
CONTRIBUTIONS TO PALEONTOLOGY

I

LATER TERTIARY EQUIDAE FROM THE TEJON HILLS,
CALIFORNIA

ARTHUR B. DRESCHER

With three plates and six text figures

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LATER TERTIARY EQUIDAE FROM THE TEJON HILLS, CALIFORNIA

INTRODUCTION

Fossil vertebrates were first discovered in continental sediments of the Tejon Hills (for location see fig. 1) in 1911, by R. W. Pack, of the U. S. Geological Survey. The occurrence of these fragmentary specimens was briefly described at a meeting of the Pacific Coast Paleontological Society in 1913 (Merriam and Pack, 1913). Thereafter some collecting was done by the University of California party of 1915, the results of which were presented in papers by Merriam (1915*a*, 1915*b*, 1916). During the latter part of 1928, field parties of the California Institute of Technology obtained a much larger fauna than that previously collected in the Tejon Hills. As a result of further field work by R. W. Wilson, R. M. Leard, Jack Dougherty, and the writer in 1938, considerable fossil material was obtained from this area, and the existence of three distinct faunas was disclosed. These were collected at seven localities along the ridge to the south and west of Comanche Creek (see map, fig. 2).

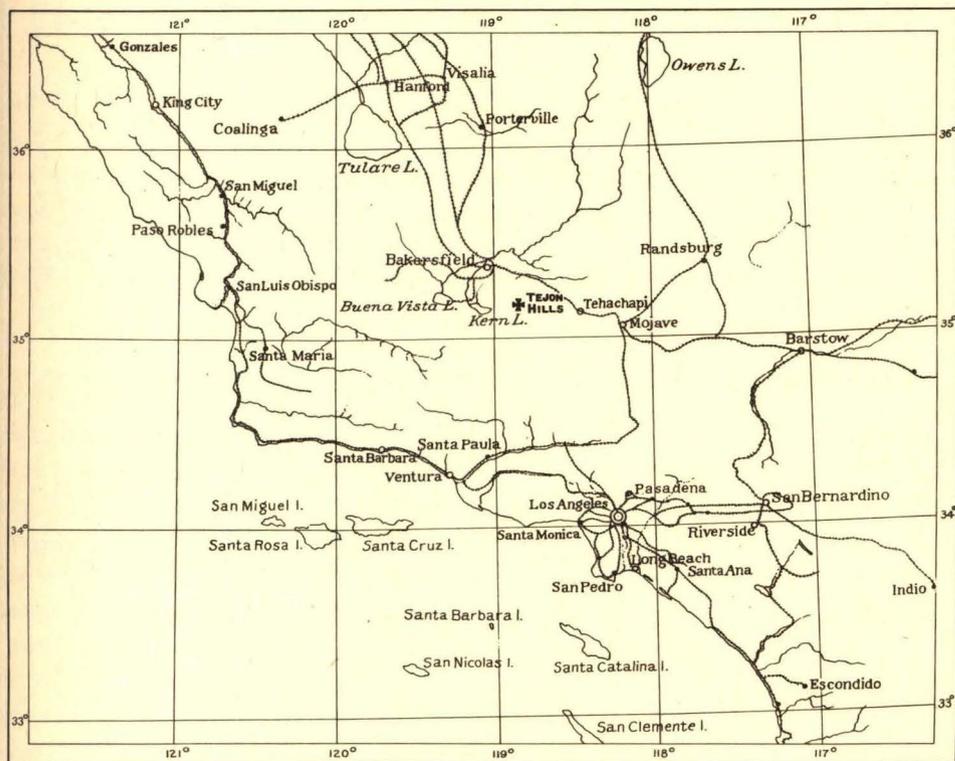


Fig. 1. Index map of a part of southern California, showing location of the Tejon Hills

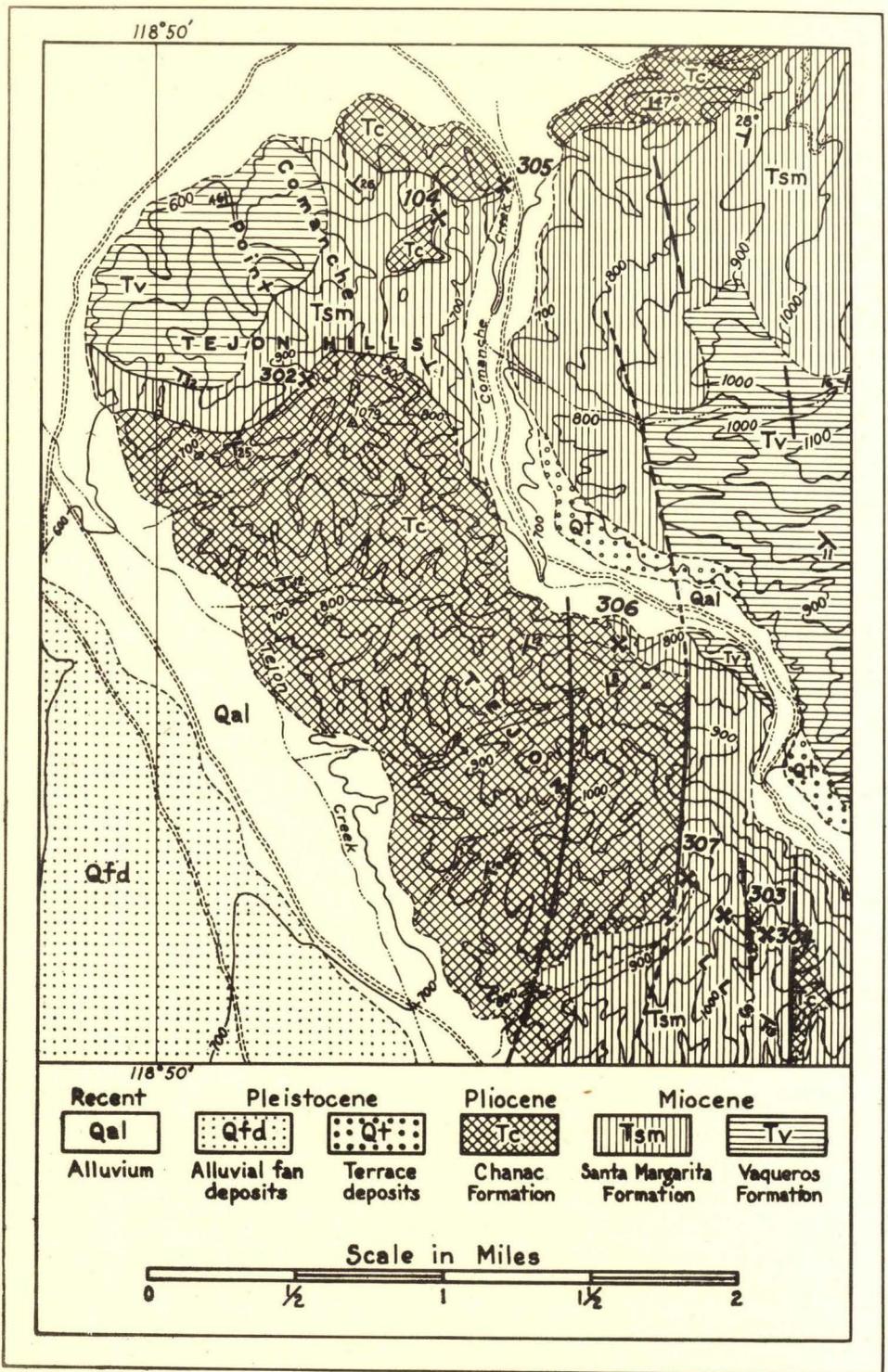


Fig. 2. Geology of a part of the Tejon Hills, slightly modified after H. W. Hoots, U. S. Geol. Surv. Bull. 812. Note position of Calif. Inst. Tech. Vert. Pale. localities.

The present research limits itself to a study of the fossil Equidae of the Tejon Hills, and gives evidence of the presence of two groups of horses, one occurring in the Santa Margarita formation, the other in the Chanac formation. Each group is apparently confined to its respective horizon. Recently Stirton (1939a, 1939b) called attention to the presence of two equid faunas in the Tejon Hills. A preliminary survey of the mammals other than horses reveals the fact that a similar segregation in time is suggested by the relationships of certain forms. Observations of the stratigraphy likewise point to this conclusion, and indicate, furthermore, that the lowest and therefore the earliest of the several fossil sites occurs in a continental phase of the Santa Margarita formation. A comparison of the material previously described from the Tejon Hills with that obtained in recent years leads to the conclusion that the former specimens came from the lower horizon and represented float material. The suggestion that two faunas were present in the first collections made probably followed the recognition of an association of *Merychippus* and *Hipparion* (*Nannippus*). The type of horse originally described as *Merychippus*, however, is actually *Pliohippus tehonensis*.

ACKNOWLEDGMENTS

I wish to express my appreciation of the assistance rendered by Dr. Chester Stock in the course of the present study. Dr. R. W. Wilson offered many helpful suggestions. I am indebted to the U. S. National Museum, the Nebraska State Museum, and the Museum of Paleontology, University of California, for the loan of comparative material. The illustrations were prepared by David P. Willoughby and John L. Ridgway.

OCCURRENCE OF MATERIAL

All fossil specimens collected by the California Institute of Technology occurred within a zone approximately 150 feet thick which included the uppermost 50 feet of the Santa Margarita formation, the "transition zone," and approximately 50 feet of the typical buff sediments of the Chanac formation. The fossil vertebrates are not evenly distributed within this zone, but are definitely confined to three subzones. The lowest or oldest of these is represented by three quarries, C.I.T. Vert. Pale. localities 303, 304, and 307, all of which are located in the Santa Margarita formation as mapped in this area by H. W. Hoots (1930). Above this horizon is another subzone, located near the Santa Margarita-Chanac contact and regarded as a "transition zone," in which three quarries, C.I.T. localities 104, 302, and 305, were developed. The latter three sites are on the nose of the anticline in the northwestern part of the area. The highest subzone is situated geographically midway between the two zones already mentioned, and in this horizon occurs C.I.T. locality 306. The fauna from

306 is meager, and includes a number of small carnivores and a large *Hipparton*, probably the species *H. cf. mohavense*. In the present paper little further mention is made of this highest horizon, and the two older subzones will be distinguished as the lower and upper Tejon Hills faunas. The upper Tejon Hills fauna and that from locality 306 contain types hitherto not described from the Tejon Hills. All the quarries are in sandy clays interbedded with coarse gritty sandstones.

PRESERVATION OF MATERIAL

The fossil material is well preserved, especially in the lower zone. Unfortunately, no complete skulls or lower jaws were obtained. Several complete series of cheek teeth are available. The bones and teeth do not show evidence of water wear or long exposure to weathering. Lack of complete specimens may be due to breakage incurred before burial, as, for example, in and about a water hole where disturbance and destruction of material resulted from the presence of carnivores and ungulates.

The conditions of deposition were probably those of a flood plain close to the shores of the Santa Margarita sea. It is worthy of note that the deposits show cross-bedding of a fluvial type. Also of significance perhaps is the presence of several carapaces of tortoises associated with the mammalian bones. Vertebrate materials found with marine invertebrates in the Santa Margarita formation may have been eroded and redeposited after accumulation in continental beds or may have been laid down on a sea beach.

STRATIGRAPHIC RELATIONSHIPS OF FAUNAS

The Santa Margarita formation in the Tejon Hills varies in thickness from 100 to 1000 feet (Hoots, 1930). The upper part of this formation consists of dominantly grayish-white marine sediments in the northwestern part of the Comanche Point area and its stratigraphic equivalent, the greenish nonmarine gravels to the southeast. In the near vicinity of locality ³⁰²~~303~~, white marine beds with a typical Santa Margarita invertebrate fauna underlie the Chanac formation with apparent conformity (Buwalda, 1916), the marine fossils occurring only 25 feet stratigraphically below the vertebrate-bearing horizon. A short distance to the west, imperfectly preserved invertebrate fossils were found above fragmentary teeth and bones of *Pliohippus tehonensis*, definitely placing this form in the Santa Margarita formation.

Unless reworking of the marine deposits and invertebrates has taken place, no marine Santa Margarita was deposited in the southeastern part of the area to the north of Tejon Creek. Marine deposits lower in the Santa Margarita formation may exist here, but no invertebrate-bearing beds were seen, and the lithology is that of typical fanglomerates, in contrast with the chalky-white to grayish marine sands.

Hoots states that "the light gray Santa Margarita beds grade upward into the overlying buff strata through a transition zone 50 to 100 feet thick that is composed of beds of alternating gray and buff color" (Hoots, 1930). The contact recognized in the present paper is at the base of the lowermost buff-colored bed; in other words, the "transition zone" is included in the Chanac formation.

It is rather unusual that the striking differences which distinguish the two principal faunas of the Tejon Hills should be associated with a stratigraphic separation of merely 50 feet, involving strata which evidently were deposited rapidly, as is indicated by the coarse grain and shape of particles of the sediments and by the cross-bedding. Evidence of the ^{stratigraphic} small time interval between the two faunas may be seen best in the small down-faulted block of sediments in which quarry 304 is located. This is one of the few places in the Tejon Hills where the exposed section is of such thickness as to include both horizons. Less than 50 feet above the level of this quarry the Chanac-Santa Margarita contact is exposed, and fossil rodents like those collected at quarry 302, a contact quarry, were found in similar sediments. Approximately 50 feet above this contact, in the same fault block, occur fragmentary limb bones of a large horse and camel. This horizon is tentatively assigned to the third (uppermost) subzone because of the similarity of the sediments and on the basis of the stratigraphic position.

Although no definite field evidence was obtained of an important break in deposition between the Santa Margarita and Chanac formations, such a break is believed to exist at the base of the "transition zone." It appears possible that a considerable thickness of coarse sediments was deposited and later removed by erosion without leaving a recognizable disconformity in the sediments. That the difference in faunas is due to a difference in environmental conditions seems unlikely in view of the proximity of the faunas and in view also of their stage of development.

Thus, the history of this portion of the Tejon Hills, as interpreted from the stratigraphy and occurrence of fossil materials, may be summarized as follows: With the coming of upper Santa Margarita time, environmental conditions changed from marine to nonmarine as the shore line of the sea retreated to the northwest, furnishing an opportunity for preservation of a record of the mammalian life, probably on a wide flood plain near the sea. At the time when the earliest mammalian assemblage was being deposited in the southeastern portion of the Tejon Hills, the northwestern area was still under marine waters, although a probable oscillation of the shore line permitted an interdigitation of continental beds containing vertebrate fossils with invertebrate-bearing marine deposits. These conditions continued into Lower Pliocene time, when renewed elevation initiated a period of erosion which removed some of the sediments previously deposited. Following this

episode, there occurred a period of oscillation in the conditions of deposition, during which the "transition zone" of alternating gray and buff sediments, namely the lower Chanac, was laid down. Finally, the typical continental buff conglomerates of the upper Chanac formation were deposited.

AGE AND CORRELATION

The lower fauna of the Tejon Hills is associated with, and probably essentially equivalent in time to, a marine invertebrate assemblage of Santa Margarita age. U. S. Grant IV is of the opinion¹ that the invertebrate fauna of the Tejon Hills cannot belong to the Lower Pliocene as we understand the invertebrate faunal characteristics of that epoch in California. He notes, furthermore, that if the species in this assemblage have been correctly identified, the fauna is pre-Jacalitos in age. Since the Jacalitos is generally considered to be Lower Pliocene, this places the Santa Margarita formation in the Miocene. Recently some workers (Gester and Galloway, 1933) have considered the Jacalitos to be part of the Middle Pliocene Etchegoin formation, and if this is correct, the allocation of the lower Tejon Hills fauna to the Lower Pliocene (Stirton, 1939a, 1939b) is a logical conclusion. The present study, however, shows that the lower fauna from the Tejon Hills is more primitive than the Orindan, which Stirton places at the base of the Pliocene column. Hence, taking into account the likelihood of an unconformity between the formations at Comanche Point, and the existence of a Miocene invertebrate fauna above the vertebrates of the lower horizon, the view that the latter are Upper Miocene in age seems justified. Thus, there would appear to be no important discrepancy in the time scales based on terrestrial vertebrates and marine invertebrates.

That the faunas discussed here are not younger than Lower Pliocene is shown by the stages of evolution exhibited by members of the Equidae. Presence of *Hipparion molle* might indeed be taken as an indication of later time, but the reported occurrence of this form is not substantiated by our present knowledge. *Merychippus* sp. was also reported in the first collection from Tejon Hills, but better material has shown this type to be *Pliohippus tehonensis*. The forms from the lower quarries show a number of primitive characteristics as compared with Lower Pliocene types, and the lower fauna is probably the youngest Miocene assemblage known from the Pacific Coast region.

The vertebrate-bearing beds of the Kern River region are considered to be younger than the Chanac beds of the Tejon Hills. The hipparion species in the Kern River fauna is clearly a more advanced form than the species recognized in the Tejon Hills area. A *Pliohippus* which occurs in the Kern River is hardly distinguishable from *Pliohippus leardi*, n. sp., of the Tejon Hills, although in some characters it exhibits a more advanced stage of evolution

¹Personal communication.

than the latter. It seems probable that the Kern River species was derived from *P. leardi*.

The presence of *Hipparion molle* in the Jacalitos at several localities on the west side of the San Joaquin Valley (Merriam, 1915b) similarly suggests that the strata containing this type are of later age than the horizons in the Tejon Hills. Arnold and Anderson as well as Nomland mention the occurrence of *Pliohippus* sp. in the basal Jacalitos of the Coalinga region and point out that it is similar to *Pliohippus tehonensis* (Arnold and Anderson, 1910; Nomland, 1916). The Jacalitos form, however, is probably more advanced than the latter.

Nannippus tehonensis occurs in the Neroly and Orinda of the San Francisco Bay region (Stirton, 1939a, 1939b). A similar form was reported some years ago from the eastern flank of the Diablo Range southwest of Modesto (Merriam, 1916) and more recently from several scattered localities in the same region (Stirton, 1939b). Again, *N. tehonensis* has been reported from the Mint Canyon formation (Maxson, 1930; Stirton, 1933). These occurrences suggest that the faunas are more or less equivalent to that of the lower zone at Comanche Point (Stirton, 1936, 1939). The Mint Canyon, however, on the evidence of stratigraphy (Jahns, 1939), is probably Miocene, although later than the Barstow. Moreover, the *Nannippus* species from both southern localities are more primitive than those of the San Francisco Bay area. It would appear then that there are at least two occurrences of hipparions in the Upper Miocene of this region. Similar occurrences may be expected in the Ellensburg and possibly in the Neroly.

Present evidence tends to show that the upper Tejon Hills fauna is slightly more advanced than the Siesta. Teeth referred to *Hipparion* cf. *mohavense* from the Chanac, for example, are slightly higher-crowned than those of a comparable form from the northern locality. This conclusion was also reached by Stirton (1939b).

Lower teeth of *Hipparion condoni* from the Ellensburg formation of Washington (Merriam, 1915b) are very similar to those of *Nannippus tehonensis*, and indicate apparently a close relationship in time. A fauna, as yet not completely described, from the Smith Valley beds of Nevada contains a *Pliohippus* similar to *P. leardi* and a species of *Hipparion* which is smaller than *Nannippus tehonensis* and in which the upper teeth have more complicated fossettes. A single upper tooth of *Pliohippus* from near Sunland, California, reported to have come from the Saugus formation, is similar to those of the large *Pliohippus* from the Tejon Hills.

Neohipparion gratum of the Great Plains Tertiary is more advanced than *Nannippus tehonensis*. This is indicated by its more hypsodont teeth, greater elongation of protocone, absence of spur on this cusp, more distinctly curved crown, greater flattening of outer walls of protoconid and hypoconid, and less angular gutter. (See also page 11.)

Two horses from the Ricardo formation (Merriam, 1919) appear to be slightly more advanced than those of the Chanac, although the Ricardo formation may be in part equivalent to the upper Chanac. *Hipparton* sp. B from the Ricardo is similar to *Nannippus* cf. *tehonensis* of the upper fauna. The Barstow forms are distinctly less advanced than those from the lower horizon of the Tejon Hills.

Hipparton near *mohavense*, from the Puente formation (Stock, 1928), appears to be almost identical with the species *H.* cf. *mohavense* in the Tejon Hills upper fauna. This suggests that the Puente formation is in part Lower Pliocene.

CORRELATION CHART OF VERTEBRATE FAUNAL HORIZONS

Age	Pacific Coast province	Great Basin province
Middle Pliocene	Etchegoin Pinole Kern River Jacalitos	Thousand Creek Rattlesnake
Lower Pliocene	Upper Tejon Hills (Chanac) Siesta Orinda	Upper Ricardo Lower Ricardo Avawatz*
Upper Miocene	Mint Canyon Lower Tejon Hills (Santa Margarita)	Barstow

* Henshaw, 1939.

DESCRIPTION OF SPECIES

EQUIDAE FROM THE SANTA MARGARITA FORMATION

Nannippus tehonensis (Merriam)

Neohipparion gratum tehonense, n. subsp. Merriam. J. C. Merriam, Mammalian remains from the Chanac formation of the Tejon Hills, California. Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, no. 8, pp. 118-120, figs. 1-9, 1916.

Hipparion gratum tehonense Merriam. H. F. Osborn, Equidae of the Oligocene, Miocene and Pliocene of North America, iconographic type revision. Mem. Amer. Mus. Nat. Hist., vol. 2, p. 189, fig. 152, 1918.

Nannippus tehonensis (Merriam). R. A. Stirton, Cenozoic mammal remains from the San Francisco Bay region. Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 24, no. 13, pp. 347-352, figs. 10-24, 1939.

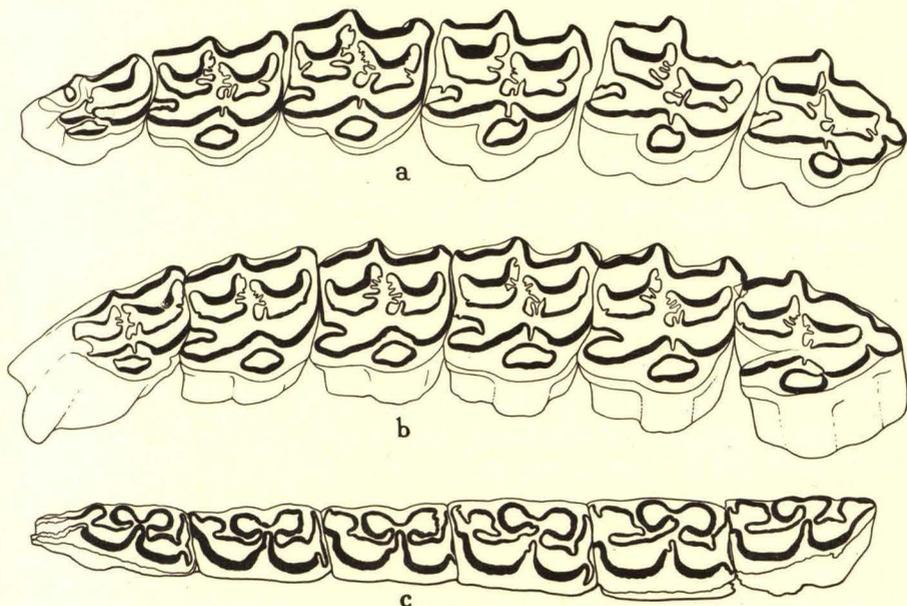


Fig. 3. *Nannippus tehonensis* (Merriam). a, slightly worn P²-M³, no. 2591; b, moderately worn P²-M³, no. 2598; c, moderately worn P₂-M₃, no. 2606. Natural size. Calif. Inst. Tech. Vert. Pale. locality 303.

This species was originally described as *Neohipparion gratum tehonense* by John C. Merriam in 1916 on the basis of isolated teeth. Certain constant and important differences between the California and Great Plains forms necessitate the recognition of the former as of specific status. These differences have not been adequately established in print, so far as the writer is aware. They may be stated as follows: *Neohipparion gratum* has higher-crowned molar teeth with crowns more curved. Its upper teeth have an isolated enamel lake in the hypocone formed by total constriction of the posthypoconal valley. Moreover, in these teeth the protocone is more elongate, the fossettes are

relatively wider transversely, and the parastyle and mesostyle are weaker than in the California type. In the lower molars *Neohipparion gratum* differs from *Nannippus tehonensis* in having a shallower gutter and more complex plications of the enamel in the central valleys. The valley in the outer wall does not extend so deeply into the interior of the tooth and is often characterized by a plication between metalophid and hypolophid.

In view of these differences and in view also of the larger collection now available at the California Institute of Technology from the Tejon Hills, it seems desirable to record additional characters of *Nannippus tehonensis*.

Upper dentition. The upper cheek teeth are moderately high-crowned and heavily cemented. They are squarish in shape and only slightly curved. The premolars are noticeably larger than the molars in crown size. The protocone is small, and rounded to semilenticular, that of M^2 and M^3 being relatively flat. As a rule, this cusp is not separate at the base in P^2 . In the premolars, and also occasionally in the molars, the protocone has a spur which projects in the direction of the protoconule and with which it becomes united in advanced stages of wear. The protocone is approximately equal to the hypocone in size. The hypocone is given definition by a strongly developed posthypoconal valley. The pli caballin is a simple fold. The outer borders of the fossettes are transversely narrow. One of the plications on the border of the prefossette is almost completely pinched off to form an isolated lake, but it is never completely isolated as in *Neohipparion gratum*. The crown tapers definitely toward the base, so that the tooth size becomes distinctly smaller as wear increases. The mesostyle approximates the parastyle in heaviness, although it is slightly more slender than the latter in the premolars. Frequently the premolars, and sometimes the molars, show a faint metastyle. The protocone is less flattened in the milk teeth than in the permanent grinders. The crown is subhypsodont and is not heavily cemented.

Lower dentition. The lower molars have high crowns and are also heavily cemented. They are rectangular in shape and taper toward their bases. As in the upper teeth, the premolars are much larger than the molars. The metaconid-metastylid column is distinct to the base of the tooth. It is long anteroposteriorly, and has a moderately deep to shallow gutter. The outer walls of protoconid and hypoconid are either slightly flattened or round. A prominent style is present at the anteroexternal corner of the protoconid. An outer valley extends deeply into the tooth. The deciduous lower molars do not have a heavy coating of cement.

Several fragmentary limb elements are in the collection, but the specimens apparently have no characters of diagnostic value.

Measurements of dentition of Nannippus tehonensis (in millimeters)

The transverse diameter of the crown does not include the mesostyle, but is measured from the farthest indentation of the paraconid-metaconid wall to the farthest lingual projection of the protocone (Bode, 1935). This method of measuring makes possible a comparison of a greater number of teeth, since the mesostyle is often broken away. Moreover, it gives a better indication of the general shape of the tooth. The anteroposterior length of the crown in the upper molars is taken between the wearing facets on the anterior and posterior faces of the tooth. In the lower molars the width of the tooth is measured across the enamel walls of the metaconid and protoconid.

A: C.I.T. no. 2591 (fig. 3a)

B: C.I.T. no. 2598 (fig. 3b)

C: C.I.T. no. 2604

D: C.I.T. no. 2606 (fig. 3c)

Anteroposterior diameter

Anteroposterior diameter				Length of protocone		Length of metaconid-metastylid column	
A	B	C	D	A	B	C	D
P ²....22.1	22.4	P ₂....19.3	20.4	5.1	6.4	8.6	8.4
P ³....19.0	18.9	P ₃....18.8	19.1	5.9	7.2	10.4	11.1
P ⁴....19.1	18.7	P ₄....19.4	18.8	6.3	7.7	10.5	11.1
M ¹....18.3	17.8	M ₁....18.5	17.9	5.8	6.4	10.8	10.6
M ²....16.8	17.4	M ₂....18.8	17.8	5.8	6.1	9.7	10.0
M ³....15.8	16.4	M ₃....18.7	17.5	5.9	6.4	7.4	8.9

Transverse diameter

P ²....14.0	13.3	P ₂ 8.2	8.0
P ³....13.0	14.6	P ₃....10.5	10.7
P ⁴....14.6	14.1	P ₄....10.1	10.4
M ¹....14.7	14.2	M ₁ 9.2	9.4
M ²....13.2	14.5	M ₂ 8.8	8.9
M ³ 8.9	10.4	M ₃ 6.8	7.7

Length of upper molar series: A, 50.9; B, 52.2

Length of upper premolar series: A, 58.2; B, 60.5

Length of lower molar series: C, 56.0; D, 52.9

Length of lower premolar series: C, 57.5; D, 59.0

Maximum length of crown of unworn specimens, 40

In the light of the larger collection available, the teeth from the Tejon Hills originally referred to *Neohipparion* near *molle* by Merriam are now seen to be a variation of the dentition characteristic of *Nannippus tehonensis*. All the differences listed by Merriam can be duplicated in specimens of the latter species. Similarly, those teeth referred to *Neohipparion* near *gratum tehonense* by Merriam are likewise referable to *Nannippus tehonensis*.

Nannippus tehonensis closely resembles the species *Hipparion condoni* as based upon the lower molars described by Merriam from the Ellensburg formation of

Washington (Merriam, 1915b). It differs only in slightly smaller size, but this difference does not appear to be of sufficient importance to separate the two. However, since no upper teeth have thus far been described from the Ellensburg, and since the type specimen of *H. condoni* is now not available for comparison, it seems best to await larger collections from the Ellensburg before a more detailed statement is made concerning the relationships of these species.

The species of *Nannippus* from the lower horizon of the Tejon Hills differs from *Neohipparion molle* and from the hipparion from the Kern River beds in its smaller size and in the shorter and smaller protocone. *Hipparion dolichops* Gidley from South Dakota appears to be very similar, but is larger, with more complicated fossette borders in the cheek teeth. In this species also the fossettes are wider transversely and the protocone is flatter than in *Nannippus tehonensis*.

Although teeth of *N. tehonensis* are similar to those referred to *Nannippus* by Stirton from the vicinity of San Francisco Bay, several differences prevail which suggest that the species from the Tejon Hills is more primitive than the northern forms, and which may ultimately necessitate a recognition of the latter as a separate species. On the other hand, more material from the northern localities may demonstrate that the differences are due to individual variation. *Nannippus tehonensis* from the type locality is slightly less hypsodont, the maximum height of the unworn crown being 40 mm., as compared with 44 mm. in the specimens described by Stirton. There appears to be less tendency for the protocone to be separate from the protoselene in teeth from the Tejon Hills. Many specimens are available in which this cusp is not distinct at 15 or more millimeters above the base of the tooth. Stirton states that in only one specimen among a number of teeth from the Orinda is the protocone connected with the protoselene 8.5 mm. above the base; in all others apparently the protocone is separate to the base (Stirton, 1939b). Associated with this character, and pointing toward relation with *Merychippus*, is the frequent presence of a spur on the buccal side of the protocone, which becomes connected with the protoselene with wear. In specimens of *N. tehonensis* from the type locality the crown is slightly less curved and slightly smaller than that in the teeth described by Stirton. The lower teeth have a prominent protostylid.

Material of a *Nannippus*-like form from the Mint Canyon formation is insufficient to permit a satisfactory comparison with *N. tehonensis*. A single tooth, M³, described by Maxson and referred by him to the genus *Merychippus*, has an open postfossette, an unusual character which may be duplicated in specimens from the Tejon Hills that are regarded as variants of *N. tehonensis*. However, the tooth has more slender styles and the crown appears to show slightly greater curvature than in specimens of *N. tehonensis*. On the

basis of these characters the Mint Canyon specimen may represent a slightly more primitive type of horse than *N. tehonensis*. It is significant that teeth compared with those of *Hipparion mohavense* occur higher in the Mint Canyon section. That portion of the Mint Canyon formation whence the single tooth comes may be related in time to the lower zone of the Tejon Hills.

Pliohippus tehonensis (Merriam)

Protohippus tehonensis Merriam. J. C. Merriam, Mammalian remains from the Chanac formation of the Tejon Hills, California. Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, no. 8, p. 125, figs. 14, 15, 1916.

This species from the Tejon Hills was described by Merriam on the basis of a single upper molar, no. 21779 in the University of California collections. To this species is assigned also a lower premolar, no. 21484. Although much fossil material has subsequently been found by field parties of the California

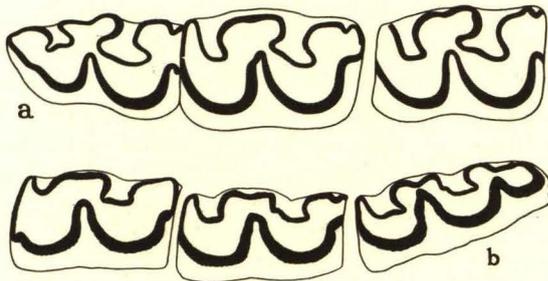


Fig. 4. *Pliohippus tehonensis* (Merriam). a, moderately worn P_2 - P_4 , no. 2617; b, moderately worn M_1 - M_3 , no. 2618. Natural size. Calif. Inst. Tech. Vert. Pale. locality 303.

Institute of Technology, no additional complete upper teeth of this species were obtained. A sufficient number of fragments have been uncovered in place, however, to demonstrate that the species belongs to the lower fauna. Moreover, two specimens of the lower dentition, C.I.T. no. 2617 with P_2 to P_4 and no. 2618 with M_1 to M_3 , were obtained from quarries in the Santa Margarita formation.

In 1935 Stock described a section of a lower jaw, C.I.T. no. 1825, containing Dp_2 - Dp_4 and M_1 , taken from a depth of 5217 feet in the core of a well located several miles northwest of Comanche Point (Stock, 1935). This specimen was identified as *Protohippus tehonensis* and the characters of the milk dentition and of M_1 were given.

M_1 in the specimen from the well core is practically unworn, whereas in those teeth obtained at the surface the crowns are worn. The latter demonstrate that with increased wear the gutter between metaconid and metastylid becomes shallower and almost disappears. Similarly, the internal valleys tend to be reduced, especially in the molars. The external valley, however, remains deep although the cant to the front becomes less pronounced. In

general, with advancing wear the appearance of the occlusal surface becomes more like that in *Merychippus*. The posteroexternal style, which in the milk teeth is very prominent, is slightly less so in the permanent teeth. On the other hand, the anteroexternal style practically disappears, although it is still seen in a reduced state in M_1 . The length of the metaconid-metastylid column is less in the permanent dentition than in the milk dentition, and seems to decrease somewhat with wear. The entoconid is large.

Measurements of dentition of Pliohippus tehonensis (in millimeters)

Specimen no.	Anteroposterior diameter	Transverse diameter	Length of metaconid-metastylid column
C.I.T. 2617, P_2	23.9	11.4	8.9
C.I.T. 2617, P_3	24.1	13.7	9.1
C.I.T. 2617, P_4	23.8	13.8	9.7
C.I.T. 2618, M_1	21.9	11.0	8.4
C.I.T. 2618, M_2	22.6	10.3	8.4
C.I.T. 2618, M_3	26.5	9.1	7.9
U.C. 21484, P_4	22.8	11.7	9.2
C.I.T. 1825, M_1	26.3	11.4	11.8
C.I.T. 1825, Dp_3	26.4	14.9	13.9
C.I.T. 1825, Dp_4	28.6	13.8	12.9
U.C. 21779, M^1	22.5	20.5	....

There are differences between the specimen from the well core and teeth obtained from surface exposures of the Santa Margarita. Particularly is this true of the relative length of the metaconid-metastylid column and of the width of the tooth. Although it is possible that the specimen from the well core represents a species distinct from *P. tehonensis*, it appears more likely that the differences in dimensions are due to individual variation and to stage of wear.

An upper tooth from the Jacalitos of the north Coalinga region, which according to Merriam resembled *P. tehonensis* (Merriam, 1916), appears to be more advanced than this species and is similar to the *Pliohippus* species from the Chanac (upper Tejon Hills fauna) in the peculiar shape of the protocone. A fragmentary upper molar assigned to *Merychippus* sp. by Merriam in his first publication on the fauna from the Tejon Hills resembles *P. tehonensis* in size and in the character of the fossettes.

EQUIDAE FROM THE CHANAC FORMATION

Hipparion cf. *mohavense* Merriam

Hipparion (?) *mohavense* Merriam. J. C. Merriam, New protohippine horses from Tertiary beds on the western border of the Mohave Desert, Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, no. 23, pp. 436-440, figs. 1a-3b, 1913.

The material in the collections of the California Institute of Technology, referable to this type, consists of ten upper and twelve lower cheek teeth, both permanent and deciduous. There are no specimens that can be directly associated.

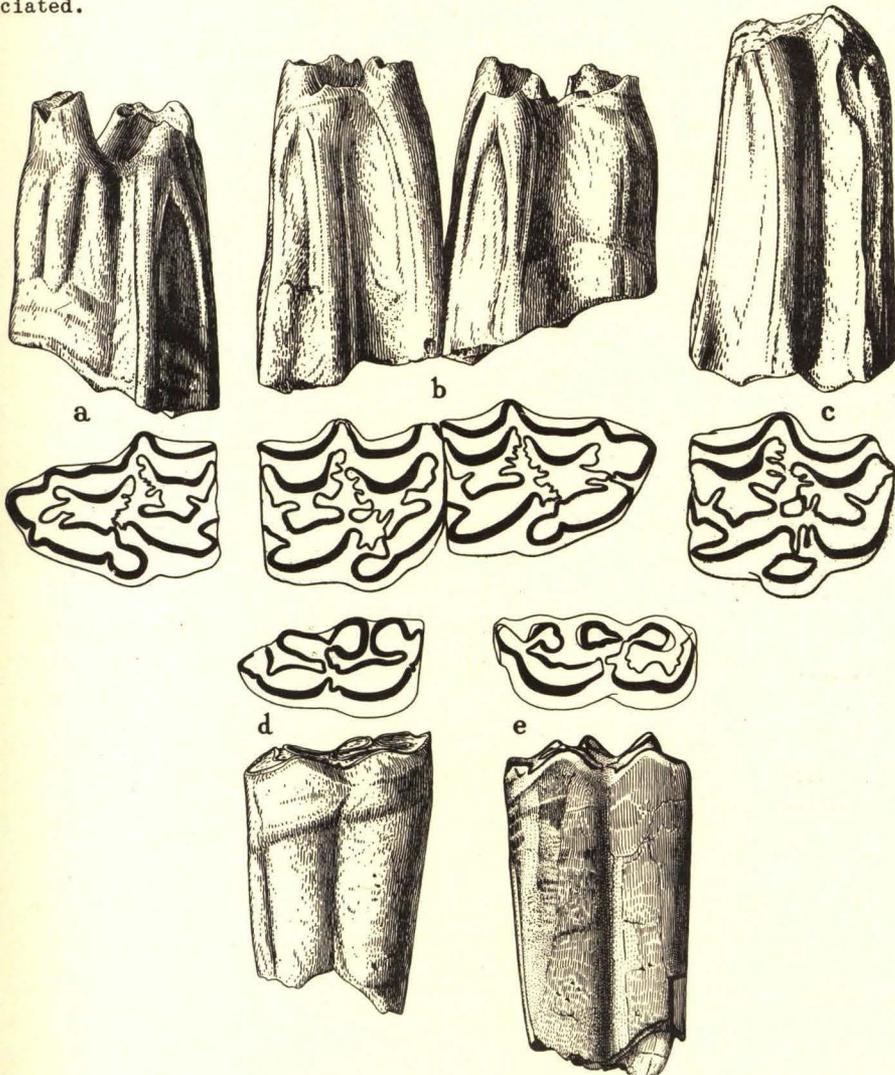


Fig. 5. *Hipparion* cf. *mohavense* Merriam. a, P², no. 1177; b, P² and P³, nos. 1178 and 1179; c, P⁴, no. 1180; d, P₂, no. 1176; e, M₁, no. 2623. Natural size. Calif. Inst. Tech. Vert. Pale. locality 104.

These specimens differ from the type of *Hipparion mohavense* (Merriam, 1913) in having a smaller protocone which shows less tendency to become discrete; in several teeth the protocone and protoconule are connected in crowns showing only moderate wear. The enamel plications of the fossette borders are slightly less complicated than in the Ricardo species, and the teeth appear to be somewhat shorter-crowned. In these characters the teeth from the Chanac seem to be more primitive than the type from the Ricardo formation. Other differences may be pointed out, as follows: The prefossette in the Chanac form is frequently open in the premolars, and may be open both lingually and posteriorly. In the lower teeth the protoconid and hypoconid may be separated by a canal, and the metastylid is often separate. In these characters the Chanac species seems to approach *H. mohavense callodonte* Merriam from the Ricardo (Merriam, 1919), but it differs in having fewer plications of the fossette borders, and especially in the enamel pattern of the lower molars.

The teeth from the Chanac are elongate anteroposteriorly, as may be seen in figure 5 and from the table of measurements. The mesostyle is heavier in the premolars than in the type of *H. mohavense*. In the milk molars the crowns are elongate and have a heavy deposit of cement, the fossettes are open in worn stages, and the length of crown is less than the anteroposterior diameter.

Additional as well as better specimens from the Chanac may demonstrate that the species from these deposits is distinct from *H. mohavense*. It may be more closely related to *H. mohavense callodonte*.

Measurements of dentition of Hipparion cf. mohavense (in millimeters)

Specimen no. (C.I.T. coll.)	Anteroposterior diameter	Transverse diameter	Length of protocone	Length of metaconid- metastylid column
1177, P ²	29.3	15.0	5.5	....
1178, P ²	28.9	16.4	5.5	....
1179, P ³	24.4	16.8	6.1	....
1180, P ⁴	27.4	17.6	6.7	....
2618, M ¹	24.1	15.9	5.5	....
2620, M ²	21.9	16.3	6.4	....
2623, M ₁	25.8	10.8	...	12.3
1176, P ₂	25.3	9.1	...	12.0
2628, P ₃	22.5	13.0	...	13.1
2622, P ₃	22.7	11.7	...	13.7

Nannippus cf. tehonensis (Merriam)

From the Chanac quarries come nine upper and four lower teeth which closely resemble comparable teeth of *Nannippus tehonensis* from the quarries lower in the stratigraphic section. It appears possible that this equid evolved from the species *N. tehonensis* during the period represented by the transitional beds between the Santa Margarita and the Chanac formations. Some constant features distinguish the two, but the characters do not seem of such importance as to merit specific separation.

The teeth are larger than those of *N. tehonensis*; they have a smaller and more rounded protocone; their fossettes are relatively wider transversely, but the difference is not great; they have a shallower posthypoconal valley. *Nannippus* sp., described by Stirton (Stirton, 1939b) from Univ. Calif. locality V3611, northeast of Moraga, Contra Costa County, is probably identical with the Chanac form.

A comparison of this form with similar types from the lower quarries suggests that in the evolution of the group a larger-crowned molar was developed. This appears to be at variance with the view that in later stages of time cheek teeth of *Nannippus* undergo reduction in size with increase in length of crown.

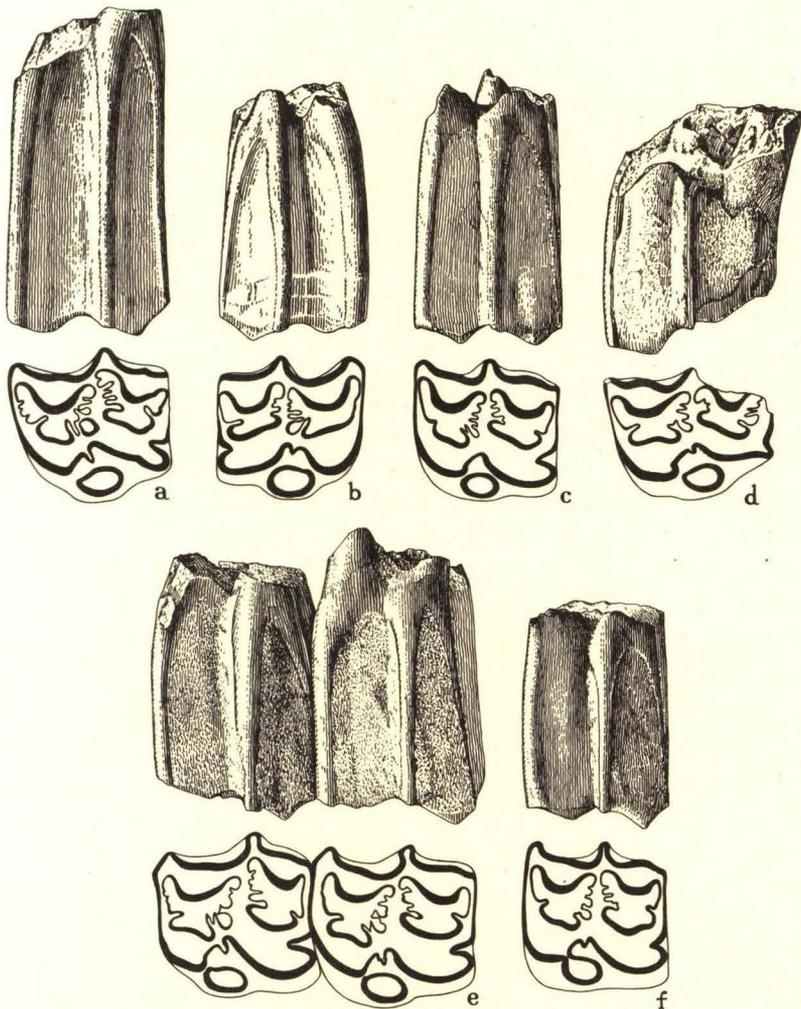


Fig. 6. *Nannippus* cf. *tehonensis* (Merriam). a, M¹, no. 1181; b, M¹, no. 1182; c, M¹, no. 1185; d, M³, no. 1184; e, P³, no. 1186; f, P³ and P⁴, no. 1183. Natural size. Calif. Inst. Tech. Vert. Pale. locality 104.

Measurements of dentition of Nannippus cf. tehonensis (in millimeters)

Specimen no. (C.I.T. coll.)	Anteroposterior diameter	Transverse diameter	Length of protocone	Length of metaconid- metastylid column
1183, P ³	21.1	17.3	6.4	....
1183, P ⁴	21.7	17.6	6.4	....
1181, M ¹	19.8	15.8	5.4	....
2624, M ³	19.4	13.2	4.9	....
2619, P ₃	22.4	12.8	...	13.0
2761, M ₁	20.1	11.9	...	12.4
2618, M ₂	22.5	10.5	...	12.6

Pliohippus leardi, n. sp.

Holotype. C.I.T. no. 2645, M¹, about one-fifth worn, from locality 302, Comanche Point; plate 2, figures 3, 3a, 3b.

Paratypes. C.I.T. no. 578, a composite series with P² to M³, about two-fifths worn, from locality 104, Comanche Point; plate 2, figure 1. C.I.T. no. 2650, P₃, locality 302; plate 3, figures 5, 5a, C.I.T. no. 2654, Dp³, locality 104; plate 2, figures 4, 4a, C.I.T. no. 2633, Dp₂-Dp₃, a slightly worn, complete set in lower jaw, from locality 305; plate 3, figures 1, 1a.

Teeth of this species are the most abundant specimens in the Chanac quarries. Unfortunately, in no instance was a complete dental series uncovered; in fact, only a few teeth were found associated. A sufficient number of upper teeth were obtained, however, to construct composite series, and many single teeth in all positions and stages of wear are available. No known fossil horses are identified with this form, and the type is therefore described as a new species. It is a pleasure to name the species for R. M. Leard, field collector for the California Institute of Technology.

Specific characters. The size of the molars is like that in *Pliohippus nobilis* Osborn, or larger in unworn teeth. The cheek teeth are long-crowned and moderately curved, with a very strong taper toward the root region associated with pronounced changes in enamel pattern. The protocone, which in unworn teeth is elongated and lenticular, with flattened buccal side, and is connected with the protoconule by a very narrow isthmus, becomes rounded and more strongly connected with increased wear. Although this change follows normally with wear, it is usually not so marked in other species. The tapering of the crown is so pronounced that the tooth diminishes to three-fourths or less of its original size after extreme wear. This feature is most evident in the molars, less so in the premolars. In the upper teeth the fossettes are simple; a single pli caballin is present; the hypocone is small with no lingual constriction. The teeth are squarish after wear, and heavily cemented; there is a prominent pli crochet in most teeth in early stages of wear; occasionally there is a small plication in back of the postfossette; the fossettes are sometimes connected; the prefossette is sometimes open internally in early stages. One prominent single fold enters the postfossette from the median portion of the metaloph,

and another enters the prefossette opposite the pli caballin; the hypoconal valley does not remain distinct, but disappears with wear. The lower molars are very long and straight, with distinctly separated metaconid and metastylid and prominent external valley. The premolars are much heavier than the molars; the protoconid and hypoconid have rounded external faces; there is a moderate postero-external style; the entostylid is swollen. The milk teeth have less cement and much shorter crowns than the permanent teeth.

A number of limb elements are assigned to *Pliohippus leardi* on the basis of size and proportions, but no diagnostic characters were observed.

Comparisons. The pronounced tapering of the crown toward the root region of the upper molars, and the decided changes which take place in size and in enamel pattern with wear, require recognition of similar stages of wear when comparisons are made between *P. leardi* and other species. Since many of the figured and described specimens are not moderately worn or unworn teeth, it is possible that

Measurements of dentition of Pliohippus leardi (in millimeters)

Specimen no. (C.I.T. coll.)	Anteroposterior diameter	Transverse diameter	Length of protocone	Height of crown	Length of metaconid- metastylid column
578, P ₂ *.....	34.7	21.8	7.2	....	....
578, P ₃ *.....	28.1	22.6	7.3	....	....
578, P ₄ *.....	28.6	22.8	7.6	....	....
578, M ₁ *.....	26.9	22.7	8.5	....	....
578, M ₂ *.....	27.5	21.4	8.4	....	....
578, M ₃ *.....	26.9	19.9	9.7	....	....
2642, P ₂	34.8	23.0	8.7	50.5	....
2638, P ₃	30.7	23.6	9.7	64.8	....
2660, P ₄	30.8	21.7	11.1	68.5	....
2658, M ₁	30.5	20.7	9.9	71.5	....
2659, M ₂	31.9	21.8	9.7	70.6	....
2647, M ₃	27.1	19.1	9.8	62.5 _a	....
2762, P ₂	31.8	11.3	....	.....	10.5
2650, P ₃	30.5	15.1	....	69.0	12.1
2650, P ₄	31.7	14.6	....	71.0 _a	13.4
2673, M ₁	27.7	12.4	....	.....	10.7
2673, M ₃	32.9	11.3	....	59.0 _a	10.0
2633, Dp ₂	37.6	8.9	....	2657 25.0 _a	14.7
2633, Dp ₃	33.6	11.6	....	2657 32.0 _a	14.0
2633, Dp ₄	34.5	10.7	....	2636 33.0 _a	12.7

* About half worn.

a, approximate.

future examination of such teeth may demonstrate relations between species already described and that occurring at the Tejon Hills. At present five species are known to be sufficiently close to the Chanac type to deserve comparison here.

Pliohippus leardi most closely resembles *P. nobilis* Osborn, from Long Island, Kansas. It differs in the following details: Although unworn cheek teeth are a little larger, the pronounced tapering of the crown soon reduces the size to such an extent that for most of its wear the crown size is actually smaller than in *P. nobilis*. The protocone does not become united with the hypocone until ex-

treme wear takes place; this cusp is more elongate at first and has a flat buccal side; later the protocone becomes rounded in the premolars and oval in the molars. The fossettes in the molar teeth are not so expanded as in *P. nobilis*.

As compared with *P. supremus* Leidy from South Dakota, the Chanac form is larger and the upper cheek teeth of the latter have more curved crowns with slightly larger protocone. The teeth are more elongate; the para- and mesostyles seem more prominent; the fossettes are not open; the hypocone has no lingual indentation.

Teeth of *P. leidyani* Osborn from the Snake Creek beds are considerably smaller and slightly less hypsodont, and have less pronounced tapering of the crown. Moreover, the enamel pattern is more complicated, especially in the lower molars, and the hypocone is set off more strongly by an indentation on the lingual side.

Pliohippus tantalus Merriam from the Ricardo formation (Merriam, 1913) differs in smaller size. The fossettes are larger and their borders more complicated.

Pliohippus cf. *interpolatus*, recently described from the Pinole tuff (Stirton, 1939b), is smaller with a somewhat different protocone and hypocone. A hypocoanal lake is also present, a feature not observed in *P. leardi*.

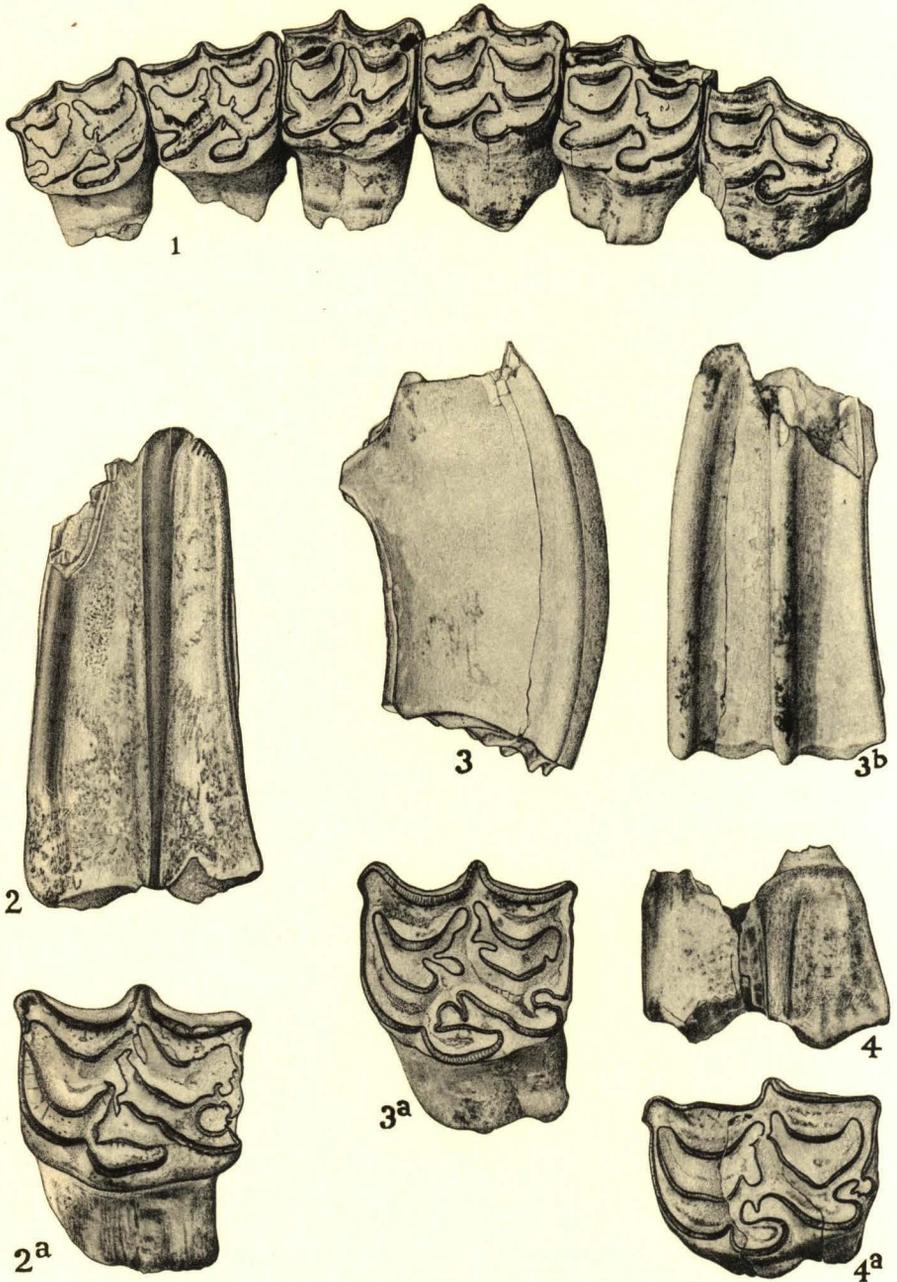
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View looking east in northern part of Tejon Hills, Kern County, California, showing disconformable contact between the soft, white to gray, coarse, granitic sandstones of the marine Santa Margarita formation and the overlying buff, coarse, cross-bedded, ill sorted Chanac fanglomerates.



Pliohippus leardi, n. sp.

FIG. 1. No. 578, paratype, composite upper cheek-tooth series, occlusal view. $\times \frac{2}{3}$.

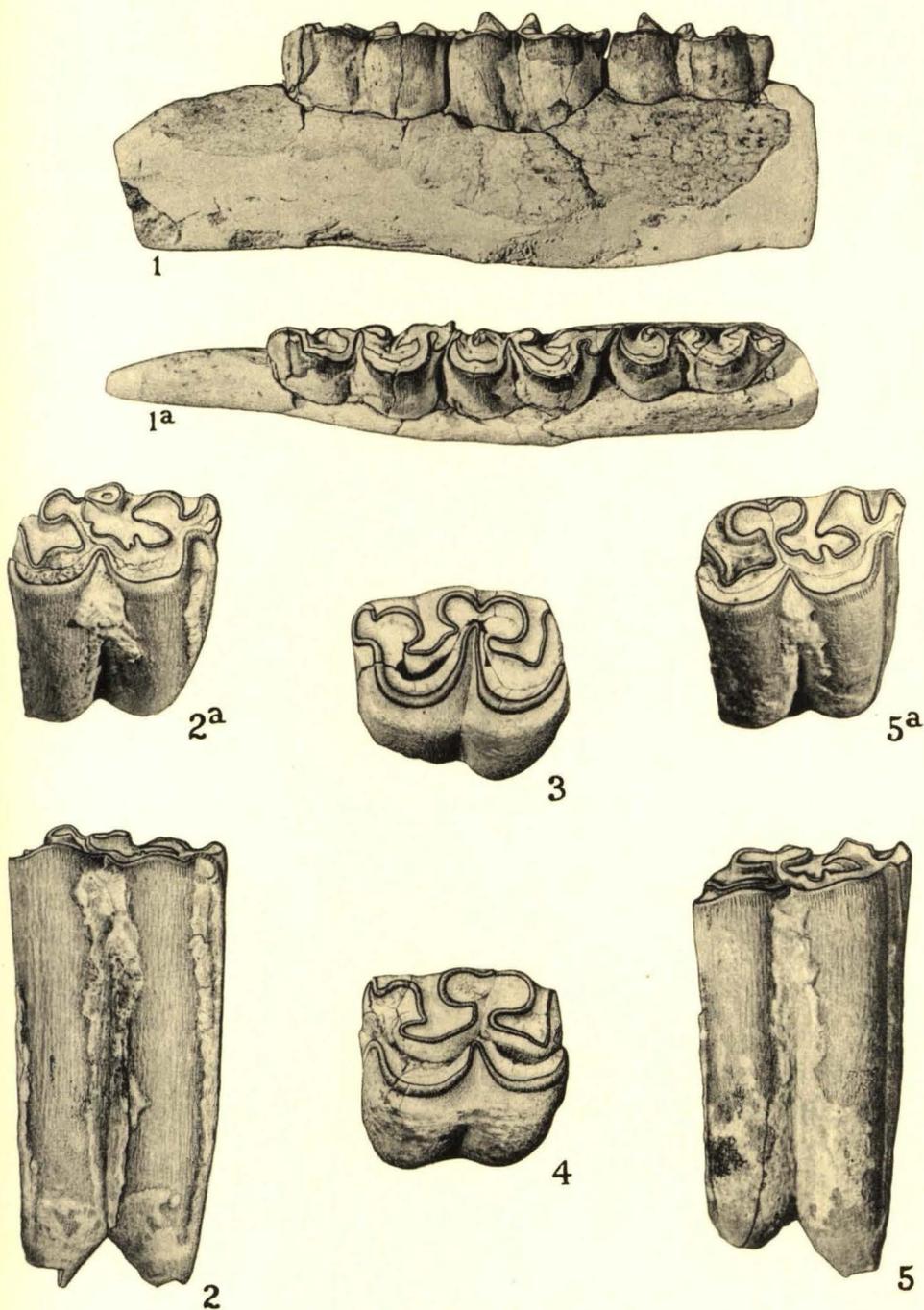
FIGS. 2, 2a. No. 2660, P⁴, lateral and occlusal views. $\times 1$.

FIGS. 3, 3a, 3b. No. 2645, holotype, M³, anterior, occlusal, and lateral views. $\times 1$.

FIGS. 4, 4a. No. 2654, paratype, Dp³, lateral and occlusal views. $\times 1$.

Calif. Inst. Tech. Vert. Pale. Coll.

Lower Pliocene, Tejon Hills, Kern County, California



Pliohippus leardi, n. sp.

FIGS. 1, 1a. No. 2633, paratype, Dp₂-Dp₄, lateral and occlusal views. × ⅓.

FIGS. 2, 2a. No. 2650, paratype, M₁, lateral and occlusal views. × 1.

FIG. 3. No. 2674, P₄, occlusal view. × 1.

FIG. 4. No. 2805, P₄, occlusal view. × 1.

FIGS. 5, 5a. No. 2650, paratype, P₃, lateral and occlusal views. × 1.

Calif. Inst. Tech. Vert. Pale. Coll.

Lower Pliocene, Tejon Hills, Kern County, California