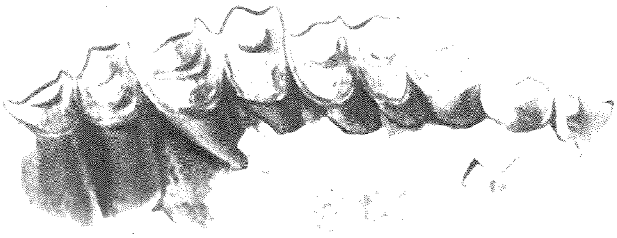

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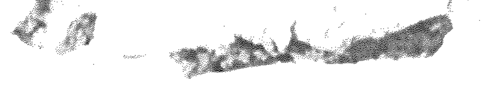

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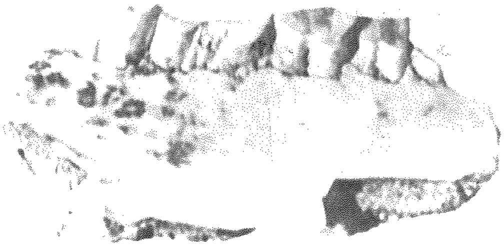

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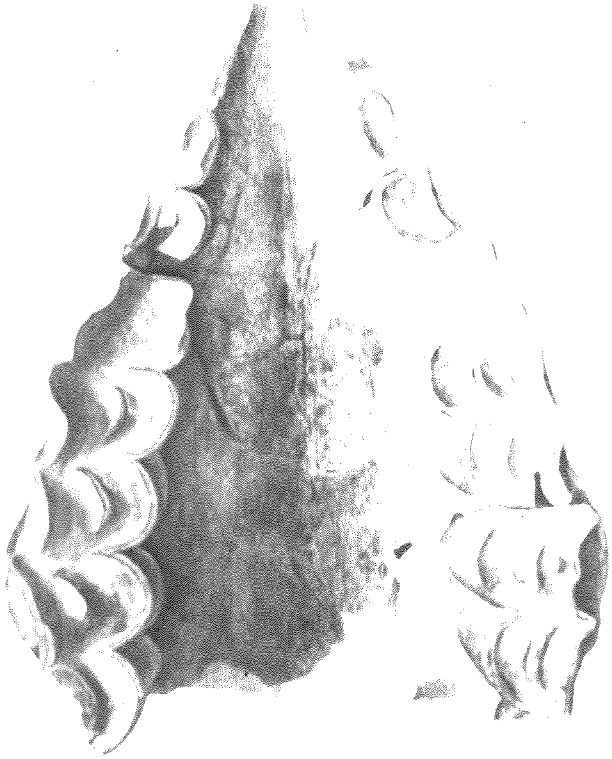

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1

# PLATE VII

Fig. 1 - *Procamelus coartatus* Stirton. No. 2324, proximal end of radius, anterior view. x½.

Fig. 1a - *Procamelus coartatus* Stirton. No. 2324, proximal end of radius, superior view. x½.

Fig. 2 - *Procamelus coartatus* Stirton. No. 2333, medial phalanx, anterior view. x½.

Fig. 3 - *Procamelus coartatus* Stirton. No. 2320, mandibular symphysis, ventral view. x½.

Fig. 4 - *Procamelus coartatus* Stirton. No. 2328, distal end of tibia, posterior view. x½.

Fig. 4a - *Procamelus coartatus* Stirton. No. 2328, distal end of tibia, inferior view. x½.

Fig. 5 - *Procamelus coartatus* Stirton. No. 2325, distal end of radius-ulna, anterior view. x½.

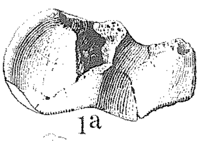
Fig. 5a - *Procamelus coartatus* Stirton. No. 2325, distal end of radius-ulna, inferior view. x½.

Fig. 6 - *Procamelus coartatus* Stirton. No. 2329, cannon bone, anterior view. x½.

Fig. 7 - Camelid, sp. No. 2336, distal end of tibia, posterior view. x½.

Fig. 8 - Camelid, sp. No. 2340, proximal phalanx, anterior view. x½.

Plate VII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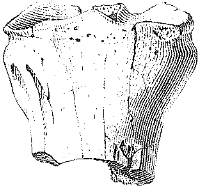
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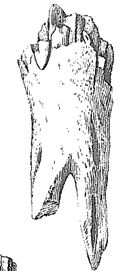
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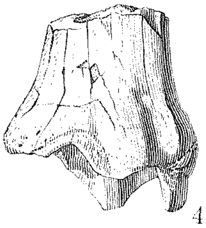
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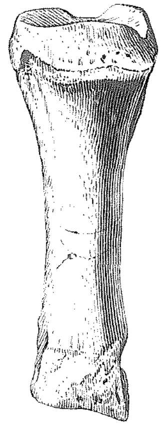
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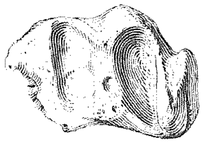
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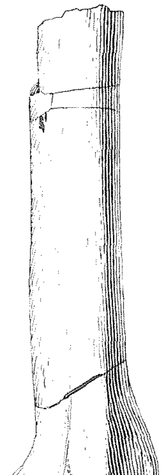
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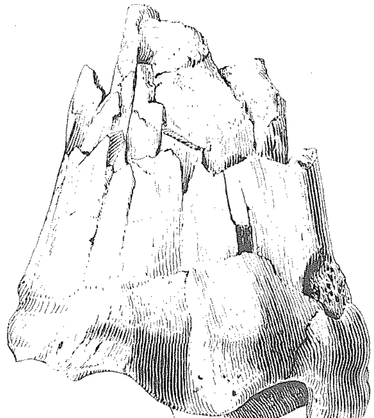
5a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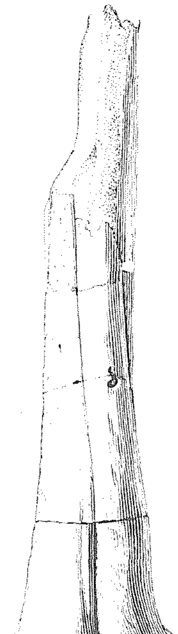
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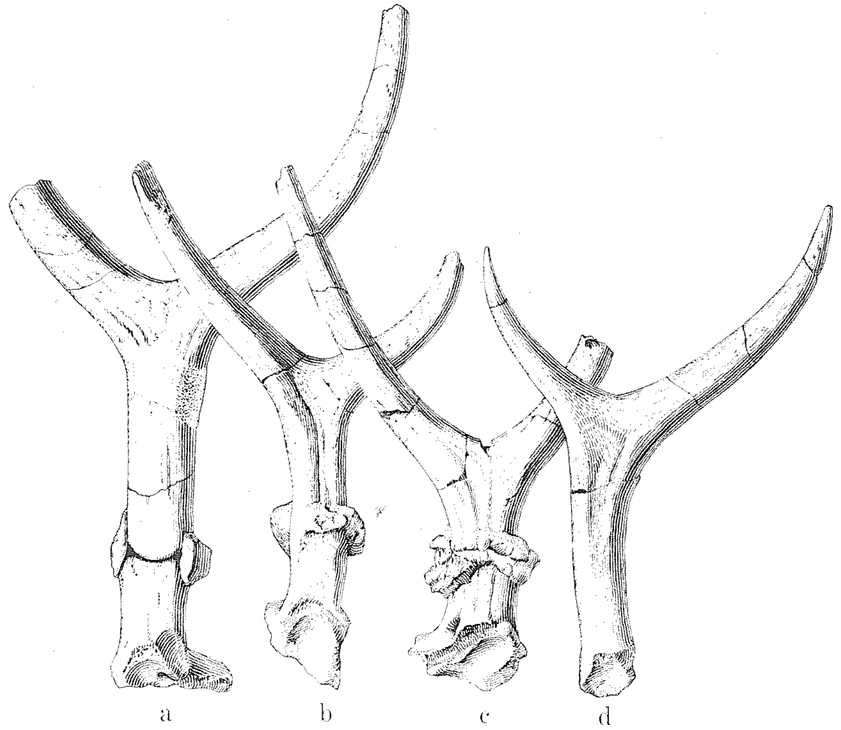
## PLATE VIII

Figs. a, b, c and d - *Merycodus* cf. *cerroensis* (Frick). Nos. 1991, 1992, 1993 and 1994, horn-cores, oblique view. x½.

Plate VIII



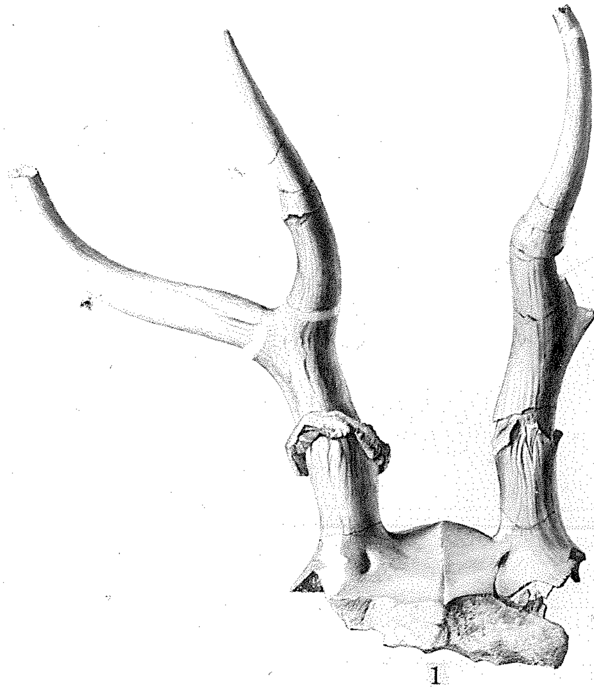
## PLATE IX

Fig. 1 - *Merycodus* cf. *cerroensis* (Frick). No. 1990, frontlet with horn-cores, anterior view. x$\frac{1}{2}$.

Fig. 2 - *Merycodus* cf. *cerroensis* (Frick). No. 1997, left ramus, P$\overline{2}$ - M$\overline{3}$, lateral view. x1.

Fig. 2a - *Merycodus* cf. *cerroensis* (Frick). No. 1997, left ramus, P$\overline{2}$ - M$\overline{3}$, occlusal view. x1.

Plate IX



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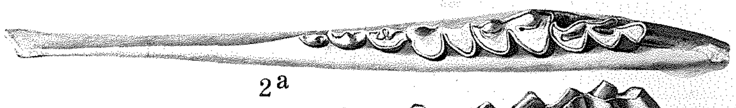
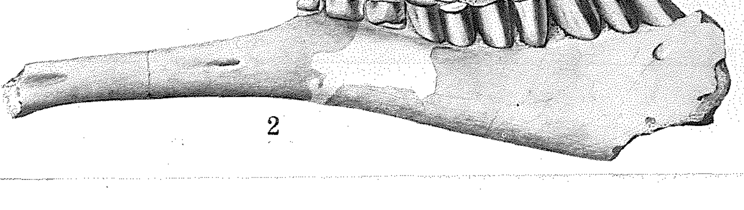


$2^{a}$



2

## PLATE X

Fig. 1 - *Merycodus* cf. *cerroensis* (Frick). No. 1990, frontlet with horn-cores, lateral view. x½.

Plate X