

CONTRIBUTIONS TO PALÆONTOLOGY

VI

THE FAUNA OF THE MERYCHIPPUS ZONE, NORTH
COALINGA DISTRICT, CALIFORNIA

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With two plates and ten text-figures

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THE FAUNA OF THE MERYCHIPPUS ZONE, NORTH COALINGA DISTRICT, CALIFORNIA

INTRODUCTION

The fauna from the Merychippus zone, north of Coalinga, California, was first described by J. C. Merriam¹ in 1915. The assemblage as listed by Merriam included four genera of land mammals, namely, *Merychippus*, *Prosthennops*, *Procamelus* and *Tetrabelodon*. As recognized by Dr. Merriam, the discovery of mammalian remains in the marginal marine series of California possesses particular significance in that it furnishes an important aid in determining the time relationships between the marginal marine deposits of the Pacific Coast and the continental formations of the Great Basin and Great Plains areas of North America. The present studies were initiated, therefore, with a view to enlarging the fauna from this horizon and to establishing more accurately the time relationships of the assemblage. Moreover, it seemed desirable to record information concerning the mode of accumulation of the fossiliferous deposits and of the ecologic conditions under which the fauna existed.

Field work was conducted by the California Institute of Technology from 1928 to 1932, with the exception of the summer seasons. Much of the fossil material on which the present report is based was obtained by the late E. R. Inglee, field assistant in palæontology at the California Institute. A study of the assemblage from the Merychippus zone was suggested by Dr. Chester Stock, to whom the writer is indebted for helpful criticism in the course of the investigation. Dr. R. D. Reed, Chief Geologist for the Texas Company in California, furnished valuable information regarding the stratigraphic position of the Merychippus zone in the marine Tertiary section exposed near Coalinga and correlated horizons in oil well sections of the north dome of the Kettleman Hills. The plates and illustrations of fossil specimens were prepared by Mr. John L. Ridgway.

LOCATION AND OCCURRENCE

The horizon from which the fossil material was obtained is located on Domengine Creek (see Plate 1, fig. 1), on the east flank of the Diablo Range, 12 miles north of Coalinga, Fresno County, California. The north dome of the Kettleman Hills lies approximately 25 miles to the southeast. The general course of Domengine Creek is perpendicular to the strike of the sediments, but at a point approximately 4 miles from its mouth, the stream turns and flows south along the strike for nearly one quarter mile, thence resuming its easterly direction. The

¹ J. C. Merriam, Trans. Amer. Philos. Soc., n. s., vol. 22, art. III, 1915.

fossiliferous beds comprising the Merychippus zone outcrop along this north-south course and the type locality occurs on the east bank of Domengine Creek at an elevation approximately fifty feet above its bed. The accompanying chart (fig. 1) shows the geographic location of Domengine Creek on the west side of the San Joaquin Valley and its position with reference to the Diablo and Temblor Ranges and to

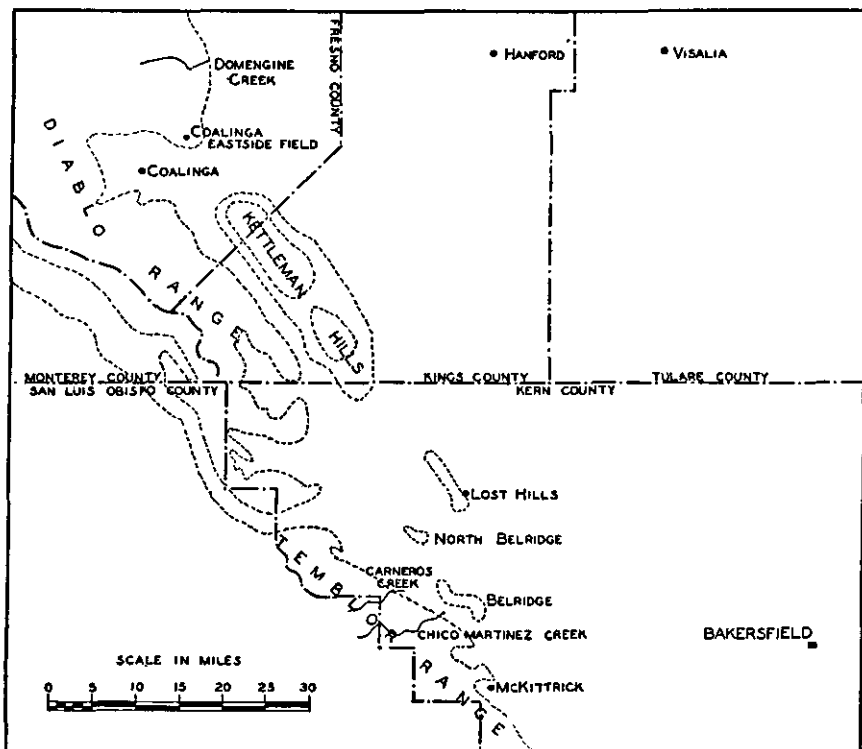


FIG. 1.—Map of portion of west side of San Joaquin Valley showing geographic position of Domengine Creek in relation to Coalinga and to various oil fields and surface areas with which stratigraphic correlations are made.

the several oil fields occurring between Coalinga and McKittrick. It is by means of correlations with the subsurface sections from these oil fields and the surface sections in the Diablo and Temblor Ranges that the stratigraphic position of the Merychippus zone is determined.

The original material described by Merriam from the Merychippus zone was obtained from sandstones and conglomerates, 2 to 3 feet in thickness, lying at the top of the so-called Miocene "Temblor" section on Domengine Creek and immediately below Miocene beds known locally as the "Big Blue." This field locality has been recorded in the catalogues of the California Institute of Technology as No. 108. The major portion of the material obtained by the Institute was

collected from pockets at this same stratigraphic level. In addition, however, a considerable quantity of material was collected at a point farther south along the strike of the beds and approximately twenty feet stratigraphically below the level of locality 108 (see Plate 1, fig. 2). This locality is known as No. 129. No differences have been noted between the two assemblages. The position of locality 129 in the series gives added reason for regarding the Merychippus fauna as occurring within the "Temblor" as indicated by Merriam, and not in the base of the Big Blue.

The underlying one hundred feet of sediments increase gradually in coarseness as they approach the Big Blue contact, the deposits changing gradually from alternating shales and fine sandstones to sandstones, and then to coarse sandstones and pebble conglomerate lenses. Throughout the upper twenty feet cross-bedding is visible in the sandstone. The three feet of sediments underlying the Big Blue consist for the most part of sandstones containing lenticular pebble conglomerates. Here lenses are numerous and give the false appearance of a continuous bed. Closer examination reveals, however, that none of them extends along strike for more than twenty feet. Their continuous appearance is due largely to their abundance. Excavations show that the average width of these lenses, down the dip, is usually equal to half their length along the strike, giving them a lateral ellipsoidal area with an elongation approximately in the direction of strike. Frequently small pockets of clay are found within and underlying the conglomerates. Clay pockets not associated with pebble lenses have also been observed. While fossil mammalian remains are found scattered throughout a hundred feet stratigraphically, the material becomes abundant only in the upper twenty feet. At this level the material is usually concentrated in the conglomerates and is most abundant at the top of the section. Here the number of horse teeth frequently exceeds that of the larger pebbles. Small concentrations of specimens have also been found in clay pockets not associated with the conglomerates. Fossil material has been found northward from the lower bend on Domengine Creek to a point where the fossiliferous strata disappear under the grassy mantle of the top of a ridge, a distance of nearly a thousand feet. Only scattered remains were found along the strike of the beds, on the south and west side of Domengine Creek. In this direction the conglomerate lenses disappear, leaving the Big Blue in contact with sandstones. The zone of maximum concentration has a lateral extent along the strike of approximately four hundred feet. Its extent in the direction of the dip of the beds is unknown.

With the exception of three horse rami, the material from the Merychippus zone consists entirely of scattered teeth and fragments of limb elements. But few of the teeth show signs of abrasion, although many of the specimens exhibit a tendency to shatter into many frag-

ments when removed from the matrix. The skeletal material, on the other hand, is usually so well rounded that few characters of taxonomic value are available. The relatively compact carpal and tarsal bones are the most numerous skeletal parts represented. In this collection the astragali far outnumber other elements. As with the teeth, the skeletal material is assignable principally to the Equidæ. Upper limb material is rare and is represented by one complete horse metapodial and a score or more of fragments of the articulatory portions. Among upper limb specimens, camel and horse are equally well represented, offering a point of contrast with remaining parts of the skeleton which belong chiefly to members of the Equidæ. Presence of rhinoceroses and of mastodonts is indicated by remains of cheek-teeth. No large limb material referable to these forms has been found. Bone material of large size is completely absent in the deposits, the larger fragments never exceeding a maximum diameter of four inches. Sharks teeth are plentiful and are associated with an occasional tooth fragment of the aquatic mammal *Desmostylus* in all the quarries. No skeletal parts of these forms have been found. Mud casts of a gastropod and of a lamellibranch were found in one of the fossiliferous pockets at locality 129.

FAUNA OF THE MERYCHIPPUS ZONE

The following species are now recognized in the collections from the Merychippus zone:

Carnivora:

- Tomaretus sp.
- Ælurodon sp.
- Amphicyon sp.
- Hemicyon? sp.

Rodentia:

- Monosaulax sp.

Proboscidea:

- Miomastodon or Trilophodon? sp.

Perissodactyla:

- Hypohippus sp.
- Parahippus brevidens Marsh
- Archæohippus mourningi (Merriam)
- Merychippus brevidontus Bode
- Merychippus californicus Merriam
- Rhinocerotid cf. *Apelops*

Artiodactyla:

- Prosthennops sp.
- Procamelus sp.
- Oxydactylus? or Alticamelus? sp.
- Miolabis? sp.
- Blastomeryx (*Dyseomeryx*) sp.

Marine vertebrates as follows:

- Cetacean remains
- Desmostylus cf. hesperus Marsh
- Selachian teeth
 - Carcharodon
 - Lamna
 - Isurus
 - Odontaspis?
 - Teleosts

FREQUENCY OF OCCURRENCE OF INDIVIDUALS

Individuals assigned to the species *Merychippus californicus* far outnumber all other forms in the fauna from the Merychippus zone, this species being represented in the collections by more than two thousand well-preserved cheek-teeth. At least five hundred additional teeth were discarded because of their fragmentary preservation, when the collections from the field were prepared in the laboratory. Moreover, many specimens, too incomplete to collect, were discarded in the field. According to E. R. Inglee the numerical relation of complete and incomplete teeth encountered to those actually shipped was well over five to one. It appears safe to assume that more than five thousand teeth were encountered during the progress of the excavations. On the basis of the scattered distribution of the teeth removed from the Merychippus zone, it seems likewise safe to assume that not all of the twenty-four cheek-teeth assignable to one individual are included in the collections. A reasonable estimate of the minimum number of individuals obtained may be placed at two hundred and fifty. The number of individuals indicated by third upper molars of the right side is one hundred and twenty. However, because of the teeth discarded and the probability that not all individuals in the collections are represented by the third molar, the former estimate is regarded as being nearer the actual number.

The number of individuals of species other than *Merychippus californicus* has been determined from the total number of teeth in the collections after taking into account the size, shape and stage of wear of all teeth occupying opposite but similar positions in the skull or mandible. The possibility of duplication of number arising from counts of lower and upper teeth actually representing the same individual has been taken into consideration.

With the exception of *Merychippus californicus* all other species in the collection are represented by less than one hundred teeth. The volume of rock excavated to obtain the present collection was well over a thousand cubic yards. Since the teeth were distributed rather uniformly through this volume and over an area of at least six thousand square feet, it seems likely that not many of the specimens belong to the same individual. In the case of all species the number of indi-

viduals is probably a minimum. However, since the same procedure has been followed for all forms and since the number of merychippine teeth greatly exceeds that of all other forms, the relative frequency of occurrence of all forms is considered to be essentially correct.

The accompanying chart (fig. 2) shows graphically the representation of individual groups, but for those mammals in which relatively few individuals per species are known, only the size of the family is shown.

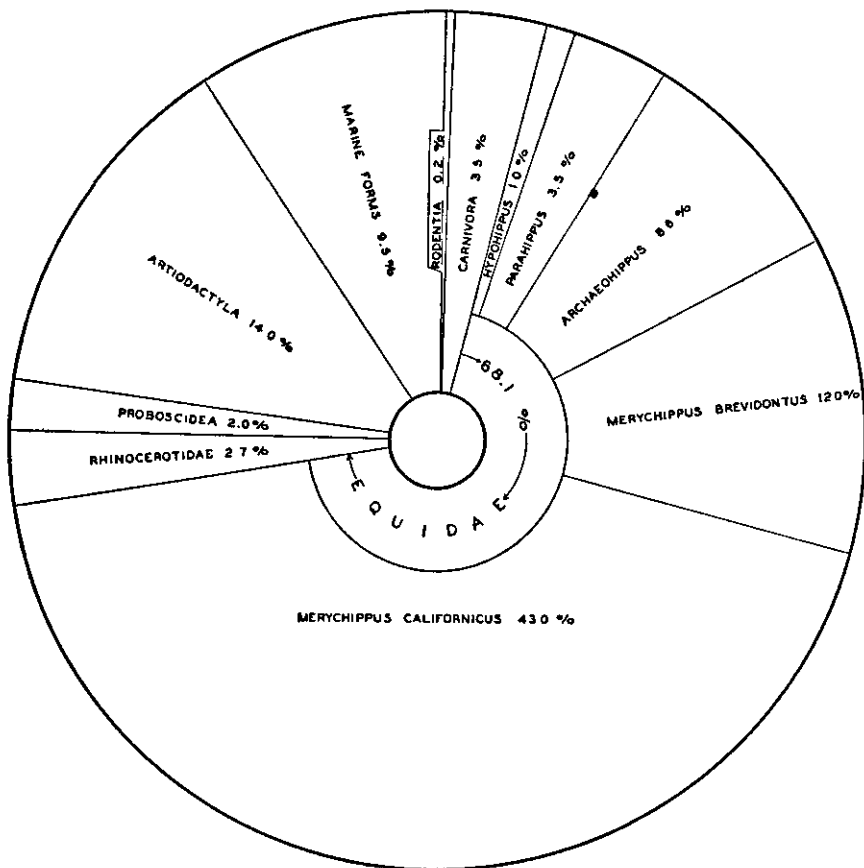


FIG. 2.—Chart showing percentage of frequency of occurrence of individuals in fauna of Merychippus Zone.

MODE OF ACCUMULATION

The relative abundance of sharks teeth and the presence of *Desmostylus* and of several other marine forms indicate the marine origin of the deposits containing the Merychippus zone. The preponderance of remains of land mammals, on the other hand, suggests that the accumulation took place in an area close to shore, at a locality where

fragments of these forms were readily obtainable. That the accumulation occupied a period of time of greater duration than a few years is suggested by the fact that the fossil material is found distributed throughout the upper hundred feet of the "Temblor beds" in the Domengine Creek section. The gradual increase in coarseness of the sediments, accompanied by a similar increase in concentration of fossil material toward the top of the section, may be interpreted as indicating the approach of a land area. The "Temblor" section on Domengine Creek has a thickness of four hundred and eighty feet. Six miles south, on the Coalinga anticline, this formation has a thickness of approximately six hundred feet.¹ In axial wells on the north dome of the Kettleman Hills the Temblor has increased in thickness to approximately fifteen hundred feet.² This southward increase in thickness suggests that the land area from which the material was derived lay to the north and possibly to the northwest. The northwest derivation of the material forming the Big Blue may be regarded as corroborative evidence.³

As previously mentioned, the fossil material occurs as scattered teeth and small fragments of limb elements buried in ellipsoidal conglomerate lenses. It would appear quite likely, from the nature of the occurrence, that the fossil material accumulated on a sandy surface of the sea floor over which were scattered more or less elliptical pebbly areas. Within the latter and especially at their bottoms occurred small concentrations of mud. These areas evidently lay in slight depressions on the floor. Apparently other small depressions contained only mud. Employing the terms defined by Twenhofel,⁴ the pebble conglomerates are composed of a heterogeneous mixture of pebbles, granules, varying sizes of sands, and small quantities of mud. The sediments exposed on the surface surrounding the pebble areas were comprised mainly of medium to fine-grained sands. The maximum diameter of the pebbles rarely exceeds one inch, although particles closely approximating this size are numerous in the upper three feet of the "Temblor" sediments. In the pebbly areas and infrequently in the few clay pockets, fossil vertebrate specimens were found lodged between pebbles or were buried almost entirely in the clay. Invertebrate fossils are absent.

As indicated by the presence of marine vertebrates, the surface on which the accumulation took place lay submerged beneath salt-water. The maximum strength of the currents during the period of deposition is indicated by the size of the largest pebbles. These pebbles probably were rolled along the bottom, coming to rest ultimately in shallow de-

¹ G. C. Gester and John Galloway, *Bull. Amer. Assoc. Petrol. Geol.*, vol. 17, 1180, 1933.

² G. C. Gester and John Galloway, *op. cit.*

³ Robert Anderson and Robert W. Pack, *U. S. Geol. Surv. Bull.* 603, 83, 1915.

⁴ W. H. Twenhofel and Collaborators, *Treatise on Sedimentation*, The Williams and Wilkins Co., 155 pages, 1926.

pressions on the sandy floor. The clay or mud within the gravels may be regarded as material caught and protected from further movement after sinking through the interstices between the pebbles and coarse sands. Fossil material rolled along the bottom would also become lodged between the pebbles and thus resist further movement. The presence of fossils of slightly greater size than the pebbles may be accounted for by the lower density of this material.

In reviewing the types of deposits under which the *Merychippus* zone may have accumulated, at least four possibilities present themselves. These may be indicated, with regard to the environmental conditions under which they are formed, as littoral, marginal lagoon, estuarine, and delta accumulations.

The stratigraphic position of the *Merychippus* zone at the top of the "Temblor," the type and distribution of the sediments, and the thickness of the deposit may be regarded as indications favoring a littoral origin of the deposits. However, several features are opposed to this type of origin of the *Merychippus* zone. While the absence of marine invertebrate fossils may have no significance, it seems more probable from the presence of other marine forms, that shell fragments would have been in evidence if the concentration north of Coalinga occurred under littoral conditions. The deposits laid down under a littoral environment are largely the result of wave action. Lack of abrasion of most of the fossil teeth from the *Merychippus* zone, some specimens preserving intact their long thin roots below the base of the crown, and the perfect preservation of the delicate structures of small teeth as in *Archæohippus* are some features of the organic remains which appear to mitigate against the postulate of accumulation on a wave-pounded beach. Moreover, it is difficult to conceive of large concentrations of fossil specimens (horse teeth sometimes outnumbering the pebbles), as forming on a beach.

A "marginal lagoon" is a body of water partially separated from the sea by a bar or barrier beach. Sediments from the land are brought in by fresh water and those from the sea by tidal currents. The water is usually salty. This type of environment might be regarded as favorable for the accumulation of sharks teeth and remains of land mammals. However, in a marginal lagoon the waters are quiet and as they periodically receive new sediments brought in by tides, the deposits become well stratified at the time of accumulation. The stratification of lagoonal deposits is even and regular and the sediments consist for the most part of fine mud and silts. Remains of invertebrates are usually abundant. These characteristics are not in accord with those exhibited by the deposits of the *Merychippus* zone.

Estuarine deposits are laid down in an enlargement of a river channel near its mouth, when the latter has been drowned through coastal subsidence. Tidal currents are commonly more active here

than along the shores of the open sea, resulting in much scouring of the bottom. Remains of strictly marine invertebrates are uncommon. The sediments riverward are usually sands and silts, while those seaward are not unlike marine deposits. The intermediate estuarine area may have a bottom quite similar in appearance to that which probably prevailed in the locality of the Merychippus zone. With the exception of the absence of evidences of scoured channels, the deposits north of Coalinga present no other characteristics opposed to those seen in the bottom of estuaries. However, an estuary, primarily resulting from a subsidence of the coast, is in direct opposition to the probable conditions obtaining in the vicinity of the Merychippus zone during the time represented by the upper part of the "Tembler."

On the other hand, the deposits at the Merychippus zone present no characters serving to distinguish them from those of delta deposition. Delta deposits are divided into four classes;¹ the topset beds of the subaerial plain, the topset beds of the subaqueous slope, the deposits of the foreset slope, and the bottomset beds beyond the foreset slope. Sediments of the first two are characterized by sands and clays with gravel uncommon in the first. The bottomset deposits are similar to those deposited entirely under marine conditions.

Both river and marine waters are concerned with the deposition of sediments on the foreset slope, the former adjacent to the ends of river distributaries and the latter over the intervening areas. The coarsest materials of the delta are found here. These are usually deposited with an initial inclination, although the angles of inclination are usually low in large bodies of water. The upper portions of the foreset beds are deposited above wave base and the lower portions may be below that level. In turbid waters, marine organisms may be absent. The sediments of the foreset slope are poorly sorted but stratified, in contrast to evidence of scour channels seen in the subaqueous topset beds. The rather uniform stratification of the last hundred feet of the "Tembler" on Domengine Creek, the gradual increase in coarseness toward the top of the section, the uniformity of size of the pebbles and of their disposition along the strike, the presence of cross-bedding, the association of fossil types, the lenticular disposition of the conglomerates, are all in accord with this type of deposition. As judged in the light of the characters mentioned above, the Merychippus zone may be interpreted as an accumulation which took place in the subaqueous beds of a large river.

The subaqueous region of a delta deposit appears to account for all the characteristics of occurrence exhibited by the fossil material at the vertebrate localities north of Coalinga. The scene of deposition may be visualized as the region in front of the mouths of distributary

¹ W. H. Twenhofel, *op. cit.*, 591-595.

streams and below the level of the sea, with a total area of accumulation whose width approximated one thousand feet, with a central area in which most of the material was concentrated within a width of approximately four hundred feet. The marine water above accounts for the presence of the shark teeth and other forms. The constant movement of sand and pebble particles along the bottom afforded the probable agent preventing population by marine invertebrates. The currents of the river over the subaerial part possessed a maximum strength capable of bringing pebbles up to one inch in diameter to the scene of accumulation. Within the areas of accumulation the water had sufficient strength to continue movement of the pebbles, but as these progressed seaward, less and less movement occurred. The specific areas of pebbles resulted from a trapping of this sedimentary material in shallow depressions from which the currents were unable to remove it. Clay, silt and slightly coarser particles, on sinking into the interstices between the pebbles, were thus protected from further movement. In like manner, isolated teeth and fragments of bones of land mammals were rolled seaward along the bottom. When a tooth or fragment became lodged between pebbles, it was able to successfully resist further movement. As the pebbly areas were built up, obstructions were developed which hindered for a time a seaward movement of the finer material behind them. Eventually, however, a stage was reached where the fine sediments washed over and buried the gravel areas, protecting them from further disturbance. A new depression to the side or behind probably originated by this action with consequent initiation of a new cycle of accumulation.

The lower density of the teeth and especially of the bone material accounts for their larger size in comparison with that of the pebbles. As mentioned under occurrence, the teeth rarely show signs of rounding, many of the specimens still possessing all of their root portions. Transportation with rock material for a considerable distance would certainly be expected to remove all signs of the more fragile structures. This feature is suggestive of a relatively gentle process of transportation and seems to indicate that the river bringing down the material carried very little large material. This type of stream is generally characteristic of a country well covered by vegetation. The angularity and excellent preservation of the teeth indicate further that in all probability many of the teeth did not fall from the individual jaw or skull, to which they belonged, until these organic remains had reached a position close to the area of burial. The skeletal elements are nearly always rounded. This is to be expected, for after lengthy immersion bone is considerably softened, whereas teeth retain their hard structure for a much longer period of time. The rounding of the bone fragments is thus probably due as much to long immersion before burial as to abrasion during transportation.

None of the limb bones are complete, and large elements belonging to such forms as a mastodon or rhinoceros are entirely lacking. Skulls are also absent. These large skeletal parts were probably too heavy for transportation and were thus forced to lie upstream until disintegration developed fragments small enough to be transported.

The organic remains were probably acquired originally by the river as material washed from its sides and from tributaries. This appears to be a normal process, since animals frequently die near or immediately adjacent to stream courses. Unlike the case observed by Matthew¹ in his study of *Merychippus primus* from the Sheep Creek horizon of western Nebraska, the equine teeth from the Merychippus zone of California do not show ontogenetic stages of wear. Seasonal floods are thus insufficient to account for the acquisition of the material; rather does the acquisition appear to have been a continuous process. The type of deposit and its thickness suggest that the material required a period considerably longer than a brief span of years to be concentrated.

ENVIRONMENT OF FAUNA

While the merychippine horses were unquestionably the most prevalent mammals in the fauna of the Merychippus zone, their presence does not necessarily point to the existence of a wide-spread plain or steppe environment. These forms, in contrast to their living descendants, possessed quite clearly a number of more primitive structural characteristics in skull, skeleton and dentition, in which respect they were less favorably adapted to open country and to a diet comprised chiefly of gritty grasses. As a matter of fact, the hyposodont horses of to-day exist not only on the desolate plains of central Asia but are found also in open wooded country of South Africa and in the Himalayas. Thus a wooded region with interspersed grass-covered areas may be postulated as an environment particularly advantageous to the development of large numbers of merychippine horses.

In this connection it is significant to recognize likewise the presence and diversity of the brachyodont horses in the fauna. Among the latter, *Hypohippus*, with its broad feet and brachyodont teeth, seems well adapted to life in a wooded environment. *Parahippus*, with teeth similar to those of *Hypohippus*, was probably also a browsing type. *Archæohippus* may well have occupied an environment similar to that of the present day deer, forms more typical of wooded areas than of a plains environment. On the other hand, *Archæohippus* with its slender limbs can hardly be regarded as having a range restricted to small tree-covered areas along stream courses. Similar suggestions

¹ W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 50, 162-166, 1924.

are offered by members of the camelidæ and by *Dyseomeryx*. These are all brachydont forms, whose habits are presumably akin to modern types occupying large wooded areas.

The presence of rhinoceroses is not necessarily indicative of swampy ground since two of the living Indian species and both of the African forms are found in wooded areas adjacent to grassy plains. The living types feed on grasses and on the leaves of small shrubs and young trees. Judged in the light of its long limbs and brachydont teeth, *Aphelops* may have occupied a habitat featured by an open forest and its floral association including an undergrowth of grass.

The Proboscidea as represented in the fauna by the mastodonts were without much question browsing forms. Like the rhinoceroses, brachydont horses and camels, these forms were certainly not restricted to small tree-covered areas adjacent to stream courses.

The type of environment as here conceived readily admits of the presence of peccaries. The character of the carnivore assemblage suggests a plentiful food supply. Doubtless these forms found ample opportunity to stalk their prey.

Comparison of the fossil assemblage with a characteristic living assemblage of South Africa tends to emphasize the essentially normal numerical representation of individual types in the former. The large number of individuals of the Equidæ obtained from the Merychippus zone may be misleading from the standpoint of actual representation of these mammals in the contributing area. It is quite probable that these forms were abundant on the land areas, but it must be remembered also that the structure of an equine tooth is such as to withstand better the vicissitudes incident to burial than that of teeth of many other types. In addition, the protohippine horses may have been more susceptible than other forms to the processes which brought about their ultimate entombment in the record.

The fauna regarded as a unit suggests the presence of wooded country with sufficient ground-cover of grass to be attractive to both browsing and grazing types. An analysis of the fauna gives no special reason for recognition of a highly variable external environment. In view of the mobility of the types occurring in the fauna of the Merychippus zone, this assemblage doubtless furnishes a representative cross-section of the regional life of that time.

Additional information concerning the climate and vegetational cover of this region of California during Temblor time may be drawn from the fields of invertebrate palæontology and palæobotany. Thus Kleinpell¹ has pointed out that the foraminifera of the Temblor sea indicate warm and almost tropical conditions. Warm water during this period is indicated also by the megafossil fauna.

¹ R. M. Kleinpell, paper on *A Proposed Biostratigraphical Classification of the California Miocene*, presented at a meeting of the Micropaleontological Society in Los Angeles, Nov. 1933.

According to Chaney¹ the fossil floras of western North America indicate rather uniform climatic conditions during the Miocene. Chaney considers the Mascall flora and its equivalents as related to the oak-madrone forests of California, where topographic conditions of low relief have no particular influence upon a vegetation resulting from a rainfall of approximately thirty inches.

STAGE OF EVOLUTION AND RELATIONSHIPS OF FAUNA

On the basis of present age-determinations of Tertiary vertebrate horizons in western North America, the Merychippus zone assemblage may be regarded as late middle Miocene in age. In its stage of evolution and in its relation to faunas of the Great Basin Province, the Merychippus zone occupies a position intermediate between the upper Miocene Barstow of the Mohave Desert and the middle Miocene Mascall of eastern Oregon. The Virgin Valley and Skull Spring faunas of north-western Nevada and eastern Oregon, respectively, are currently regarded as approximately equivalent to the Mascall and their relationship to the fauna from the north Coalinga district is approximately comparable to that which the Mascall bears to the latter. The Merychippus zone fauna represents an intermingling of genera found either in the Barstow or in the Mascall. In general, the more progressive Mascall forms are found also in the horizon north of Coalinga. Likewise, types having affinities with Barstow species are usually found to be related to the more primitive forms in the fauna from the Mohave Desert. This relationship is particularly interesting in view of the fact that the Barstow fauna is distinctly advanced beyond that of the Mascall.

The Equidæ afford an excellent illustration of this intermediate position on the part of the fauna from the Merychippus zone. *Parahippus brevidens* is a species commonly occurring in the Mascall but not found in the Barstow. The Coalinga *Hypohippus* is considerably smaller than that found in the Barstow. However, the *Archæohippus* material from the Merychippus zone is clearly distinct from the Mascall species, *A. ultimus*, and is specifically inseparable from the Barstow form, *A. mourningi*. Within the Merychippus group the small species, *M. brevidontus*, is found also at Skull Spring and Virgin Valley. *M. brevidontus* represents a more primitive species than any of the Barstow forms. Among two thousand teeth representing the species *Merychippus californicus* a considerable number present characters which are indistinguishable from those of *M. isonesus* of the Mascall. An equal number of these teeth, on the other hand, possess characters identical with those of *M. sumani* from the Barstow. Thus the characters displayed by this species reflect the intermediate

¹R. W. Chaney, Carnegie Inst. Wash. Pub. No. 349, 25, 1925.

position of the fauna. The primitive Mascall species, *M. severus* and *M. relictus*, are absent from the Coalinga fauna, as is also the progressive species *M. intermontanus* which is characteristic of the Barstow.

Among the carnivores the *Amphicyon* material is close to *A. sinapius*, a species recognized in the Mascall fauna. *Amphicyon* has not been recorded from the Barstow. *Tomarctus* from the Merychippus zone is not clearly distinguishable from either the Mascall or Barstow types. The presence in the Coalinga fauna of a large dog referred to the genus *Æluroidon* and similar to *A. wheelerianus* from the Santa Fé, is another indication of Barstow affinities. *Æluroidon* is a more progressive form than related canids from middle Miocene horizons of the northwest. *Hemicyon* has not been recorded from the Mascall or Virgin Valley. However, a single upper carnassial from Skull Spring has been identified as belonging to this form. A lower molar from North Coalinga is comparable to the corresponding tooth of *Hemicyon barstowenses* from the Mohave Desert horizon.

The mastodont teeth, referred questionably to *Miomastodon* or *Trilophodon*, are similar in size to specimens from Virgin Valley. The proboscidean material from the Barstow is noticeably larger, although the difference in size may have no special significance.

Among the Artiodactyla, the camels offer some indication of the intermediate position of the Merychippus zone fauna. The largest of the Coalinga forms is comparable in size to the smallest members of the group referred to *Procamelus* from the Barstow.

Curiously, the genera *Dromomeryx* and *Merycodus*, although found in the Barstow assemblage and in the middle Miocene faunas of northwestern Nevada and eastern Oregon, are absent in the Merychippus zone. Possibly ecological conditions are responsible for this absence at the Coalinga locality.

A detailed comparison of the Merychippus zone fauna with the more important Miocene assemblages of the western Great Plains is unsatisfactory, due to incompleteness of information regarding a number of species occurring in the California horizon. On the basis of the stage of evolution of the Equidæ from the "Temblor" beds, this horizon represents an advance beyond the Sheep Creek or *Merychippus primus* zone of western Nebraska. The lower Snake Creek fauna differs from that of the Merychippus zone in the absence of *Æluroidon* and the presence of more progressive camels.

STRATIGRAPHIC POSITION IN MARINE TERTIARY SERIES

The type Temblor section described by F. M. Anderson¹ is located on Carneros Creek on the west side of the San Joaquin Valley northwest of the town of McKittrick. A similar section, also used for corre-

¹ F. M. Anderson, Proc. Calif. Acad. Sci., 3d ser., vol. 2, 156-247, 1905.

lation purposes, is found on Chico-Martinez Creek a few miles farther south. At these localities, the top of the Temblor was placed by Anderson at the top of the so-called "Button Bed" sandstone. The Temblor is also somewhat loosely regarded as a stage name for beds containing the mollusk *Turritella ocoyana*. However, *T. ocoyana* has been reported from beds thought to be stratigraphically higher than the "Button Bed" on Carneros Creek,¹ and its value as a marker fossil for the Temblor is thus questionable.

The next higher stage is the Monterey, deposits so called being regarded as equivalent to beds found in the type section on the Monterey Peninsula. At the base of the type section occurs the foraminiferal zone characterized by *Valvulineria californica*, one of the most wide-spread microfaunal zones known in the Coast Ranges of California.

At Chico-Martinez Creek and the type Temblor Section on Carneros Creek, the top of the Button Bed sandstone is separated from the base of the *Valvulineria californica* zone by two hundred and fifty feet of shales which Cunningham and Barbat called the Gould shale.² It is with reference to the Gould shale that that part of the Kettleman Hills' section, containing beds regarded as equivalent to the Merychippus zone, are correlated.

On Domengine Creek the beds assigned to the "Temblor" have a thickness of approximately five hundred feet. These beds lie unconformably above sandstones containing the "Leda zone" of the Kreyenhagen Group. The section is composed for the most part of alternating shales and sands increasing in coarseness toward the top of the section and containing the following recognizable units: (1) A thin zone of black or coaly clays sixty feet above the base. (2) A reef bed containing *Scutella merriami*, one hundred and sixty feet above the top of the coaly clay member. (3) White siliceous and diatomaceous shales fifteen feet in thickness, the "Indicator" bed of Arnold and Anderson,³ forty-five feet above the top of the reef bed. The indicator bed may be traced southward across the Coalinga anticline. (4) The conglomerates containing the vertebrate fossils, one hundred and twenty feet above the indicator bed. (5) The overlying Big Blue is a large lens with a lateral extent of approximately twenty miles. This member is unusual in view of the fact that throughout most of its extent it consists of a compact mass of fine detritus made up of dust, flakes and pebbles of serpentine and, at some localities, conglomerates composed almost entirely of serpentine boulders. On Domengine Creek the Big Blue has a thickness of nearly two hundred and fifty feet. It is unconformably overlain by beds of upper Miocene, Santa

¹ R. D. Reed, *Geology of California*, Pub. Amer. Assoc. Petrol. Geol., 219, 1933.

² C. F. Cunningham, and W. F. Barbat, *Bull. Amer. Assoc. Petrol. Geol.*, vol. 16, 417-421, 1932.

³ R. Arnold and Robert Anderson, *Bull. U. S. Geol. Surv.* 398, 81-82, 1910.

Margarita age. North of Domengine Creek, in the vicinity of Salt Creek, the Big Blue attains a maximum thickness of more than one thousand feet. In a southerly direction it varies in thickness from two hundred to forty feet and finally lenses out on the south flank of the Coalinga anticline, north of Coalinga.

In the vicinity of Oil Creek between Coalinga and Domengine Creek, Galloway¹ reports the presence of *Turritella ocoyana* in beds stratigraphically higher than the base of the Big Blue at the Merychippus zone locality. According to Reed,² north of Domengine Creek sandstones containing *T. ocoyana* are found overlying the Big Blue. Anderson and Pack³ state that the fauna of the marine beds underlying the typical serpentinous shale occurs also in sandy beds interstratified with or overlying the Big Blue. The Big Blue and the underlying Merychippus zone are thus placed within the stratigraphic range of *Turritella ocoyana*.

The Domengine Creek section can be correlated with sections on the Coalinga anticline, which in turn are correlated with those penetrated by oil wells on the north dome of the Kettleman Hills.

Correlations of oil well sections from the north dome of the Kettleman Hills with the surface sections on Carneros and Chico-Martinez Creeks are made by means of successive comparisons southward of oil well sections from the south dome of the Kettleman Hills, the Lost Hills, North Belridge and Belridge oil fields.

The following chart (fig. 3) attempts to show this correlation. The data for the Domengine Creek section are based on observations by the writer, as well as from the section illustrated by Merriam⁴ and from information furnished by Reed.⁵ Information concerning the Coalinga anticline was derived from Reed's *Geology of California*.⁶ Data for the Kettleman Hills were furnished by Dr. Reed and were obtained also from correlation charts illustrating the geology and stratigraphy of the area by Gester and Galloway, and by P. P. Goudkoff.⁷ The Carneros-Chico Martinez Creek composite section was obtained from charts published by Goudkoff.⁸ A correlation of the coaly clay member in the Domengine Creek section with the "lower variegated" in the Kettleman Hills and the base of the Big Blue with the base of the "upper variegated" was suggested by Dr. Reed.⁹ The correlation of the base of the Big Blue with the "upper variegated" also follows

¹ John Galloway, Paper presented before Amer. Assoc. Petrol. Geol., Los Angeles, Nov. 1933

² R. D. Reed, personal communication.

³ Robert Anderson and Robert W. Pack, *op. cit.*, 83, 1915.

⁴ J. C. Merriam, *op. cit.*, 5, 1915.

⁵ R. D. Reed, personal communication.

⁶ R. D. Reed, *op. cit.*, 1933.

⁷ G. C. Gester and John Galloway, *op. cit.*, 1169 and 1180, 1933; P. P. Goudkoff, *op. cit.*, 435-475, 1934.

⁸ P. P. Goudkoff, *op. cit.*, 1934.

⁹ R. D. Reed, personal communication.

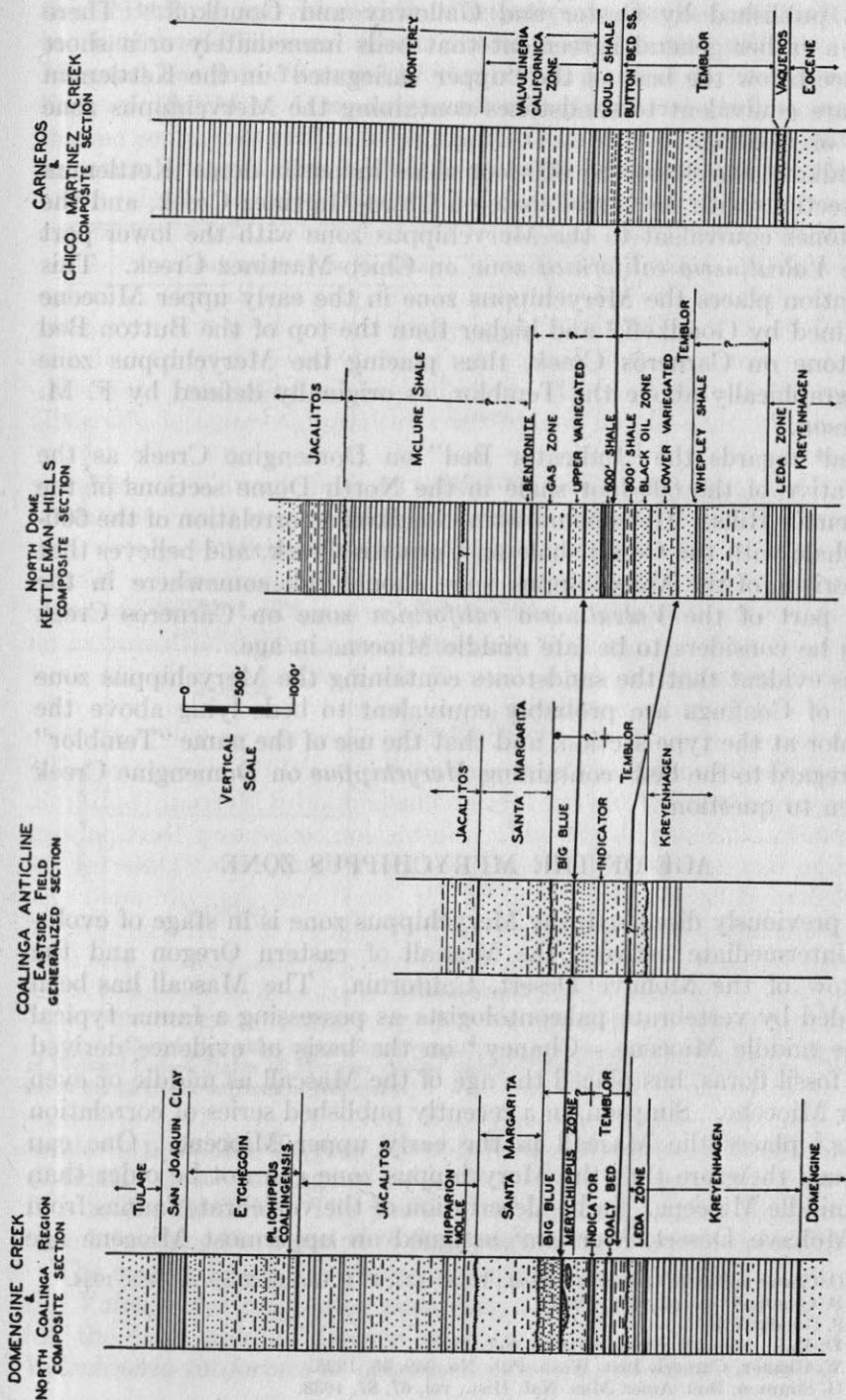


FIG. 3.—Correlation chart showing position of Merychippus Zone in Tertiary section on Domengine Creek and its relation to a generalized section from Coalinga eastside oil field, a composite section from north dome of Kettleman Hills, composite section representing sequence of strata at type Temblor section on Carneros Creek and portion of Miocene section at Chico-Martinez Creek.

charts published by Gester and Galloway and Goudkoff.¹ There exists a rather general agreement that beds immediately or a short distance below the base of the "upper variegated" in the Kettleman Hills are equivalent to sandstones containing the *Merychippus* zone north of Coalinga.

Goudkoff² correlates the 600-foot shale in north dome Kettleman Hills sections with the Gould shale on Chico-Martinez Creek, and the sandstones equivalent to the *Merychippus* zone with the lower part of the *Valvulineria californica* zone on Chico-Martinez Creek. This correlation places the *Merychippus* zone in the early upper Miocene as defined by Goudkoff,³ and higher than the top of the Button Bed sandstone on Carneros Creek, thus placing the *Merychippus* zone stratigraphically above the Temblor, as originally defined by F. M. Anderson.

Reed⁴ regards the "Indicator Bed" on Domengine Creek as the correlative of the 600-foot shale in the North Dome sections of the Kettleman Hills. He concurs with Goudkoff's correlation of the 600-foot shale with the Gould shale on Carneros Creek, and believes that the horizon of the *Merychippus* zone should fall somewhere in the lower part of the *Valvulineria californica* zone on Carneros Creek which he considers to be late middle Miocene in age.

It is evident that the sandstones containing the *Merychippus* zone north of Coalinga are probably equivalent to beds lying above the Temblor at the type section, and that the use of the name "Temblor" with regard to the beds containing *Merychippus* on Domengine Creek is open to question.

AGE OF THE MERYCHIPPUS ZONE

As previously discussed, the *Merychippus* zone is in stage of evolution intermediate between the Mascall of eastern Oregon and the Barstow of the Mohave Desert, California. The Mascall has been regarded by vertebrate palæontologists as possessing a fauna typical of the middle Miocene. Chaney,⁵ on the basis of evidence derived from fossil floras, has placed the age of the Mascall as middle or even upper Miocene. Simpson, in a recently published series of correlation charts,⁶ places the Mascall in the early upper Miocene. One can conclude therefore that the *Merychippus* zone can not be older than late middle Miocene. In his description of the vertebrate faunas from the Mohave Desert, Merriam⁷ assigned an uppermost Miocene age

¹ G. C. Gester and John Galloway, *op. cit.*, 1169, 1933; P. P. Goudkoff, *op. cit.*, 465, 1934.

² P. P. Goudkoff, *op. cit.*, 456, 1934.

³ P. P. Goudkoff, *ibid.*

⁴ R. D. Reed, personal communication, Feb. 1935.

⁵ R. W. Chaney, Carnegie Inst. Wash. Pub. No. 349, 48, 1925.

⁶ G. G. Simpson, Bull. Amer. Mus. Nat. Hist., vol. 67, 87, 1933.

⁷ J. C. Merriam, Univ. Calif. Pub., Bull. Dept. Geol., vol. 11, 454, 1919.

to the Barstow and referred the distinctly younger beds of the Ricardo to the lower Pliocene. Since these age determinations were made, Maxson¹ has found several of the horses peculiar to the Ricardo in beds of the Mint Canyon formation, which presumably underlies marine sediments of Cierbo or upper Miocene age. If the age determination of the marine horizon is essentially correct, this relationship

	CALIFORNIA MARINE STAGES	VERTEBRATE HORIZONS		
		WESTERN UNITED STATES	CENTRAL UNITED STATES	
UPPER MIOCENE	MONTEREY	<u>MINT CANYON</u>		UPPER MIOCENE
		<u>CUYAMA</u>		
		<u>BARSTOW</u>	<u>LOWER SNAKE CREEK</u>	
LOWER MIOCENE	?	<u>MERYCHIPPUS ZONE</u>		MIDDLE MIOCENE
	VALVULINERIA CALIFORNICA ZONE	<u>SKULL SPRING</u>		
	GOULD SHALE	<u>MASCALL</u>		
	TEMBLOR	<u>PHILLIP'S RANCH</u>	<u>SHEEP CREEK</u>	
	VAQUEROS	<u>TECUYA</u>		
		<u>UPPER JOHN DAY</u>		LOWER MIOCENE

FIG. 4—Correlation chart suggesting time relationships of several Miocene Vertebrate horizons in Western United States to Miocene marine stages of California and to the Sheep Creek and lower Snake Creek horizons of Nebraska.

tends to push the Barstow lower into the Miocene. The Barstow is distinctly closer in stage of evolution to the Merychippus zone than it is to the Ricardo. The position of the Merychippus zone can not then be assigned to a period of time younger than early upper Miocene.

The correlation of the Merychippus zone on Domingine Creek with the *Valvulineria californica* zone has a distinct stratigraphic value, for the late middle Miocene or early upper Miocene age of the *Valvulineria californica* as determined by its invertebrate faunas indi-

¹ J. H. Maxson, Carnegie Inst. Wash. Pub. No. 404, 77-112, 1930.

cates that, if the Miocene time scale as determined by the marine invertebrate faunas on the Pacific Coast is to remain essentially equivalent to that determined by means of continental vertebrate assemblages, the Mascall must be regarded as occupying a position very close to the exact middle of the Miocene and not in the upper third as has been recently suggested.

Figure 4 is a correlation chart suggesting the stratigraphic relations of several vertebrate horizons to the Miocene Marine stages of California.

SYSTEMATIC DESCRIPTION OF FAUNA

Carnivora

The carnivore material from the Merychippus zone consists entirely of isolated teeth. With the exception of a single tooth, referable to *Hemicyon*, the specimens fall naturally into three group sizes. These groups are referred to *Tomarctus*, *Æluroidon* and *Amphicyon*. Unfortunately, the characters displayed by the carnassial teeth of members of the Canidæ are usually only of generic significance. Comparisons with known types emphasizes the fact that the present material is too incomplete to serve as a satisfactory basis for specific determinations.

Tomarctus sp.

The teeth of this small carnivore are referred without question to the genus *Tomarctus*. While a critical study of the relationships of *Tomarctus* Cope and *Tephrocyon* Merriam have not been attempted, there appears to be no reason why Matthew's¹ suggestion of generic identity of the two forms should not be accepted. In the following discussion the name *Tephrocyon* is regarded as a synonym of *Tomarctus*.

The material from the Merychippus zone consists of four upper carnassials (Nos. 1603, 1604, 1605, and 1606), two lower sectorial teeth (Nos. 1607 and 1608) lacking the anterior portions of the trigonids, the greater portion of an M₁ (No. 1609), and a single premolar (No. 1610) (Plate 2, figs. 1, 2, 4, and 5). In the superior carnassials the parastyle is a small cusp or elevation on the anterior ridge of the paracone. The protocone has been broken away on three of the specimens, but is present on the fourth (No. 1603). In this tooth the position of the protocone is anterior to that of the paracone and the cusp is rather small and low. A distinct cingulum is present on the external side of the metacone in all four teeth. The upper molar is rectangular in shape, the lingual side having approximately the same anteroposterior diameter as the external side. The paracone and metacone are low cusps connected by a slight ridge. The metaconule and protoconule are well developed. These cusps become connected at an early stage of wear and form an anteroposterior ridge across the middle of the tooth. The protocone is represented by a relatively heavy ridge, which runs across the entire lingual side of the tooth. In the two specimens presumably representing M₁, the entoconid and hypoconid are equally developed. When slightly worn these

¹ W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 50, 81-88, 1924.

two cusps evidently form a transverse ridge with a small basin in front and a valley behind. In one of the teeth (No. 1608) the metaconid is distinctly larger than in the second specimen (No. 1607).

In size and arrangement of cusps these teeth compare favorably with several of the species referred to *Tephrocyon* or *Tomarctus*. The teeth are smaller than in the type of *T. rurestris* (Condon) from the Mascall, and slightly larger than those of the specimen referred by Merriam to *T. temerarius* Leidy from the Barstow. *T. kelloggi* (Merriam) from the middle Miocene beds of Virgin Valley is a larger form. Compared to species from the Great Plains region the Coalinga specimens approach *T. optatus* Matthew more closely in size than they do any of the other known types. *T. brevirostris* Cope is larger and the type of *T. confertus* Matthew lacks the strong development of the proto- and metaconules seen in M1 from the Merychippus zone. Apart from size differences there appears to be very little to distinguish the Coalinga species from most of the described forms. The material compares most favorably with *T. optatus* and may represent a species closely related to or identical with this form.

Elurodon sp.

Four upper carnassials (Nos. 1611, 1612, 1613, and 1618), three of them complete, and three lower sectorial teeth (Nos. 1614, 1615, and 1617), one of which is perfectly preserved (No. 1615), are assigned to *Elurodon* (Plate 2, figs. 6-9). In the upper teeth the parastyle is distinct, though small. The protocone is also small and occupies a position slightly anterior to that of the parastyle. The shearing blade is robust and heavy. In the lower teeth the metaconid is a distinct and well-developed cusp. The paraconid is smaller than the protoconid. The transverse diameter of the talonid region is smaller than that across the posterior side of the trigonid. The talonid possesses two cusps of which the hypoconid is the larger.

The superior carnassials are almost identical in size, shape and in arrangement of cusps with those of *Borophagus littoralis* Vander Hoof,¹ described from Santa Margarita beds near McKittrick, California. The lower jaw of this form is not known, and it is principally for this reason that the material from the Merychippus zone is not referred to *Borophagus*. The specimens from north Coalinga, although slightly smaller, agree also with upper teeth of *Borophagus cynoides* (Martin) from the Hemphill quarries, Texas. The lower teeth of the Texan species are distinguished by larger size of talonid, relative to the trigonid. However, this Pliocene species obviously represents an advance over forms from the Miocene. It seems possible that the lower teeth of the Coalinga form may represent an ancestral stage to the later hyænogonathoid dogs. These specimens from the Merychippus zone are considerably larger than those of any species of *Tomarctus*, although the dental characters offer but little to distinguish them from that genus.

When compared with *Elurodon wheelerianus* Cope, the teeth from north Coalinga appear to be quite similar. In fact, no clear distinctions can be made between the two types. The lower teeth are practically identical and the principal difference in the upper teeth is presented by the slightly smaller parastyle of the Coalinga specimens. Because of the agreement between the Coalinga form and *A. wheelerianus* in both upper and lower teeth and because the lower teeth of *B. littoralis* are unknown, the Coalinga material is referred to *Elurodon*. However, the relative heaviness of the upper carnassials, coupled with the presence of a parastyle that is relatively smaller than in most

¹ V. L. Vander Hoof, Univ. Calif. Pub., Bull. Dept. Geol. Sci., vol. 21, 15-24, 1931.

Ælurodon, is rather suggestive. In view of the late middle Miocene position of the *Merychippus* zone it may be possible that this material represents a form, larger although not otherwise clearly distinguishable from *Tomarctus*, and ancestral to either or both *Borophagus* and *Ælurodon*. The Coalinga type is considerably smaller than *A. haydeni* Leidy and the Ricardo form, *A. aphobus* Merriam.

Amphicyon sp.

Amphicyon is represented by two upper molars, an M_1 (No. 1619) and an M_2 (No. 1616), the trigonid and talonid portions of two lower carnassials (Nos. 1620 and 1621, respectively), a well-worn M_2 (No. 1622), a canine tooth (No. 1623) and a premolar (No. 1624) (Plate 2, figs. 11-14). M_2 (No. 1616) is a well-preserved tooth of the right side. In this tooth the paracone is more than twice as large as the metacone. The protoconule and metaconule are only slightly developed and form a small ridge on the internal occlusal surface. The protocone is a heavy ridge which runs across the entire lingual side and halfway up the posterior side of the tooth. The paracone has been lost from the M_1 (No. 1619). The metacone in this tooth was probably equal in size to the paracone. In this tooth the protoconule-metaconule ridge is well developed and encloses a distinct basin behind the paracone. The protocone has been damaged by abrasion and its exact form is therefore not represented.

In the lower carnassial fragments, the trigonid is considerably compressed in an anteroposterior direction. The metaconid is small and is essentially a part of the protoconid. The talonid is well worn; however, the hypoconid seems to have been the only important cusp, although some damage by abrasion has removed any indications of an entoconid if present. A well-worn M_2 (No. 1622) is also assigned to this genus. The characters of this tooth have been largely obliterated by wear; however, the tooth appears to have had two anterior cusps and a single posterior cusp as in *Amphicyon*. The antero-external corner of this tooth probably possessed a cusp sufficiently prominent to account for the small pocket worn in this area. This character was noted by Gazin¹ in a fragmentary M_2 referred to *A. sinapius* Matthew from the Skull Spring deposits of eastern Oregon. A small pocket worn on the postero-internal corner of the tooth may represent either a small entoconid or the worn surface may be due to an occlusion of the tooth with a cusp of an upper molar.

These teeth are smaller than those of *Amphicyon frendens* Matthew. The fragmentary material available compares favorably in size and in arrangement of cusps with *A. sinapius* from the Great Plains. This species has also been recognized in the Mascall fauna. It seems probable that the Coalinga specimens represent *A. sinapius*.

Hemicyon? sp.

A lower second molar (No. 1625) (Plate 2, fig. 10) from the *Merychippus* zone resembles closely the corresponding tooth of the type of *Hemicyon barstowensis* Frick² from the Barstow Miocene of the Mohave Desert, California. The cusps in this tooth are low and lack the trenchant character seen in *Amphicyon*. The tooth is still further distinguished from the latter genus in the more posterior position of the protoconid-metaconid ridge with reference to the anterior edge. Moreover, the hypoconid is a small low cusp, only slightly larger than the distinct entoconid. The exact relationships of the

¹ C. L. Gazin, Carnegie Inst. Wash. Pub. No. 418, 52, 1932.

² C. Frick, Bull. Amer. Mus. Nat. Hist., vol. 56, 28, 1926.

form characterized by this tooth are uncertain. However, the resemblances are more with *Hemicyon* than with any other genus. The tooth quite certainly does not belong to any of the described canid types from the Merychippus zone. In *Tomarctus*, *Ælurodon* and in *Borophagus* the anterior cusps of M₂ stand higher and have a considerably more trenchant character than in this tooth.

RODENTIA

Monosaulax sp.

Among the rodents only the beaver group is recorded in the collections. A single cheek-tooth (No. 496) and a fragment of a ramus (No. 653) with two teeth were referred to this castorid genus by R. A. Stirton¹ of the University

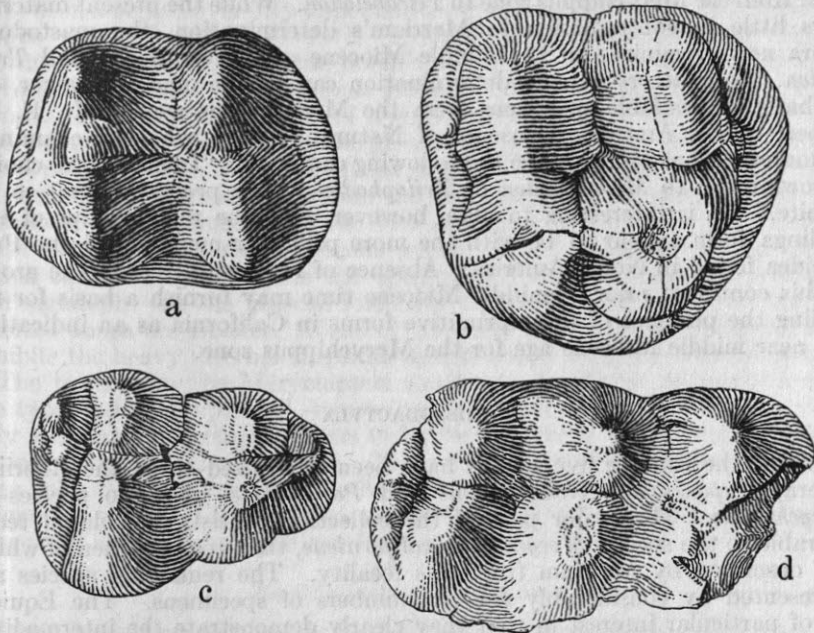


FIG. 5—*Miomastodon* or *Trilophodon*? sp. a, deciduous premolar, No. 1628; b, P₄, No. 1630; c, deciduous premolar, No. 1629; d, M₁?, No. 1633. Calif. Inst. Tech. Coll., Merychippus Zone North Coalinga district, California; x 1.

of California. This genus has been recognized by Mr. Stirton in the Miocene of the Great Plains and in the Cedar Mountain fauna of Nevada.

PROBOSCIDEA

Miomastodon or *Trilophodon*? sp.

The proboscidean material in the collections consists of the following specimens: Four deciduous premolars (Nos. 1626, 1627, 1628, and 1629), three fourth upper premolars (Nos. 1630, 1631, and 1632), an upper M₁? (No. 1633), a partially complete M₂? (No. 1634), and a number of miscellaneous tooth fragments. Four of these specimens are illustrated in figure 5.

¹ R. A. Stirton, personal communication.

No tusk or skeletal materials were found during the course of the excavations. The milk teeth and the permanent premolars possess four cusps, with each cusp remaining distinct and isolated until the tooth is worn almost to the base of the crown. Very few secondary cusps are present and these are extremely small, being minor tubercles situated between the major cusps near the base of the crown. On several teeth the enamel of the four cusps is perfectly smooth. The crown of the first molar, No. 1633, possesses three rows of two cusps each, although the individuality of the cusps disappears with wear. The partially complete M2? (No. 1634) is considerably larger than M1 but is otherwise essentially similar.

No. 1634 compares favorably with the type of *Miomastodon merriami* Osborn from the Virgin Valley beds of northwestern Nevada. In 1915 Merriam¹ tentatively assigned a milk molar and a fragment of a permanent molar from the Merychippus zone to *Tetrabelodon*. While the present material offers little in contradiction to Merriam's determination, the mastodont genera now recognized in the middle Miocene are *Miomastodon* and *Trilophodon*. Satisfactory generic determination can not be made, however, on the basis of available specimens from the Merychippus zone. Mr. E. H. Colbert² of the American Museum of Natural History, who has examined the materials, has kindly made the following comment: "I believe the choice narrows down to *Miomastodon* or *Trilophodon*. It is pretty difficult to be definite." It is interesting to note, however, that the relationships of the *Coalinga* form appear to be with the more primitive members of the Proboscidea found in North America. Absence of representatives of the group on this continent prior to middle Miocene time may furnish a basis for regarding the presence of these primitive forms in California as an indication of a near middle Miocene age for the Merychippus zone.

PERISSODACTYLA

Among the Equidæ five species have been recognized three anchitheriine genera, *Hypohippus*, *Archæohippus* and *Parahippus*, and two species of *Merychippus*. The major part of the collection consists of isolated teeth referable to the species *Merychippus californicus*, the type specimen of which was described by Merriam from this locality. The remaining species are represented by considerably smaller numbers of specimens. The Equidæ are of particular interest in that they clearly demonstrate the intermediate position of the Merychippus zone with respect to the Mascall and the Barstow. Three of the species, *Hypohippus*, *Parahippus* and *Merychippus brevidontus* are found in the Mascall and in other middle Miocene horizons of eastern Oregon and northwestern Nevada, while the *Archæohippus* is unquestionably a Barstow species. The material determined as *Merychippus californicus* includes teeth that show close resemblance to specimens from the Barstow and the Mascall. The Equidæ from the Merychippus zone have been described in detail in two previous papers by the writer.³ A résumé of these descriptions are included in the present paper.

Hypohippus sp.

An upper molar (No. 885) and three lower premolars (Nos. 886, 887 and 888) belong to the genus *Hypohippus*. The material is unfortunately in-

¹ J. C. Merriam, *op. cit.*, 13, 1915.

² E. H. Colbert, personal communication to Dr. Chester Stock.

³ F. D. Bode, Carnegie Inst. Wash. Pub. No. 440, art. V, 1933; Carnegie Inst. Wash. Pub. No. 453, art. V, 1934.

adequate for more than a generic determination. The Coalinga specimens are considerably smaller than the few teeth described as *Hypohippus* near *affinus* (Leidy) by Merriam from the Barstow, and they are unquestionably specifically separable from this form. *Hypohippus* has not been recorded from the Mascall. *Hypohippus* near *osborni* Gidley from the Virgin Valley beds is similar in most respects though somewhat larger than teeth from the Merychippus zone. The relationships of the north Coalinga form as based upon these teeth seem rather to be with the Virgin Valley form than with the *Hypohippus* from the Barstow.

Archæohippus mourningi (Merriam)

Following *Merychippus*, *Archæohippus* is one of the more commonly occurring forms in the collections from the Merychippus zone. To this genus have been assigned over fifty upper and lower cheek-teeth and a well-preserved ramus with P³-M³ (No. 484). *Archæohippus mourningi*, with higher-crowned cheek-teeth, from the north Coalinga locality, is a decidedly more advanced type than *Archæohippus ultimus* (Cope) from the Mascall. In *A. ultimus* the hypostyle consists of a single cusp, while in the Coalinga teeth this structure is triangular in shape and encloses a small fossette. M³ in the type of *A. ultimus* is not reduced in size. On the other hand, the upper third molars of *Archæohippus* from the Merychippus zone show considerable reduction when compared to the two preceding molars. In the Coalinga teeth the protocone and hypocone widen toward their base to an extent which considerably obstructs the opening of the valley between protoloph and metaloph. In the Mascall form this valley is widely open and the two internal cusps are smaller. None of the teeth from the Merychippus zone exhibits the heavy internal cingulum seen in the type of the Mascall species.

The teeth from the Merychippus zone agree in almost all respects with the type and paratype of *A. mourningi* (Merriam) from the Barstow. The only noticeable difference appears to be the absence of an external cingulum on lower teeth of the paratype. This character varies considerably in the large collection of teeth from the Merychippus zone and appears to have no diagnostic value. The Coalinga material is referred unquestionably to *A. mourningi* and is clearly distinct from the Mascall species.

Parahippus brevidens Marsh

Parahippus is represented in the collections by some twenty well-preserved upper and lower cheek-teeth. That the material should be assigned to a progressive parahippine form is indicated by the relatively high crowns, abundant cement, and progressive character of the ptychoid crenulations of the walls of the metaloph. These features serve to isolate the Coalinga form from most of the species of *Parahippus*. In development of the crenulations on the walls of the metaloph, the teeth from the Merychippus zone agree closely with *Parahippus crenidens* Scott. They differ from *P. crenidens*, however, in their less strongly developed ectoloph, shape of protoloph and heavy coating of cement. The deciduous teeth of *Parahippus cognatus*, while similar in some characters, represent a much larger horse. Comparisons with this form are inadequate, since no milk teeth of *Parahippus* have been recognized in the collections from the Merychippus zone.

Several teeth in the collections of the California Institute of Technology from the Mascall and referred to *Parahippus brevidens* Marsh are practically identical with the *Parahippus* teeth from North Coalinga. A comparison with the type of *P. brevidens* as well as with the topotype material fails to disclose

any characters which may serve to separate the Coalinga form from this species. *Parahippus* has not been recorded from the Barstow nor, so far as the writer is aware, from any Miocene horizon as late in age as the Barstow. The presence of *Parahippus* may therefore have some significance in pointing toward a close time relationship between the faunas from the Merychippus zone and the Mascall.

Merychippus brevidontus Bode

This species is known by approximately seventy-five upper and lower cheek-teeth. The specimens, although representing fully hypsodont teeth, possess exceptionally low crowns and exhibit extreme complexity of the enamel pattern. The characters seen in these teeth do not intergrade with those of the larger and more abundant species, *M. californicus*, and were employed therefore in the recognition of a new specific type. Teeth referable to this species are relatively abundant in middle Miocene collections from eastern Oregon and northwestern Nevada. Teeth similar to *M. brevidontus* are absent in the Barstow and related upper Miocene horizons. A detailed description of *M. brevidontus* has been given in a previous paper.¹

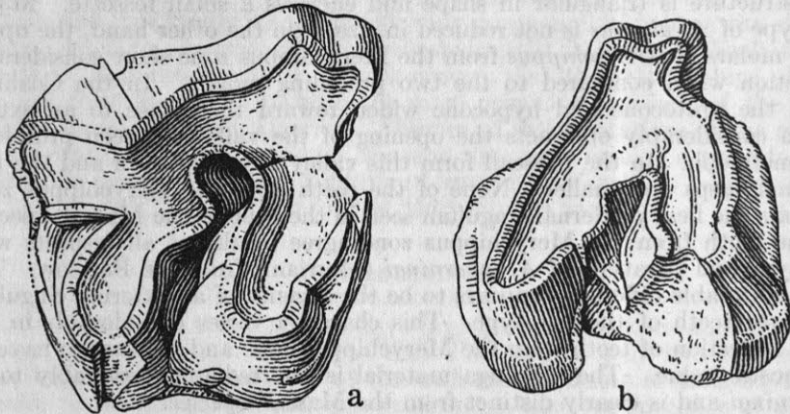


FIG. 6—Rhinocerotid cf. *Aphelops*. a, upper cheek-tooth, No. 1639; b, M3, No. 1744. Calif. Inst. Tech. Coll., Merychippus Zone, North Coalinga district, California; x 1.

Merychippus californicus Merriam

The Merychippus zone derives its name from the abundant representation of this species in the north Coalinga horizon. Cheek-teeth of *Merychippus californicus* comprise nearly half of all the specimens collected from this zone.

The degree of variation of the cheek-tooth characters as seen in this collection makes it difficult to determine the exact affinities of this species. The average grouping of characters seems to be generally distinct from the average grouping of characters seen in similar large collections from other horizons. Individual teeth can frequently be assigned to any one of several species of this genus from North American Miocene horizons. In general, the variations more frequently represented are those which would include *Merychippus isonesus* (Cope) from the Mascall and *M. sumani* Merriam from the Barstow. A fuller discussion of the characters and relationships of *M. californicus* has been given in a previous paper.²

¹ F. D. Bode, Carnegie Inst. Wash. Pub. No. 453, art. V, 42-43, 1934.

² F. D. Bode, *Ibid.*, 43-47, 1934.

Rhinocerotid cf. *Aphelops*

Some fifteen teeth in the collections are referable to the Rhinocerotidæ. A generic determination is questionable. However, the brachydont character of the dentition tends to affiliate this form with *Aphelops* rather than with *Teleoceras*. The teeth show a slight development of the crochet and ante-crochet. The two features of the enamel pattern were not found associated in a single tooth. Two tarsal elements (Nos. 1636 and 1637) are also present in the collections. These elements resemble those of *Aphelops* more closely than they do *Teleoceras* and may afford corroborative evidence for the present determination.

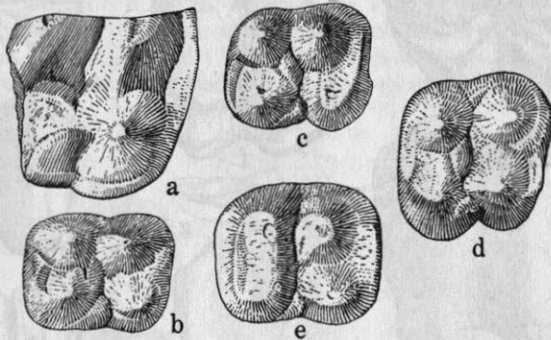


FIG. 7.—*Prosthennops?* sp. a, Dp 4, No. 1638; b to e, isolated cheek-teeth, Nos. 1745, 1746, 1747, and 1748 inclusive. Calif. Inst. Tech. Coll., Merychippus Zone, North Coalinga district, California. $\times 1\frac{1}{2}$.

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Prosthennops? sp.

A dicotyline form previously known by a few teeth is represented in the collections by fifteen upper and lower molars and premolars. Definite generic determination of the form on the basis of this material is not trustworthy, but certain characters of the premolars are suggestive of *Prosthennops*. The four-cusped arrangement, on the occlusal surface in the premolars, in contradistinction to a fewer number of cusps seen in species of *Desmathyus* and the tendency of the four cusps to remain distinct rather than to develop into cross-crests as in *Platygonus* are characters in which the Coalinga genus resembles *Prosthennops*. A deciduous fourth premolar (No. 1638) (fig. 7a) and two specimens assigned to Dp $\frac{3}{2}$ (Nos. 1639 and 1640) are similar to corresponding teeth in the type of *Desmathyus validus* Matthew. The permanent teeth are bunodont with a tendency to become multi-cuspid, which distinguishes them from teeth of *Platygonus* in which the cusps are simpler, higher and fused into cross-crests. Several astragali in the collection are also referred to this form. These specimens are approximately comparable in size to similar elements in the Barstow collections.

Camelidæ

The collections from the Merychippus zone contain nearly one hundred teeth referable to the Camelidæ. These teeth do not fall into any distinctive groups according to size but appear to be gradational in this character from

the smallest to the largest. The dentition is brachyodont. In addition to the teeth, however, the collection contains a representation of carpal and tarsal elements. Within this collection there appear to be three types of sizes represented, although specimens intermediate in size between those of individual groups are not lacking.

The characters displayed by the cheek-teeth, as for example size and strength of the external styles, have little value in attempting to make a generic determination. Most of the skeletal material has suffered considerably from abrasion. As a result, the diagnostic characters are for the most part

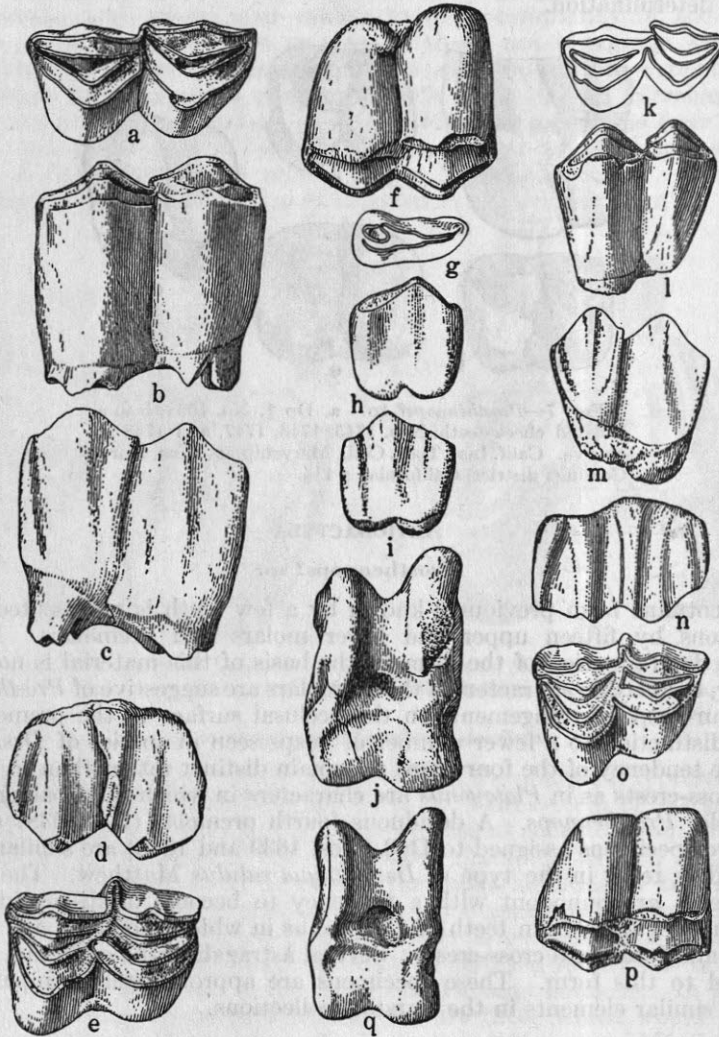


FIG. 8—a to j, *Procamelus* sp. a to c, lower molar, No. 1749; d to f, upper molar, No. 1750; g to i, P_2 , No. 1751; j, astragalus, No. 1752. k to q, *Alticamelid?*; k to m, lower molar, No. 1753; n to p, upper molar, No. 1754; q, astragalus, No. 1755. Calif. Inst. Tech. Coll., Merychippus Zone, North Coalinga district, California. All teeth natural size; astragali $\times \frac{1}{2}$.

but poorly defined. The astragali offer perhaps the best basis for the grouping of the forms. The larger astragali are comparable in size to those from the Barstow referred by Merriam to *Procamelus*. The larger premolars in the collection are of a size nearly comparable to that seen in average specimens of species of this genus. The larger cheek-teeth present no characters which would serve to separate them from *Procamelus*. In view of the relative abundance of specimens representing this genus in most upper Miocene collections, it seems reasonable to suppose that these very similar teeth from the Merychippus zone represent *Procamelus*.

The second form has been recognized largely by the characters of the astragali. Approximately fifteen of these elements in the collection, slightly smaller in size than the material referred to *Procamelus*, are distinguished from the latter by their narrowness. These narrow astragali may represent an alticamelid in the collections. To this type has been assigned teeth which seem to occupy also an intermediate size position. The narrow astragali

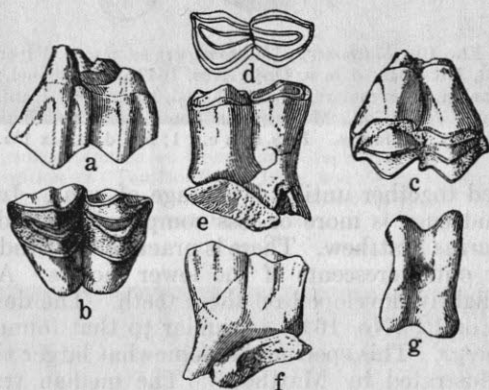


FIG. 9.—Small camelid, possibly *Miolabis*. a to c, upper molar, No. 1756; d to f, lower molar, No. 1757; g, astragalus, No. 1758. Calif. Inst. Tech. Coll., Merychippus Zone, North Coalinga district, California. Teeth natural size, astragalus $\times \frac{1}{4}$.

certainly indicate the presence of a form differing specifically from that known by the material referred to *Procamelus* and the smallest camelid. The group of smaller forms compares in size and in structure of cheek-teeth to some undescribed specimens of *Miolabis californicus* Maxson from the Mint Canyon beds of California. It appears possible that the small teeth and limb elements in the collection from the Merychippus zone may belong to this genus.

Pliauchenia and *Protolabis* differ from the types recorded in the present collection in larger size and hypsodont cheek-teeth.

Blastomeryx (Dyseomeryx) sp.

One upper (No. 1641) and four lower molars (Nos. 1642, 1643, 1644, and 1645), a third or fourth lower premolar (No. 1646) and two deciduous upper molars (Nos. 1647 and 1648) together with several astragali are referred to *Dyseomeryx* Matthew, known from the Sheep Creek beds of western Nebraska. All of the teeth are short-crowned and are thus excluded from the genus

Merycodus. The metaselene and protoselene of the milk teeth (Nos. 1647, 1648) remain isolated throughout most of the wear of the tooth. These crescents are connected to the ectoselene in the permanent molar, but are ap-

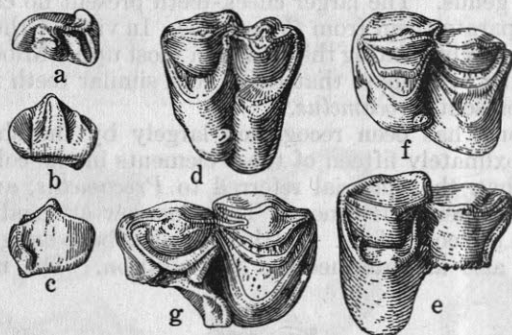


FIG. 10—*Blastomeryx* (*Dyseomeryx*) sp. a to c, P $\bar{4}$ or P $\bar{3}$, No. 1646; d to e, Dp $\bar{4}$? Nos. 1647 and 1648 incl.; f and g, lower molars, Nos. 1643 and 1644 incl. Calif. Inst. Tech. Coll., Merychippus Zone, North Coalinga district, California. Figs. a to c, x 1; figs. d to g, x 1½.

parently not joined together until a late stage of wear. In M $\bar{3}$ (No. 1642) the internal talonid cusp is more or less completely united with the hypoonid, as in *D. riparius* Matthew. There is practically no indication of a basal cusp between the outer crescents of the lower molars. An anterior basal cingulum is but slightly developed on these teeth. The development of the cross-crests in P $\bar{3}$ or P $\bar{4}$ (No. 1646) is similar to that found in many of the species of *Blastomeryx*. This specimen is somewhat larger than in the ramus of *D. riparius*, illustrated by Matthew.¹ The median transverse crest is expanded internally with an incipient pillar developing from the postero-internal side of the main pillar. The remaining crests have a simple rectilinear appearance. The astragali are small but present no other distinguishing characteristics.

The character of brachydonty excludes this form from *Merycodus*. Compared to teeth in species of *Blastomeryx*, the Coalinga specimens are considerably larger. The latter are almost identical in appearance to *Blastomeryx* (*Dyseomeryx*) *riparius* Matthew from the Sheep Creek beds of western Nebraska. This subgenus was erected by Matthew to include large species otherwise referred to *Blastomeryx*. The enamel walls of the teeth are slightly rugose, but this character is not so well developed as in *Dromomeryx*.

¹ W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 50, 196-199, 1924.



FIG. 1—View of geologic section on Domengine Creek from the west, showing approximate position of "Temblor," Big Blue, and Santa Margarita contacts, and stratigraphic position of Calif. Inst. Tech. localities 108 and 129. Merychippus zone, North Coalinga district, California.



FIG. 2—View of quarry wall in Merychippus zone at Calif. Inst. Tech. locality 129. Pebble conglomerate lenses containing fossil material are outlined in dotted lines.

PLATE 2

FIGS. 1 and 2—*Tomarctus* sp. Figure 1, P₄, No. 1603; figure 2, M₁, No. 1601.

FIG. 3—*Amphicyon* sp., talonid of M₁, No. 1621.

FIGS. 4-5a—*Tomarctus* sp. Figure 4, M₁, No. 1607; figure 5 and 5a, M₁, No. 1608.

FIGS. 6-9a—*Elurodon* sp. Figures 6 and 6a, P₄, No. 1613; figures 7 and 7a, M₁, No. 1614; figures 8 and 8a, M₁, No. 1615; figures 9 and 9a, P₄, No. 1611.

FIGS. 10-10a—*Hemicyon?* sp., M₂, No. 1625.

FIGS. 11-14a—*Amphicyon* sp. Figures 11 and 11a, M₂, No. 1622; figure 12, M₂, No. 1616; figure 13, M₁ with paracone restored, No. 1619; figures 14, 14a, trigonid of M₁, No. 1620.

All specimens from Calif. Inst. Tech. Collections, Merychippus zone, North Coalinga district, California; x $\frac{3}{4}$.

