

**Article III.—TERTIARY LAND MAMMALS OF FLORIDA**

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## INTRODUCTION

The Tertiary mammals of the United States west of the 95th meridian are fairly well known. East of there they are almost unknown, including only a few confusing occurrences along the central Atlantic seaboard and a larger number of specimens from the State of Florida. It is to the latter that one must turn for any positive knowledge, but the literature on the Tertiary mammals of Florida is widely scattered, incompletely representative of possible present knowledge, and in some cases distinctly misapprehensive. An attempt is here made to gather together and make available what has been or can be learned from the materials now at hand.

The unraveling of this history in Florida is attended by peculiar difficulties. The specimens themselves are usually fragmentary and their identification often tentative at best. In addition to this primary palæontological problem is the still more serious task of determining their stratigraphic origin and sequence. Aside from possible errors or incompleteness in old field records, the beds in which these mammals occur often are of a peculiar nature and contain a mixture of fossils difficult to sort. With these problems solved, however tentatively, one may proceed to broader considerations.

The most general of these broader problems are: first, whether the eastern faunal sequence is similar to that known in the West; second, whether Florida has been a part of the American mainland, or whether, as often supposed, it was at one time rather a part of the Caribbean province, and third, what the respective ages of the Florida mammal-bearing deposits are relative to the western deposits. It seems possible now to give reasonable answers to all of these questions. In Florida, at least, the later Tertiary mammalian sequence seems to have been very like that in the western States. The known genera are all known also in western deposits, and the specific distinctions, in so far as they are real and in so far as they are not due to accidents of collecting, can be explained as due to geographic separation (but not isolation) and to differences in facies. In answer to the second query, it follows from this fact that central and northern Florida, at least, has been an integral part of the North American Continent since the beginning of the Miocene and shows no special affinities in the known land fauna with the Caribbean region or with Central or South America. The question of correlation of the various formations is taken up in detail below.

The basis for this revision is three-fold: actual specimens, described and undescribed, field work, and previous studies by other workers. Most of the available specimens now belong to the Florida State Geological Survey and have been generously loaned without restriction, through the courtesy of Mr. Herman Gunter, State Geologist. Other specimens are in the American Museum collections. Some material, including a number of the older type specimens, is in the United States National Museum and has been available for comparison through the courtesy of Dr. J. W. Gidley. A small amount of material is retained in private possession, but some of this has also been available for study, notably Pliocene Proboscidea in the collection of Mr. Burdette Loomis at Pierce, Florida, and some derived Pliocene fossils in the collection of Mr. J. E. Moore at Sarasota.

In February and March, 1929, I visited most of the Miocene and Pliocene mammal localities in Florida, gathering field data and collecting some new material. In this reconnaissance I was accompanied and greatly assisted in many ways by Herman Gunter and G. E. Ponton of the Florida State Geological Survey, to whom warmest thanks are due for the cooperation without which this work would have been impossible. Investigation of the river pebble phosphates of the Peace River was carried out jointly with Mr. Walter W. Holmes, Field Associate of the American Museum.

In 1924, Dr. W. D. Matthew made preliminary studies of collections and localities in Florida and incorporated his conclusions in an unpublished manuscript entitled "Observations upon Fossil Mammalian Faunas of Florida." This manuscript he has very generously placed in my hands, and while its data and conclusions are not here incorporated as such, it has been of value in preparing this more extensive revision, as acknowledged in the text by the citation Matthew (ms.).

In addition to acknowledgments already made, thanks are particularly due to the following for aid in various phases of this study: Mr. E. B. Epps of Tallahassee, Mr. G. T. Brooks and Mr. H. S. Jenkins at Midway, Mr. R. H. Hopkins, Mr. C. L. Sowell, and Mr. R. E. Mawhinney at Quincy, Mr. Franz Weston at Newberry, Mr. J. M. Mixson at Williston, Mr. H. F. Greene at Coronet, Mr. E. T. Casler, Mr. G. R. Barber, and Mr. E. W. Smith (of New York) at Nichols, the late Mr. Anton Schneider at Lakeland, Mr. H. E. Collins at Pierce, Mr. H. L. Meade and Mr. W. S. Washburn at Brewster, and Mr. J. T. Bullwinkel of New York.

Previous papers on the subjects here considered are listed in the appended bibliography. Particularly important are the studies of Leidy and Lucas on the Pliocene fauna, those of Sellards on the Miocene and Pliocene stratigraphy and faunas, and the recent general stratigraphic review and geologic map by Cooke and Mossom.

Land mammals are known only from the formations here designated as Hawthorn, Alachua, and Bone Valley, except that bones and teeth derived from one of these may be found in Pleistocene or recent deposits.

The general stratigraphy of the Tertiary of Florida is shown in Table I (essentially after Cooke and Mossom).

TABLE I

PLIOCENE	Citronelle formation, Caloosahatchee marl, Alachua formation, Bone Valley gravel—occurring in different areas and of uncertain stratigraphic relationships.			
MIOCENE	Choctawhatchee formation			
	Alum Bluff	Shoal River	Hawthorn formation	
		Oak Grove		
		Chipola		
Tampa limestone				
OLIGOCENE	Byram marl			
	Glendon limestone			
	Mariana limestone			
	Ocala limestone			
EOCENE	(Buried)			

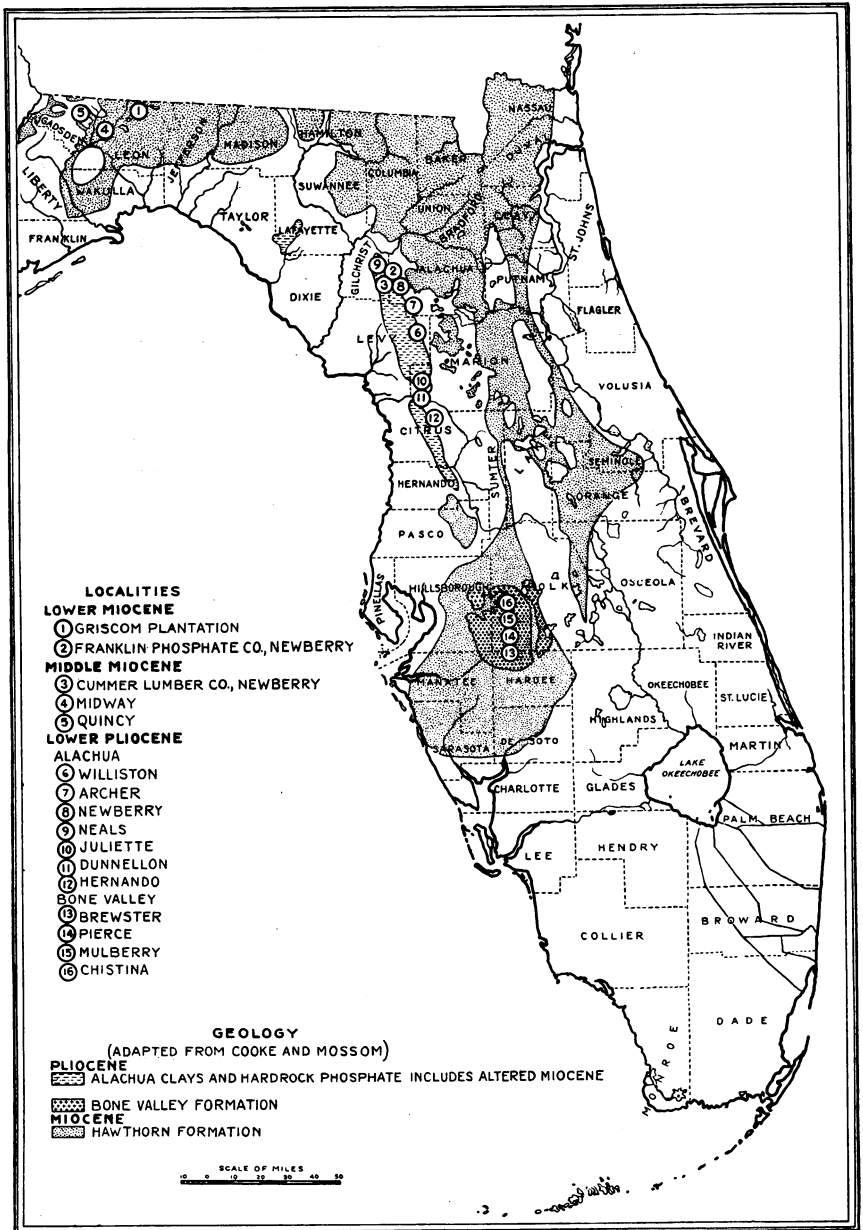


Fig. 1. Map of Florida (except extreme western part), showing distribution of Hawthorn, Alachua, and Bone Valley Formations and principal localities for Miocene and Pliocene mammals.



## MIOCENE

## HAWTHORN FORMATION

## Stratigraphy and Occurrence

Miocene land mammals occur in Florida chiefly in the Hawthorn Formation. This formation, as recognized by Cooke and Mossom, is heterogeneous and includes local members to which several other names have been given, such as the Sopchoppy limestone, Jacksonville limestone, etc. It is regarded as a member of the Alum Bluff group but in its present usage may well include equivalents of all of the three other members into which the group is divided. The separation is largely geographic, the Chipola, Oak Grove, and Shoal River occurring as such west of the Apalachicola River and being represented east of the river and south almost to Charlotte Harbor by the Hawthorn.

The Hawthorn Formation includes cream-colored, phosphate-bearing, sandy limestones, light-colored clays weathering bright red, fuller's earth, light-colored sands and marls, etc., and is generally quite variable horizontally and vertically.

The known Miocene land mammal occurrences are five in number:

1. Griscom Plantation. Sec. 32, T3N, R1E. About 15 miles north of Tallahassee, one-half mile south of an arm of Lake Iamonia, in Leon County. The fossils were encountered in digging a well on the Griscom Plantation at what is known as the Luna Place, at a point between the present house and barn, nearer the house. The well has now been filled in and the site sodded over. Sellards states that it passed through 15 to 20 feet of coarse red clayey sands, then gray phosphatic sands and clays until it terminated in hard limestone at a depth of about 60 feet. The fossils are said to have come from a depth of from 25 to 50 feet. Alfred Porter, a local negro who dug the well, was recently interviewed and stated that the bones occurred with oysters about 7 or 8 feet above the limestone, at a depth of about 55 feet from the surface. Several wells in this neighborhood were examined, but no additional materials were found. The specimens were all described by Sellards (1916, p. 82 seq.). It is uncertain whether the limestone here encountered was a basal Hawthorn limestone (Sopchoppy) or the underlying Tampa limestone. Sellards believed it to be Tampa ("Chattahoochee"), and the Tampa is said to be exposed at about this horizon on the Ocklocknee River a

TABLE II  
Typical Genera

Age	Mammal-Bearing Formations		Typical Genera	Remarks
RECENT	Beach, river, swamp and æolian deposits		<i>Odocoileus, Lynx, Procyon, Didelphis, Neofiber</i> , etc.	Derived fossils from Pleistocene and Pliocene
PLEISTOCENE	MELBOURNE BEDS and Equivalents		<i>Equus, Mastodon, Paralephas, Smilodon, Tanuopolama, Boreostracon</i> , etc.	In some places with derived Pliocene fossils.
	ANASTASIA FORMATION, etc.			Marine, almost barren of vertebrates, but proboscideans occur.
PLIOCENE	BONE VALLEY FORMATION	ALACHUA CLAYS, etc.	<i>Hipparion, Serridentinus, Teleocera, Aphe-lops, Agriotherium</i> , etc.	Bone Valley and true Alachua clays with nearly pure Lower Pliocene fauna. Hard rock phosphates, Miocene Beds reworked in Pliocene, and to less extent, later, times.
MIOCENE	HAWTHORN FORMATION	B	<i>Merychippus, Amphicyon</i> , etc.	Apparently unified formation, but with distinctive faunas at different levels. A, Lower Miocene. B, Middle Miocene.
		A	<i>Parahippus, Dinohyus, Mesocyon</i> , etc.	
OLIGOCENE				No mammals yet discovered
EOCENE	OCALA LIMESTONE		<i>Basilosaurus</i>	No land mammals.

SYNOPSIS OF MAMMALIAN FAUNAS OF FLORIDA

short distance northwest of Lake Iamonia. The Sopchoppy is exposed near Tallahassee, where it is about 80' thick and immediately overlies the Tampa.

2. Franklin Phosphate Company, Newberry. Fossils from the southwest side of Pit No. 2 of this company, in Sec. 31, T9S, R17E, in Alachua County. A small but very important and previously undescribed collection was made here of bones and teeth found in place in soft phosphate pockets on the very irregular surface of the Ocala limestone. The geology of the Newberry deposits is to be more fully treated



Fig. 2. Part of wall of abandoned Pit No. 2 of the Franklin Phosphate Company near Newberry. The phosphate has been mined out, leaving walls and projections of Ocala limestone (Upper Eocene). The Lower Miocene fauna described in the text was found in a residual pocket in this part of the pit. Photograph from Florida State Geological Survey.

in dealing with the so-called Alachua Formation, and discussion is now deferred.

3. Cummer Lumber Company, Newberry. Fossil from Sec. 25, T9S, R16E, in Alachua County. Here was found a single but unusually complete jaw of *Merychippus*, described below. The jaw was found on a picker belt in the course of phosphate mining operations and its exact

occurrence is unknown, but it doubtless came from one of two now abandoned pits in the northwest quarter of the designated section. Their geology is poorly exposed, but similar to that of the other pits in this area.

4. Midway. The fossils occur in the pits of the Fuller's Earth Company, in Sec. 8, T1N, R2W, in Gadsden County, about 12 miles west northwest of Tallahassee and  $\frac{1}{2}$  mile south of the town of Midway. At the surface of this locality there are Pleistocene or Recent sands up to about five feet in thickness and below this an overburden, up to 40 feet



Fig. 3. View in pit of the Fuller's Earth Company at Midway. The bench in the background is the boundary between the commercial earth and the overburden. In the foreground is a pile of sweepings (from immediately above the fuller's earth), in which were found the type of *Amphicyon pontoni* and other specimens.

in thickness in the profitable workings, consisting of marl, clay, and sandy clay of the Hawthorn formation. This material is stripped, either by hydraulic methods or a dragline, and the fuller's earth immediately below it mined by steam shovel. Only one stratum of fuller's earth is now exposed in the mine, but another is said to occur, separated from

the first by a sandy layer as at Quincy. The fossils so far obtained have all occurred immediately above the fuller's earth. One or two (Sellards, 1916, p. 87) were actually found in place, but all the others were from piles of material which for the most part included only "sweepings," that is, the last foot or so of overburden just above the commercial earth, and there is no question that this is the main and probably the only fossil horizon. This was confirmed by Mr. Brooks, the mine superintendent, who states that the sirenian ribs, which accompany the land mammals, are always in the last foot or so of overburden, never entirely in the fuller's earth and never far above it. The occurrence of bones seems to be definitely localized, as they are fairly common in some of the various pits of the mine and rare or quite absent in others. Sellards (1916, p. 82 seq.) mentioned a few teeth and bones of *Merychippus* from this deposit. Subsequent collecting has added numerous specimens, the most important of which are described below. The fuller's earth horizon is said to be 114 feet above sea level at Midway (Sellards and Gunter, 1918, p. 100) and about 70 feet above the base of the Hawthorn. Data are inadequate for real determination of the relative levels of the Midway and Griscom Plantation occurrences, but it is probable that the latter is at a lower horizon. The actual elevation of the Midway fossils is about 115 feet above sea level, that of the Griscom fossils nearly the same, probably between 100 and 125 feet. It is known that the Hawthorn formation dips downward from Lake Iamonia to Midway. If this is confirmed by future work, it will agree with the palæontological evidence, as pointed out below.

5. Quincy. Fossils from the mine of the Floridin Company, Sec. 36, T3N, R3W, in Gadsden County, about twenty-five miles northwest of Tallahassee and immediately north of Quincy. The overburden, up to about twenty feet thick in the cuts examined, is similar to that at Midway, consisting of variegated sandy clay, very impure fuller's earth, sand, and local lenses with lime and clay pebbles and oyster shells. Throughout the workings there are two beds of commercial fuller's earth separated by a sandy layer. The upper fuller's earth is variable in thickness, averaging about four feet, and the sand is usually two to three feet in thickness. Almost all of the vertebrate fossils occur in the latter stratum, only one indeterminate mammal bone and a few shark teeth being found above the fuller's earth. This bone-bearing stratum consists of very tough massive clayey sand, with lenses and pebbles of purer fuller's earth. It grades rapidly but conformably into the upper fuller's earth, but is unconformable on the lower bed, probably a local

feature. Sellards mentioned (1916, p. 82) and figured a single *Merychippus* tooth from this locality, and further material has since been collected. The horizon of this occurrence is probably about that of the Midway fossils. It has been assumed that the fuller's earth is at approximately the same horizon at the two localities, a conclusion not certain but sufficiently probable and not contradicted by the vertebrate evidence.

Three of the Miocene occurrences, Griscom Plantation, Midway, and Quincy, are in undoubted Hawthorn deposits, and the fossils are



Fig. 4. View in mine of the Floridin Company at Quincy. A, Top surface of lower bed of fuller's earth. B, Intermediate sandy stratum with numerous sea-cow bones and other fossils. C, Upper fuller's earth. D, Overburden, the lower part Hawthorn and the upper part Quaternary.

apparently not derived from other beds. The strata in which the land mammals occur are obviously of marine origin. They contain marine invertebrates, and also numerous sharks, rays, and sirenians. Associated skeletons of the latter have been found at Quincy, indicating little or no transportation of the bones after decay of the flesh. There are also

parts of turtle and crocodile skeletons, but these, like the land mammals, are fragmentary and isolated. A shallow sea close to the shore seems to be indicated.

### Correlation

Faunal lists of the known Miocene localities are as follows:

1. Griscom Plantation, Leon County.  
*Mesocyon iamonensis* Sellards.  
*Parahippus leonensis* Sellards  
*Oxydactylus* sp.  
*?Leptomeryx* sp.
2. Franklin Phosphate Company, Alachua County.  
*Mesocyon iamonensis* Sellards  
*Parahippus* sp.  
*Cænopus* or *Diceratherium* sp.  
cf. *Oxydactylus* sp.  
cf. *Blastomeryx* sp.  
*Dinohyus* sp.
3. Cummer Lumber Company, Alachua County.  
*Merychippus westoni*, new species.
4. Midway, Gadsden County.  
*Amphicyon pontoni*, new species.  
*Merychippus gunteri*, new species.  
cf. *Aphelops* sp.  
cf. *Miolabis* sp.  
Camelid indet.  
Hypertragulidæ or Cervidæ spp. indet.
5. Quincy, Gadsden County.  
*Merychippus gunteri*, new species.  
cf. *Aphelops* sp.

Faunas 1 and 2 of this list are clearly of about or quite the same age; 3, an isolated specimen, may be of about the age of 4 and 5; 4 and 5, both on faunal and on geologic grounds, are surely almost contemporaneous; 1 and 2, on the one hand, and 4 and 5 on the other do not appear to be of the same age.<sup>1</sup>

*Mesocyon* is limited to the late Oligocene and early Miocene. It occurs in apparently typical form in both of the first two faunas. *Parahippus* does not occur in the Oligocene but ranges through the entire Miocene, being especially abundant in the Lower Miocene. The Griscom and Franklin specimens are not in themselves diagnostic between

<sup>1</sup>An important fact not ascertainable from the more scanty materials of Sellards, and first pointed out by Matthew in his unpublished manuscript.

Lower and Middle Miocene. The Franklin rhinoceros is too little known to be diagnostic, but appears to be compatible with Lower Miocene age. *Oxydactylus* is typical of the Lower Miocene, and, while the specimens are not quite certain of generic affinity, this indication is in agreement with the more positive evidence. The record of *Leptomeryx* is also somewhat doubtful, while the *Blastomeryx*-like teeth from Newberry are not exactly like any others known, but these specimens clearly belong to groups which flourished in the late Oligocene and early Miocene, although in existence both earlier and later. *Dinohyus* adds to the more positive evidence of *Mesocyon* and *Parahippus*. It belongs to a group not known after the Lower Miocene,<sup>1</sup> and the morphology of the known parts seems to indicate that it is one of the latest members of this group.

It appears that these two faunas cannot be earlier than the Miocene nor later than Lower Miocene. They are approximately equivalent to the Lower Harrison or Rosebud.

The faunas from Midway and Quincy, on the contrary, can hardly be as ancient as the two just discussed. *Merychippus* does not occur below the Middle Miocene, and both *M. westoni* and *M. gunteri* are more nearly comparable with Sheep Creek, or at latest Mascall, species than with those of later formations. *Amphicyon pontoni* also belongs to a type of animal not recorded below the Middle Miocene and appears to be most closely comparable to a lower Sheep Creek form. The rhinoceroses and camels are not very diagnostic, but are more progressive than those from the Griscom and Franklin deposits. These faunas may be referred to the Middle Miocene with some confidence.

## DESCRIPTIONS OF MIOCENE MAMMALS

### CANIDÆ

#### *Mesocyon iamonensis* Sellards, 1916

This species was described by Sellards (1916, pp. 88–89) from a part of the right upper jaw with P<sup>4</sup>–M<sup>2</sup>. This specimen was from the Griscom Plantation, and no further material is known from this locality. The Florida State Geological Survey collection includes several canid specimens from the Franklin Phosphate Company mines at Newberry: part of a lower jaw with M<sub>1</sub>, three fragmentary lower sectorials, part of a first

<sup>1</sup>The supposed Middle Miocene Age of *Ammodon leidyanum* (Peterson, Mem. Carn. Mus., IV, p. 67) was based on the supposed degree of specialization of two isolated teeth rather than on more positive correlative methods, and the upper Harrison astragalus (Ibid., p. 69) is not surely that of an entelodont. There appears to be no good evidence that the group did survive the early Miocene.



upper molar, a calcaneum, and a metapodial. These probably belong to a single species and are tentatively referred to *Mesocyon iamonensis*. So far as diagnostic they agree with this genus and especially with *Mesocyon coryphæus* of the John Day. Although comparable parts are limited, they all appear to be a little larger than the type specimen of *M. iamonensis*, about 10%. This difference, however, is less than that between some specimens referred on good evidence to the one species *M. coryphæus* and is probably well within the range of specific variation. The size, even of the Newberry specimens, is not greater than that of the

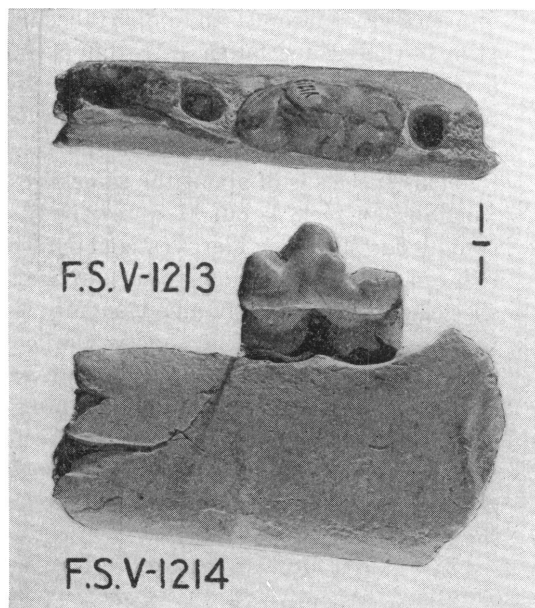


Fig. 5. *Mesocyon iamonensis* Sellards. Referred right lower jaw with  $M_1$ . Natural size. Crown and internal views.

largest individuals of *M. coryphæus*, with which very close relationship is indicated so far as such fragmentary materials are diagnostic. The teeth are much larger and heavier than in *M. josephi*, for example, but similar in structure. The heel of  $M_1$  is of the one-cusped type characteristic of this phylum, but a small basin occurs internal to the hypoconid, and its slightly raised rim is more or less cuspidate in the present specimens.  $M_1$  (F.S.G.S. No. V1213) measures 21.3 mm. in length by 10.0 mm. in width.

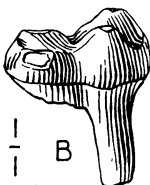
***Amphicyon pontoni*, new species**

TYPE.—F.S.G.S. V4112, isolated left M<sub>2</sub>. Collected by G. M. Ponton, 1929.

HORIZON AND LOCALITY.—Immediately above fuller's earth, Hawthorn formation, Sec. 8, T1N, R2W, Midway, Gadsden County, Florida.

DIAGNOSIS.—A relatively small *Amphicyon*. Length of M<sub>2</sub> 18.6 mm., width 14.3 mm. Trigonid elevated above talonid, trigonid basin short, paraconid vestigial, no distinct cingula. M<sub>2</sub> widest at anterior end, heel relatively narrow. Hypoconid crested but low, broad entoconid shelf.

This isolated tooth gives little basis for determination of the precise phyletic position of this large canid, but it does seem to be diagnostic



F.S. V-4112

Fig. 6.

*Amphicyon pontoni*, new species. Type. Isolated left M<sub>2</sub>. A, Crown view. B, Internal view. Natural size.

and is of great interest and importance in the consideration of this scanty fauna. M<sub>2</sub> differs especially in the heel construction from *Hemicyon*, which it otherwise resembles fairly closely, and seems entirely typical of the genus *Amphicyon* as now understood.

This species is of about the same size as *A. idoneus*, from Sheep Creek A, but M<sub>2</sub> is relatively shorter, entoconid ledge slightly wider, vestigial paraconid still more reduced. So far as this one tooth is diagnostic, these two species seem very nearly allied but distinct. From *A. frendens*, *A. pontoni* differs very markedly, M<sub>2</sub> being much smaller, with blunter, shorter hypoconid, wider entoconid ledge, etc. *A. sinapius* (including *A. amnicola*) and *A. ingens* are also much larger species. Comparable parts are not known in *A. americanus*, which is perhaps about 10% larger than *A. pontoni* and of nearly the same size as *A. idoneus*.

**EQUIDÆ*****Parahippus leonensis* Sellards, 1916**

The type of this species is a single upper molar from the Griscom Plantation (Sellards, 1916, p. 83). Two lower cheek teeth, an astragalus, and two phalanges from the same deposit were referred. They apparently represent a *Parahippus* of medium size and rather advanced, although not more so than species from the Lower Miocene. If the astragalus is correctly associated, it is small relative to the teeth, being smaller than that of *Parahippus pristinus* although the teeth are somewhat larger.

***Parahippus* sp.**

Hay (1916, p. 42) described and figured lower teeth of *Parahippus* from mines of the Franklin Phosphate Company at Newberry, stating that they appear to represent an undescribed species, to which no name

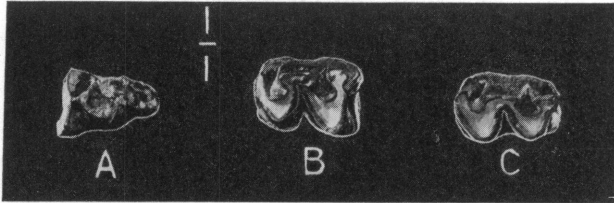


Fig. 7. *Parahippus* sp. Lower cheek teeth from Newberry. A, Posterior end of left M<sub>3</sub>. B, Left P<sub>4</sub>. C, Left M<sub>1</sub> or M<sub>2</sub>. Natural size.

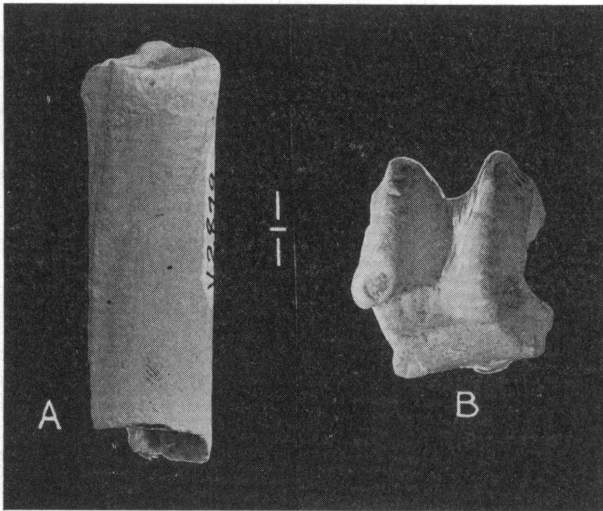


Fig. 8. *Parahippus* sp. Limb bones from Newberry. A, Proximal end of left metatarsal. B, Right astragalus. Natural size.

was given. In describing *P. leonensis*, Sellards (1916, p. 87) mentioned the fact that a lower tooth from the same deposit as the type of that species was larger than those described by Hay. Basis for comparison is really inadequate, and it is possible but perhaps improbable that they do

represent the same species. The Newberry teeth appear not only to be slightly (about 10%) too small to be conspecific with the type of *leonensis*, but also (so far as comparisons between upper teeth on the one hand and lowers on the other are possible) somewhat less progressive. The Newberry teeth indicate an animal little if any larger than *P. pristinus*, and smaller than other species of the genus. They are relatively low-crowned and of simple pattern, the metaconid-metastylid groove slight.

Basal measurements of two of these teeth follow:

	Length	Maximum width
F.S.G.S. V1540. P <sub>78</sub> -	13.6	11.2 (posterior lobe).
V503. M <sub>72</sub> -	13.6	11.0 (anterior lobe).

The seven teeth from this locality studied by me clearly represent but one species. From the same deposit there are two right astragali and the proximal end of the median left metatarsal, probably to be associated with this species. If so they may accentuate its distinction from *P. leonensis*, for the astragali are distinctly larger than that found on Griscom Plantation and referred by Sellards to *P. leonensis*. They agree in morphology with typical specimens of *Parahippus*, and are close to *P. pristinus* but slightly shorter.

F.S.G.S. V2879, left metatarsal. Transverse diameter of proximal end 20 mm.

F.S.G.S. V1507, right astragalus. Maximum transverse width, 25 mm.

This form is probably a distinct species, but I prefer not to establish a name on these materials.

#### ***Merychippus westoni*, new species**

Type.—F.S.G.S. V4088, part of right upper jaw with P<sup>3</sup>—M<sup>2</sup>. Presented by Mr. Franz Weston.

HORIZON AND LOCALITY.—Stratigraphic origin uncertain, probably derived from a Middle Miocene horizon in the Hawthorn formation. Phosphate mine of the Cummer Lumber Company, Sec. 25, T9S, R16E, near Newberry, Alachua County, Florida.

DIAGNOSIS.—A very small *Merychippus*, cheek dentition about 20% shorter than in *M. primus*. Protocone distinctly more internal than hypocone on P<sup>3</sup>, less so on following teeth. Protocones large, elongate oval, closely appressed against protoconule but without spur and separate until well worn. Pli caballin very feeble on P<sup>2-4</sup>, absent on M<sup>1-2</sup>. Metaloph folds few and small, fossette walls simple. Hypocone strongly united to metaconule.

The characters of this specimen seem fully diagnostic of the genus *Merychippus*, but quite distinctive specifically. Its small size, simple pattern, and subhypsodont crowns seem to stamp it as a fairly primitive form, most closely comparable with the Sheep Creek or Mascall species of the West. In the *M. insignis* series closest resemblance is to *M.*

*primus*, but *M. westoni* is notably smaller, and the protocones are very different, more elongate anteroposteriorly, without a spur, and more separate from the protoconules. There is a still closer resemblance to *M. relictus*, but this is also larger than *M. westoni* and has a more distinct pli caballin and other relatively slight distinctions. So far as *M. relictus* is known, it may be the closest known relative of the present species.

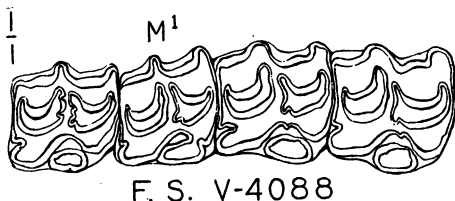


Fig. 9. *Merychippus westoni*, new species. Type. Right P<sup>3</sup>-M<sup>2</sup>, crown view. Natural size.

#### ***Merychippus gunteri*, new species**

TYPE.—F.S.G.S. V4114, single upper cheek tooth, probably P<sup>4</sup>, collected by Gunter, Ponton, and Simpson, 1929.

TOPOTYPES.—A series of about 10 upper and 17 lower cheek teeth in the Florida State Geol. Surv. and American Museum collections, collected by Sellards, Gunter, Ponton, and Simpson.

HORIZON AND LOCALITY.—Hawthorn formation, immediately above fuller's earth, Sec. 8, T1N, R2W, Midway, Gadsden County, Florida.

DIAGNOSIS.—A small *Merychippus*, intermediate in size between *M. westoni* and *M. primus*. Molars subhypsodont, about as in *M. primus*. Upper cheek teeth relatively short and broad, with strong external ridges. Protocone relatively small, almost circular, with spur, and united to protoconule near apex. Pli caballin simple but normally present. One or two well defined folds on each side of metaloph. Metastylid feebly separated on P<sub>2</sub>, strongly distinct on other lower cheek teeth. Heel of M<sub>3</sub> small and simple, elongate. Lower incisor series somewhat less transverse than in *M. primus*.

Sellards (1916, p. 87, and legend to Pl. XIII) mentioned several teeth of *Merychippus* from Midway and Quincy. These and numerous isolated teeth and skeletal parts since found at these two localities appear to represent a single species of *Merychippus*. They are not conspecific with *M. westoni*, although somewhat similar in size and character, as they are generally about 10% larger, the protocone smaller, less elongate, and united to the protoconule much nearer the apex, the pli caballin more distinct, the fossette walls more complex at all stages of wear. This species, *M. gunteri*, appears to be a member of the *M. insignis* group, its stage of evolution slightly more advanced than that of *M. primus*.

from which it differs chiefly in its smaller size, more transverse upper cheek teeth, and somewhat more complex enamel pattern. It differs from *M. secundus* still more markedly in size, but the pattern is more nearly comparable, differing in the somewhat higher connection between protocone and protoconule and, as with *M. primus*, in the proportions of the crown.



Fig. 10.  
*Merychippus gunteri*, new species. Type. Right P<sup>4</sup>, crown view. Natural size.

Sellards (1916, p. 83) reported the presence of *Parahippus* at Midway on the evidence of an astragalus, a phalanx, part of a metacarpal, and a tooth fragment. These specimens probably belong to the present species and not to *Parahippus*, the presence of which is not established by any of the much augmented series of teeth and skeletal parts now available from this locality.

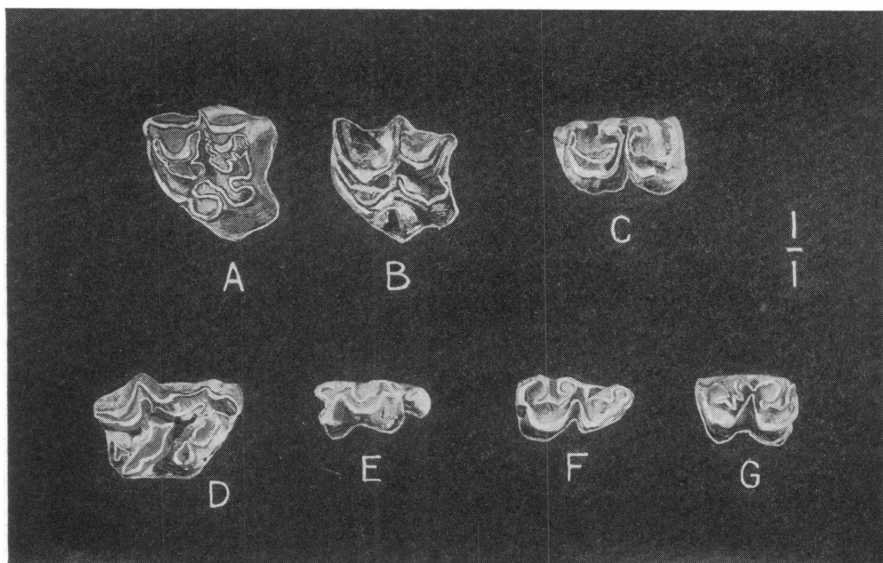


Fig. 11. *Merychippus gunteri*, new species. Topotypes. A, Left M<sup>1</sup> or M<sup>2</sup>. B, Left M<sup>3</sup>. C, Right P<sub>3</sub>. D, Right P<sup>2</sup>. E, Posterior end of left M<sub>3</sub>. F, Right P<sub>2</sub>. G, Right M<sub>1</sub>. Natural size.

#### RHINOCEROTIDÆ

*Cænopus* or *Diceratherium* ? sp. indet.

A small rhinoceros is indicated in the Franklin Phosphate Company material from Newberry by various tooth and foot fragments. These are

not determinable, even as to genus, but they agree in a general way with the small true rhinocerotines of the upper Oligocene and lower Miocene.



Fig. 12. *Merychippus gunteri*, new species. Referred specimens. A, Incisor, internal view. B, Symphysis, left lateral view. Natural size.

cf. *Aphelops* sp. indet.

An apparently more progressive rhinoceros is represented in the Midway and Quincy collections by imperfect tooth fragments. This is larger than the Newberry rhinoceros, with higher tooth crowns, and perhaps represents a relatively small early *Aphelops*-like species.

### CAMELIDÆ

Camels are present at the Griscom, Newberry, and Midway localities, but none of the remains are identifiable. Sellards (1916, p. 89) described an upper molar and other fragments from the Griscom Plantation as *Oxydactylus*? sp., an uncertain but probable assignment. A tooth from Midway is of similar size, but more progressive, the crown distinctly higher. It may represent a small *Miolabis* or some related form, and is also exemplified by astragali, phalanges, a calcaneum, etc. A much larger camel of unknown generic affinities is represented by part of a phalanx from Midway. A single phalanx in the Franklin Phosphate Company collection from Newberry suggests *Oxydactylus*.

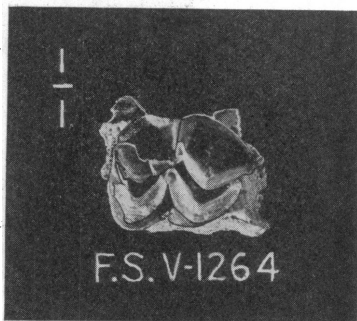


Fig. 13. *Oxydactylus* sp. Broken upper molar from the Griscom Plantation, crown view. Natural size.

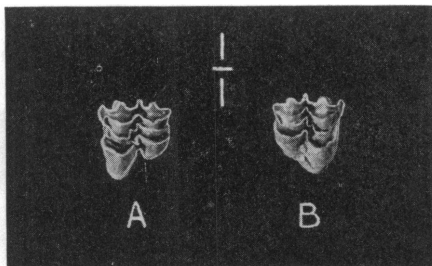


Fig. 14. Cf. *Blastomeryx* sp. Upper molars from Newberry, crown views. Natural size.

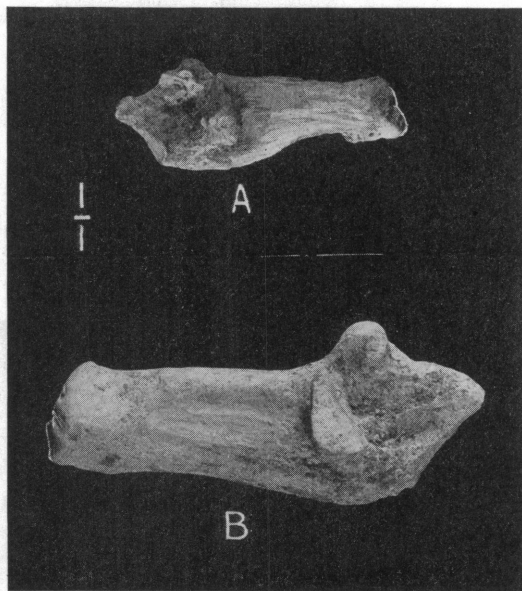


Fig. 15. ?*Hypertragulids*, indet. Two calcanea from Midway. Natural size.

#### **HYPERTRAGULIDÆ**

A single astragalus from the Griscom Plantation was described by Sellards (1916, p. 89) as *Leptomeryx?* sp. Another form is represented in the Franklin Phosphate Company collection by three upper molars. These agree in a general way with the smaller species of *Blastomeryx*, but the anterior and posterior lobes are less nearly equal in width, and the posterior external rib is strongly developed. The generic affinities



of the Lower Miocene and late Oligocene hypertragulids (or cervids?) are now poorly understood, and these teeth do not agree exactly with any others known to me.

Hypertragulids or cervids, apparently related to *Blastomeryx* and its allies, are represented in the Midway collection by two calcanea, indicating two distinct but indeterminate species.

#### ENTELODONTIDÆ

##### *Dinohyus* sp.

A very large entelodont is represented in the Franklin Phosphate Company collection by a broken premolar, half of a lower molar, and the proximal part of the ulnoradius lacking the olecranon. This is one of the largest of entelodonts, being quite as large as *Dinohyus hollandi*. It may represent a new species, but these fragmentary remains are in-

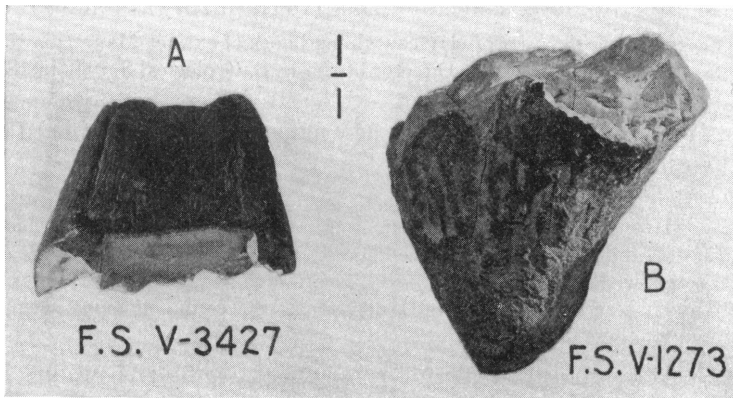


Fig. 16. *Dinohyus* sp. Broken teeth from Newberry. A, Anterior part of right  $M_1$ , posterior view. B, Apex of right  $P^3$ , internal view. Natural size.

sufficiently diagnostic. Its generic affinities appear to be close to *Dinohyus*, and it may provisionally be considered as belonging to this genus.

The molar fragment is probably the anterior half of  $M_1$  right, and is about 35 mm. in width. This is marked by complication by minor papillæ and tubercles, the metaconid being bifid and the cross-crest and crescentic wings of the two primary cusps cuspidate. There is a papillate horizontal anterior basal cingulum. The premolar fragment consists only of the principal cusp, the base wanting. It is probably  $P^3$

right, agreeing rather closely with this tooth in *Dinohyus hollandi*. As in the latter it is a very stout, rugose tooth subtriangular in section.

The ulnoradius also resembles that of *Dinohyus hollandi* rather closely in size and form, the part preserved offering no definite distinctions from Peterson's description and figures.

## PLIOCENE

### ALACHUA FORMATION

#### Stratigraphy

The Alachua formation as now recognized by the State and National Surveys extends in a strip about 100 miles long and averaging about 6 or 7 miles wide in a north-northwest south-southeast direction from southern Columbia County to the east central part of Hernando County in northwestern peninsular Florida.

The formation was defined by Dall (1892, p. 127) as follows:

"This comprises deposits of clay containing bones of extinct Mammalia which, in my [unpublished] report to the Director of the U. S. Geological Survey in 1885, I termed the Alachua clays."

In 1910 (p. 32) Sellards gave a new name to the so-called hard rock phosphate of this area:

"It is thus apparent that the [hard rock phosphate bearing] formation contains a mixture of material from several formations from as early as the Lower Oligocene [Upper Eocene] and as late at least as the Pliocene, further complicated by subsequent chemical action within the formation itself. The residual material moreover has been reworked and in places transported and redeposited. The term Dunnellon Formation is suggested for these deposits. . . ."

At a later date this name was abandoned (Sellards, 1914, pp. 161-162):

"A recent examination of typical localities has convinced the writer that the Alachua clays and the Dunnellon formation are not separable, the former representing, in fact, a local phase of the latter. . . . The term 'Alachua Clays,' although descriptive of the localities to which it was applied, yet is not applicable to the formation as a whole. Since, however, this term has precedence in time, and is also well established in the literature it seems advisable to drop the term 'Dunnellon formation,' and to designate the deposits as a whole as the Alachua formation."

This usage is adopted by Cooke and Mossom (1929, p. 173), and will perhaps be definitive. Whatever the nomenclature employed, however, it is clear that a most complex and unusual series of rocks is included, and that, to the vertebrate palæontologist at least, these can hardly be considered as a single formation within the usual sense of the word.

This area has been discussed in detail by Sellards (esp. 1913), and by Matson (1915), and reviewed in a general way by Cooke and Mossom (1929), and others. It was briefly examined throughout its length, with more detailed examination at favorable localities, by myself in February, 1929, with the guidance and cooperation of Mr. Gunter.

The Alachua deposits everywhere rest directly on soft marine limestones, the Ocala (Upper Eocene), throughout most of this area, and the Tampa (lowest Miocene) in the most southern part, south of Inverness. The Alachua is everywhere either at the surface or overlain by relatively thin sand and soil of Pleistocene or Recent age. The upper surface of the underlying limestones is almost always extremely irregular and obviously owes this irregularity largely to solution. It is a sort of buried karst topography with sinks of all sizes, irregular projecting cones and pinnacles and all the other features of a chemically eroded limestone plateau. In some places there are large areas of the limestone with numerous deep circular sinks thickly scattered, varying in diameter from about one to thirty feet. These small sinks, locally called "natural wells," like the larger depressions in the limestone, are usually but not invariably filled with later sediments or residual material.

The deposits which lie on or in the limestone are very heterogeneous. The phosphate deposits, to which the name "Dunnellon formation" was applied by Sellards, occupy very large basins in the limestone. They usually show evidence of stratification, but the bedding planes are almost invariably much distorted. The sediments are for the most part gray phosphatic sands, with greenish clay lenses or distorted beds which may weather yellow, orange, or red. Some phosphate pebble conglomerate occurs, and there are often limestone inclusions and siliceous boulders. The commercial hard rock phosphate occurs generally as angular fragments imbedded in this matrix. Soft phosphate also occurs, either as a constituent of the matrix or in pockets and small lenses. The commercial phosphate deposits are generally overlain by and not infrequently also interbedded with the coarse gray sands of low phosphatic content. In some of the phosphate mines, as around Newberry, the commercial deposit has the shape of a very irregular ring, surrounded by limestone and with a "horse" of coarse gray sand in the middle.

The origin of these deposits has been discussed by many authorities, most recently by Sellards (1913), by Matson (1915), and by Cooke and Mossom (1929). The following view seems to represent the consensus of recent workers and most satisfactorily to explain the field data:

The Hawthorn formation, now absent as such in this area, once

extended over it. Some time after its deposition in the sea, the land was uplifted and formed a low plateau with the phosphatic limestone, sands, and clay of the Hawthorn forming the surface and lying on older, very soft, soluble limestones. Groundwater dissolved the Ocala, forming sinks and basins into which the Hawthorn beds slumped or were washed by surface waters. The Hawthorn itself was further modified by solution of its lime and of much of its phosphate, the latter being in large part redeposited in the sinks where it formed secondarily enriched phos-



Fig. 17. An operating phosphate mine in the Alachua or Dunnellon Formation. Felicia Mine of the Camp Phosphate Company, Citrus County. Quaternary sands above, Pliocene and reworked Miocene below. Photograph from the Florida State Geological Survey.

phatic deposits. This sink filling was derived largely from the Hawthorn, and in some places includes relatively unaltered slumped blocks of Hawthorn, but also includes residual material and inclusions from the older rocks and more recent intrusions. The Hawthorn was also removed by surface waters over considerable areas. Locally bodies of standing water were present.

The true Alachua clay is different from the "Dunnellon" or phosphatic deposits just discussed, although its relationships to the latter

are ambiguous. As already mentioned, the name Alachua now includes the "Dunnellon," and it has also been used for quite unrelated deposits, such as the Ocala fissure fillings and the Peace Creek beds, but it was based primarily on the more superficial clays best seen in the vicinity of Williston. It is a sandy clay, or argillaceous sand, generally from 0 to 15 feet in thickness save where it fills local sink-holes of greater depth. When fresh it is gray or greenish, but it is usually weathered and of a bright orange to chocolate red color. It appears not to be phosphatic but to be a residual and doubtless in part water laid or reworked clay derived from the older limestones by weathering and solution.

The solution which has so complicated the nature both of the phosphatic deposits and of the superficial clays is still in progress. Every stage, from large filled sinks which must date back to early Pliocene times to those which are still open and receiving debris of historic age, can be seen. Appearance, proximity, or even level is an uncertain or positively misleading guide to age or correlation, since materials from Eocene to Recent enter into the making of these deposits. The true Alachua clay, for example, is now being washed into fissures and sinks where it is closely similar in appearance to the original but very much older deposit, and the same occurred in the Pleistocene.

Hay (1923, pp. 375-378) has given faunal lists, subsequently copied by other workers (as Cooke and Mossom, 1929, pp. 175-176), which fail to take into account these field relationships. From Archer<sup>1</sup> he lists *Gomphotherium* [*Serridentinus*], *Odocoileus*, *Procamelus*, *Teleoceras*, *Aphelops*, *Tapirus*, *Hipparion*, and *Megatherium*.

From "Mixon's"<sup>2</sup> he lists a similar but less extensive fauna, and "at and about Dunnellon . . . including the species dredged in Withlacoochee River," *Megalonyx*, *Chlamytherium*, *Ursus*, *Felis*, *Gomphotherium* [*Serridentinus*], *Mammut* [*Mastodon*], *Elephas* [*Archidiskodon* or *Parelephas*], *Parahippus*, *Hipparion*, *Equus*, *Tapirus*, *Aphelops*, *Procamelus*, *Odocoileus*, and *Bison*. Hay states that "the Pleistocene species are usually accounted for on the supposition that they are intrusions from more recent deposits," but concludes that this is not the case and that the supposed Pliocene [and Miocene] genera survived into the Pleistocene. In support of this view he cites other supposed cases of the survival of *Gomphotherium*, *Hipparion*, *Procamelus*, and *Teleoceras* into the Pleistocene.

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<sup>1</sup>As mentioned below, few of these fossils actually did come from Archer, even aside from other considerations.

<sup>2</sup>Properly "Mixon's."

In the first place it is not necessary to suppose that the Pleistocene species are intrusions from more recent deposits. Such intrusion is a possibility in deposits constantly subjected to solution and slumping, but its actual occurrence has not been demonstrated. It is supposed, and in fact conclusively shown in some cases, that the older genera may be inclusions in more recent deposits. For instance, a zeuglodont was found with the Alachua fauna. Evidence for the survival of this Eocene mammal into the Pliocene is even better than for the survival of the Pliocene genera into the Pleistocene, for it was in actual association, while the latter generally are not. Obviously it was derived from the Ocala.

The fundamental error, however, lies in the compilation of faunal lists not actually based on association. The region contains deposits clearly of many different ages, often superposed or contiguous. Old field records are usually inadequate. Hay has gathered together fossils from widely separate localities or from many localities in a restricted area and treated them as a unit fauna, including in one list even species dredged from a river. Furthermore, occurrence at a single locality does not necessarily mean association. A bison tooth was found at Mixson's bone bed, but it was near the surface and not associated with the Pliocene genera.<sup>1</sup>

Vertebrate fossils of six different ages have been found in the hard rock area around Williston and Newberry.

Recent—*Bos*, *Sus*.

Pleistocene—*Equus*, *Bison*, *Megatherium*, *Archidiskodon*, etc.

Lower Pliocene—*Hipparion*, *Procamelus*, *Teleoceras*, *Serridentinus*, etc.

Middle Miocene—*Merychippus*.

Lower Miocene—*Parahippus*, *Mesocyon*, *Dinohyus*, etc.

Upper Eocene—*Basilosaurus*.

There is no evidence that any two of these faunal groups were contemporaneous. *Basilosaurus* (like many invertebrates found in so-called Alachua deposits) was derived from the Ocala limestone. The two Miocene faunas were derived from the Hawthorn, from which the hard rock phosphate clearly originated.

The Lower Miocene fauna was found in a pocket probably representing relatively pure Hawthorn, perhaps somewhat concentrated, caught against the side of a sink in the Ocala. The two faunas occur in place and quite unmixed in the more northern Hawthorn, as shown above. The lower Pliocene genera, although some of these have since been

<sup>1</sup>A probable explanation of the record of a Pleistocene type of ground sloth (*Thinobadistes* Hay) here.

redeposited, were originally entombed at the time of maximum solution activity and redeposition, soon after the elevation of the plateau, when the Alachua clays proper and the bulk of the hard rock phosphate concentrates were formed. The Pleistocene species were caught in fissures or pockets open during that epoch, the Recent species in those which still remain open.

The supposed cases of survival in the West are not of immediate concern here. They have been studied in detail by Dr. Matthew (ms.), who concludes that they are isolated and very doubtful or positively erroneous cases, contradicted by overwhelming evidence of such faunas as are adequately and surely known.

#### Localities and Faunal Lists

The Alachua fauna was first described by Leidy on the basis of specimens collected between 1884 and 1890 by Neal, Dall, Johnson, and Hatcher. After several preliminary notes, this material was definitively published after Leidy's death under the editorship and posthumous collaboration of F. A. Lucas (Leidy and Lucas, 1896). The material was said (p. vii) to be "collected, for the most part, near Archer, Florida," and has been so listed (e.g.: Hay, 1923, p. 375, "at Archer"). Closer study of Leidy's various papers and inquiry on the spot, of people acquainted with the field collectors, shows that the word "near" was used with a latitude of ten miles or more in each direction and that the only fossils positively known to come from the immediate vicinity of Archer are a few Pleistocene bones and *Serridentinus* and *Hipparion* teeth found since Leidy's death. Leidy gives eight localities, but some of these are known to furnish only Pleistocene fossils, not clearly distinguished then and further confused by Hay in supposing all to be of a single fauna.

The bulk of Leidy's true Alachua fauna came from Mixson's bone bed, a locality on the former J. M. Mixson farm almost exactly one mile east and one and one half miles north of the railroad station at Williston, Alachua County. This is the true type locality of the fauna and of the formation. Fossils were also found in less abundance at several other localities in this immediate region, including what was then Simpson's place (now owned by T. J. Cone), Reddick's place, about one mile north-east of town, and in a field two miles northwest of Mixson's. The list of Pliocene mammals described by Leidy and Lucas, as here emended and supplemented by a collection made by Sellards and Gunter and material presented to the State Survey by Mrs. Eliza Mixson, is as follows:

## 1. Mixson's Bone Bed, near Williston, Levy County.

*Hipparion ingenuum**Hipparion plicatile**Hipparion minor**Teleoceras proterus**Aphelops longipes**?Megatylopus major**?Procamelus minor**?Procamelus minimus**Serridentinus floridanus*—*Serridentinus leidii*

Isolated specimens, for the most part from dredging, picker belts, or other extra-stratigraphic sources, are known from numerous localities throughout the Alachua formation area. In so far as they are of true Alachua age, they include only species known to occur at the Mixson locality. They indicate that the phosphate mines, while showing admixture with earlier and later faunas, do include a unit fauna identical with that at Mixson's. These localities, as given by Sellards, Hay, the Florida State Geological Survey collections, and my own observations, are as follows:

## 2. Hollowell's Place, near Newberry, Alachua County

*Hipparion* sp.

## 3. T. A. Thompson Mine, Neals, Alachua County

*Serridentinus floridanus**Hipparion* sp.

## 4. Dutton Phosphate Company No. 22, Juliette, Marion County.

*Serridentinus floridanus*

## 5. Dunnellon Phosphate Company No. 5, Hernando, Citrus County.

*Serridentinus floridanus**Hipparion* sp.

Camelid indet.

## 6. Mines near Newberry, exact localities unknown.

*Serridentinus floridanus**Hipparion* sp.

## 7. Hickory Hill, southwest of Archer, Alachua County.

*Serridentinus* sp.*Hipparion* sp.

## 8. C. &amp; J. Camp Blue River Mine, Dunnellon, Marion County.

*Serridentinus* sp.

## 9. Cullen River Mine, Dunnellon, Marion County.

*Serridentinus floridanus*

Camelid indet.

## 10. Dunnellon Phosphate Company No. 6, Dunnellon, Marion County.

*Hipparion* sp.

## 11. Near Dunnellon, exact locality unknown.

*Serridentinus floridanus**Hipparion plicatile**Hipparion* sp.*Aphelops* sp.



The list could be extended by further search, as mastodon and horse teeth seem to have been found in most of the hard rock mines, but the fauna bears no internal evidence of age differences, and further multiplication of localities has little interest.

### BONE VALLEY FORMATION

#### Stratigraphy

The Bone Valley gravel (or formation) occupies a roughly circular area averaging about 33 miles in diameter, including Plant City in the northwest and extending nearly to Wauchula in the southeast, chiefly in Polk County but also covering considerable areas in the adjoining counties of Hillsborough, Manatee, and Hardee, in central peninsular Florida. It was defined by Matson and Clapp (1909, p. 138) as follows:

"The deposits here called Bone Valley gravel . . . comprise nearly all of the pebble phosphates now being mined in Florida. . . . Eldridge designated the deposit as *land pebble phosphate*, while Dall called them simply *pebble phosphates*."

There has been some question as to the vertical limits of the Bone Valley, most authorities limiting attention to the commercial phosphate while others would include such of the overburden as is apparently conformable, but there has been no such confusion as in the use of the name Alachua.

The Bone Valley is everywhere underlain by the Hawthorn. The contact is clearly unconformable and very irregular in detail, but is roughly horizontal over large areas and by no means as irregular as the lower contact of the Alachua. Pleistocene and Recent sand, clay, and muck overlie the Bone Valley everywhere except along some stream banks and in excavations. Almost all the exposures and, apparently without exception, all the vertebrate fossils are due to the phosphate mines.

The phosphate bed proper consists of pebbles and nodules of phosphate, generally of small size, imbedded in clay and sand. It is usually only slightly coherent, easily broken up by a hydraulic gun, but is locally strongly indurated. The deposit is definitely stratified, and the strata show occasional but inconspicuous deformation. They are lenticular and seldom persistent for more than a hundred yards or so. Local erosional unconformities may occasionally be seen within the phosphate bed. This commercial phosphate grades upward into a less phosphatic overburden consisting generally of light-colored sands, more massive than the gravel proper but with thin lenses and strata of clay in many of

the mines. The upper limit of this sand against the strictly superficial deposits is not always clear, but it belongs in the same stratigraphic unit as the gravel proper. The latter also is often conformably underlain by one to three feet of sandy clay or greenish plastic clay which is unconformable on the Hawthorn limestone. The term gravel as applied to the formation as a whole is thus a misnomer. The total thickness of the



Fig. 18. Typical land pebble phosphate mine in the Bone Valley Formation. Pit of American Cyanamid Company near Brewster, Polk County. Quaternary soil at surface, upper Bone Valley above bench in background, commercial phosphate bed from top of bench to floor of pit, basal Bone Valley and Hawthorn exposed in floor of pit. Photograph from the Florida State Geological Survey.

formation varies from about 15 to 60 feet, and is perhaps slightly greater in the areas where the overburden is too thick for profitable mining. The phosphate bed itself varies from a few feet to about twenty feet in thickness.

It is generally agreed that the phosphatic content and much of the non-phosphatic material of this formation were derived from the Hawthorn by the erosion and disintegration of its upper part. Unlike the Alachua, chemical processes seem to have been largely secondary in importance. The formation as a whole was obviously largely deposited or

at least reworked by moving waters. Whether these were marine, estuarine, or fluviatile has been a moot point. Shaler, Dall, and Sellards have especially favored shallow marine waters. Matson and Clapp regarded the formation as chiefly fluviatile, perhaps estuarine in part. Cooke and Mossom similarly consider it to have been found in the lower reaches of a river.

The view that the Bone Valley is an estuarine deposit is the most probable, in my opinion. The nature of the sediments themselves bespeaks periods of quiescence and periods of fairly rapid shifting currents in shallow water, as in a sluggish river, estuary, or lagoon. So far as has been determined, the included shells are all derived from older beds, which would at least be unusual in a true marine deposit of this character and as well known as this. Land mammals and terrestrial tortoises are rather abundant and in several cases have been found so associated that they cannot have moved far from the place of death. Crocodiles or gavials and sirenians are common, but neither group is essentially marine, being more at home in estuarine waters. The cetaceans are primarily marine, but quite in harmony with the associated fossils' suggestion of estuarine waters. The same applies to the sharks, many of which were, furthermore, derived from older and purely marine beds.

As with almost all the Floridian mammal-bearing deposits, there is much possibility of false association in the Bone Valley, but this does not lead to much confusion in this case. All of the shells and many or most of the fish remains were probably derived from the Hawthorn. There is a possibility that mammals might be similarly derived. The only suggestive case is a possible *Merychippus* tooth, and this, even if correctly identified, may be original, as the genus does occur in western deposits of as late age as the Bone Valley. Cooke and Mossom have suggested that the marine mammals are of Hawthorn age. This remains a possibility regarding any particular specimen, but it is certainly not true of all, for many are very fresh and associated skeletal parts occur, although rare.

A second possibility of derivation, suggested by Sellards (1915, p. 71), is derivation of fossils from deposits, now reworked, intermediate in age between the Hawthorn and the Bone Valley, i.e., of upper Miocene age. The possibility has been kept in mind, but I find no evidence that this occurred. The occurrence of the land mammals and their faunal relationships seem to me to guarantee the essential contemporaneity of the forms here listed as from the Bone Valley.

The third possibility of mixture is that of faulty collecting or recording. The Bone Valley is almost everywhere overlain by younger beds. Most of the known fossils were found in mining, especially with hydraulic guns, and collected by laymen often without preservation of precise records. For these reasons, without casting any doubt on the good faith of the collector (J. C. Edmundoz), the two supposed cases of the finding of Pleistocene mammals in the phosphate cited by Hay (1923, pp. 159, 196) are inadmissible as positive evidence. Instances could be multiplied, but, in such cases as I have been able to check, the specimens were either definitely in the overburden or else in a position where they could have been washed down by the hydraulicking.

### Localities and Faunal Lists

Most of the land pebble phosphate mines have produced some vertebrate fossils, but these are very much more numerous in some mines than in others. The following are the localities of which there is positive record in the literature or in material examined for the present study:

1. Mines of American Cyanamid Company, Brewster, Polk County.
2. Pierce mines of American Agricultural Chemical Company, Pierce, Polk County.
3. Mines of Phosphate Mining Company, Mulberry, Polk County.
4. Mine of Prairie Pebble Phosphate Company, Mulberry, Polk County.
5. Mine of Standard Phosphate Company, Christina, Polk County.

The first of these localities is far the most prolific. The fauna and its distribution, so far as positively established by autoptic examination of specimens of known origin, is as follows:

	1	2	3	4	5
<i>Agriotherium schneideri</i>	×				
<i>Leptarctus progressus</i>			×		
<i>Hipparion ingenuum</i>	×				
<i>Hipparion plicatile</i>				×	
<i>Hipparion minor</i>	×				
<i>Hipparion phosphorum</i>	×				
<i>Teleoceras proterus</i>	×		×	×	
<i>Aphelops longipes</i>	×				
? <i>Prosthennops</i> sp.	×		×		
Camelid indet.	×				
<i>Serridentinus floridanus</i>	×				×
<i>Serridentinus simplicidens</i>					×
<i>Serridentinus brewsterensis</i>	×	×	×	×	
<i>Pliomastodon sellardsi</i>	×				

## RIVER DEPOSITS

It has long been known that certain river deposits contain mammal remains similar to those of the Alachua and Bone Valley. The classic example is the Peace Creek or Peace River. From the so-called Peace Creek beds Leidy (1889) described a fauna predominantly Pleistocene but including two species of *Hipparion*. Dall (1892) supposed the beds to be of middle Pliocene age, chiefly on invertebrate evidence of supposed interbedding with marine Pliocene, and named them the Peace Creek Formation. Cope (in Dall, 1892, p. 130) regarded them as containing a mixture of Loup Fork and *Equus* beds species and probably intermediate in age. Osborn (1910, p. 366) recognized the possibility of mixture (although apparently feeling that *Bison* and not *Hipparion* is the extraneous genus) but concluded that the beds are probably of very late Pliocene or early Pleistocene age. Sellards (1915, p. 78) insisted on the extraneous nature of *Hipparion* and referred the beds to the Pleistocene. Hay (1923, p. 381) refused to recognize the possibility of mixture among the mammals or reptiles and referred the deposit to the Aftonian.

Recent careful reëxamination of the formation in the field by Walter W. Holmes and myself thoroughly supports the views of Sellards. The beds from which fossils are derived are of Pleistocene and Recent age. The Pliocene fossils (two species of *Hipparion* and one of *Serridentinus*) are derived from the Bone Valley formation. The beds consist of a rather complex sequence of channel, flood plain, and dune desposits. Deposition is still going on, and recent deposits of this nature overlie and cut into the Peace Creek beds proper. In some of the shoals of the present streams are phosphatic gravels obviously reworked in recent years, but identical in nature with the true Pleistocene beds, and containing Pliocene, Pleistocene, and Recent remains. Many of the fossils at Arcadia were recovered from such Recent sand bars.

The following are pertinent points regarding the apparent mixture of Pliocene and Pleistocene species in this and other river phosphate deposits:

1. The Pliocene species occur only in rivers which do or have cut through Alachua or Bone Valley deposits.
2. The Pliocene species are identical with those of the Alachua-Bone Valley fauna, and the Pleistocene species with those of the Melbourne beds and equivalents.
3. In the Alachua and Bone Valley themselves, the Pleistocene species are absent among materials of known horizon, and, in the large

Melbourne beds collections from localities not deriving material from the Alachua or Bone Valley, the Pliocene species never occur.

4. The phosphatic river beds, which derive their phosphate direct from the pre-Pliocene formations, may contain Pleistocene, but do not contain Pliocene, fossils.

5. The Pliocene specimens are almost always water-worn, often reduced to small pebbles.

The river phosphate localities may be grouped as follows:

A. Streams draining the Bone Valley area. In all of these, derived Bone Valley specimens are to be expected.

Peace Creek  
Manatee River

{ The area between these rivers is not now drained  
by streams reaching the Bone Valley, but the Pleistocene drainage of this mesopotamic area did so.

Alafia River

Hillsborough River—Now heads between the hard rock and land pebble areas, but this intermediate region was apparently partly occupied by Pliocene beds now removed by erosion.

B. Streams in or flowing from the hard rock (Alachua) area. In these, derived Alachua fossils may or do occur.

Withlacoochee River (lower part)

Waccassassa River

Suwanee River (lower part)

C. Streams deriving their phosphate solely from pre-Pliocene beds (chiefly Hawthorn). Some of the above streams doubtless derived some but not all of their phosphate direct from this source. In this group of river deposits no Pliocene fossils occur.

Caloosahatchee River

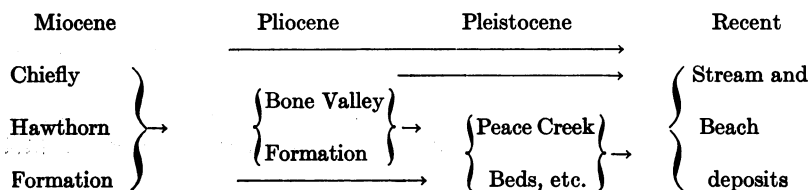
Black Creek

Olustee Creek

Allapaha River

Sopchoppy River

The constant reworking and derivation of fossils, phosphate, and other sedimentary material in west central peninsular Florida may be represented by the following diagram:



None of these river deposits is really of Pliocene age, and they have revealed no Pliocene mammals not also known in the true Pliocene deposits, so that discussion of their faunas as such is not necessary here.<sup>1</sup>

#### PLIOCENE CORRELATION

Leidy, Cope, and Lucas agreed that the Alachua clays are of upper Miocene or "Loup Fork" age. Osborn and Matthew (1909) considered them as equivalent to the "*Peraceras* zone," latest Miocene or earliest Pliocene. Osborn (1910, p. 337) later stated that the Alachua clays interbedded with marine shell-bearing formations (an error) and placed them definitely in the Pliocene. Sellards (1916) concluded that the Alachua and Bone Valley are approximately equivalent and that they belong probably in the Pliocene. Kellogg (1924) considers the Bone Valley as definitely pre-Pliocene and perhaps Helvetian. Hay (1923), on the contrary, refers both it and the Alachua to the older Pleistocene.

The first question is that of relationships between the Alachua and the Bone Valley. The terrestrial mammals may be compared as follows:

Alachua Formation	Bone Valley Formation
	<i>Agriotherium schneideri</i>
	<i>Leptarctus progressus</i>
<i>Hipparion ingenuum</i> .....	<i>Hipparion ingenuum</i>
<i>Hipparion plicatile</i> .....	<i>Hipparion plicatile</i>
<i>Hipparion minor</i> .....	<i>Hipparion minor</i>
	<i>Hipparion phosphorum</i>
<i>Teleoceras proterus</i> .....	<i>Teleoceras proterus</i>
<i>Aphelops longipes</i> .....	<i>Aphelops longipes</i>
	? <i>Prosthennops</i> sp.
? <i>Megatylopus major</i>	
? <i>Procamelus minor</i> .....?	Camelid indet.
? <i>Procamelus minimus</i>	
<i>Serridentinus floridanus</i> .....	<i>Serridentinus floridanus</i>
<i>Serridentinus leidii</i>	
	<i>Serridentinus simplicidens</i>
	<i>Serridentinus brewsterensis</i>
	<i>Pliomastodon sellardsi</i>

In view of the faulty nature of much of the material, the resemblance does not preclude a slight difference in age, but it seems to establish the two formations as approximately contemporaneous. The differences do not point to any definite age distinction and may be entirely due to

<sup>1</sup>Since this paper was completed, the American Museum has received from Mr. Stanley Kitching of Stuart a *Serridentinus* molar from the St. Lucie Canal. The derivation of the tooth is uncertain, but Pliocene beds are known to occur beneath the Anastasia in this area, and the Pleistocene is said to contain pebble phosphate, doubtless of Tertiary origin.

the very different conditions of deposition at the two localities and to incomplete knowledge of the faunas.

The Bone Valley and Alachua mammals compare as follows with those of western North America:

- Agriotherium schneideri* — *Agriotherium*, typical of the Pliocene in America, Europe, and Asia, very doubtfully recorded in the Miocene of Italy and the Pleistocene of India. Species close to *A. gregori* of the Eden.
- Leptarctus progressus* — *Leptarctus*, known elsewhere only in the Upper Miocene, but species not very close and perhaps more progressive.
- Hipparion ingenuum* } *Hipparion*, first appearing as such in the latest Miocene or  
*Hipparion plicatile* } earliest Pliocene, continuing throughout the Pliocene.  
*Hipparion minor* } Species closest to western species of the Lower and  
*Hipparion phosphorum* } Middle Pliocene. Somewhat more progressive than  
the earliest Hipparions.
- Teleoceras proterus* — *Teleoceras*, Upper Miocene and Lower Pliocene. Species close to *T. fossiger*, Republican River.
- Aphelops longipes* — *Aphelops*, Upper Miocene and Lower Pliocene. Species close to *A. malacorhinus*, Republican River.
- ?*Prosthennops* sp. — *Prosthennops*, Upper Miocene and Lower Pliocene.
- ?*Megatylopus major* — *Megatylopus*, genotype Lower Pliocene, limits of range uncertain. Florida species inadequately defined, but apparently comparable to Lower Pliocene camels.
- ?*Procamelus minor* } Too poorly known to be of value in precise correlation.  
? *Procamelus minimus* }
- Serridentinus floridanus* } — *Serridentinus*, Middle and Upper Miocene, Pliocene,  
*Serridentinus leidii* } doubtfully recorded in older Pleistocene. Florida  
*Serridentinus simplicidens* } species comparable with various late Miocene or  
*Serridentinus brewsterensis* } Lower Pliocene species of the West.
- Pliomastodon sellardsi* — *Pliomastodon*, typically Lower Pliocene, extent of range undefined. Species close to *P. matthewi*, Upper Snake Creek.

The evidence of the land mammals is very clear and not contradictory. It indicates approximate equivalence with the Upper Snake Creek or the Republican River. With this relative age established, it is of little consequence whether it be called late Miocene or early Pliocene. At present the consensus seems to be that the Republican River and equivalents are referable to the Lower Pliocene.

The evidence of the marine mammals, as reviewed by Kellogg (1924, p. 756), introduces a radical discrepancy. He states that *Metaxytherium*, *Schizodelphis*, and *Pomatodelphis inæqualis*, found in the Bone Valley, are clearly earlier than Pliocene; not later than Upper Miocene,



and possibly as old as the Helvetian. The land mammals are certainly not as old as this. There are three possibilities of reconciliation between the two classes of evidence:

1. That the marine mammals are derived from older formations. From their mode of occurrence and the scarcity of such remains in the Hawthorn, this is at best a remote possibility.

2. That the Florida pelagic mammals are survivors of genera hitherto erroneously supposed to have become extinct in the Miocene. The distribution of pelagic mammals is not so completely known as to make this inherently improbable. In fact, the evidence of the land mammals is so clear that, if the pelagic mammals can be proven to be correctly associated and to be of earlier genera, I should consider this survival as proven.

3. That the Florida aquatic mammals do not actually belong to the genera to which they have been referred. All of them have been represented only by very imperfect material, and generic determination is probably not positive. This is emphasized by the fact that discovery of better specimens of the supposed *Metaxytherium* show that it does not belong to that genus but is actually in a Lower Pliocene stage of evolution, in agreement with the land mammals.

The opposite conclusion, that the Bone Valley and Alachua are much younger than here concluded, has been advanced especially by Hay. The erroneous basis on which this argument rests has already been sufficiently exposed.

#### DESCRIPTIONS OF PLIOCENE MAMMALS

##### CANIDÆ

##### *Agriotherium schneideri* Sellards, 1916

This species was described by Sellards (1916, p. 98) on the basis of a lower jaw from Brewster. This specimen and an isolated upper molar have since been restudied and discussed by Frick (1926, pp. 75, 84) who concluded that the species belongs in the typical section of the genus ("*Hyænarctos*" = *Agriotherium*) and is closely related to *A. gregori* of the Eden Pliocene. No additional material has been found.

##### MUSTELIDÆ or PROCYONIDÆ

##### *Leptarctus progressus*, new species

TYPE.—F.S.G.S. V4255, right P<sup>4</sup>. Donated by E. T. Casler.

HORIZON AND LOCALITY.—Lower Pliocene, Bone Valley, pit of Phosphate Mining Company near Mulberry.

DIAGNOSIS.— $P^4$  with two outer roots confluent. Broader transversely than long, protocone much smaller than centroexternal cusps but well developed and projecting anterointernally. Small medium cuspule on anterior border. Broad outer slopes on external cusps. Anteroposterior diameter of tooth 7.3 mm., breadth 7.7 mm.

In *Leptarctus primus* the length of  $P^4$  is nearly the same as in this tooth, but the breadth is considerably less, only 5.4 mm.; the protocone is not so large, the anterior margin is without cuspules, and the external slope is narrower. Nevertheless, the peculiar structure of this tooth agrees so closely with that of *Leptarctus primus* and differs so radically from anything else known to me that it is referred to that genus with some confidence. It would seem to be a somewhat more progressive animal, although the phylum is so little known that this carries slight weight. It may be more nearly related to the other known species of the genus, *L. wortmani* Matthew from the Valentine beds of Nebraska.  $P^4$  of this species is unknown, but the lower dentition is longer than in *L. primus*, whereas in *L. progressus*  $P^4$  has the same length as in the latter but is wider.



Fig. 19.  
*Leptarctus progressus*, new species. Type. Right  $P^4$ , crown view. Twice natural size.

This tooth bears a general resemblance to that of *Procyon* or *Nasua*, as in *L. primus*. It is equally distinct from *Procyon*, but shows some special resemblance to *Nasua* in its greater width and relatively larger, more conical protocone.

### EQUIDÆ

The horses so far known from the Pliocene of Florida all belong to the genus *Hipparion*.

Specimens of this genus have never been found in association in Florida, consisting only of isolated teeth and a few bones. Over thirty upper cheek teeth, and about the same number of lower teeth, have been examined in the course of the present research. Four species have been proposed: *H. ingenuum* Leidy, 1885; *H. plicatile* Leidy, 1887; *H. princeps* Leidy, 1890, and *H. minor* Sellards, 1916. All types are isolated upper cheek teeth, the first two from the Mixson bone bed, the third from Peace Creek, and the last from the Bone Valley at Brewster. *H. princeps* is here rejected, and a new species is described.

Lucas (Leidy and Lucas, 1896, p. 49) considered *H. princeps* as an abnormal *Equus* tooth, *H. ingenuum* as a synonym of *H. gratum*, and *H. plicatile* as distinctive. Gidley (1907) reinstated *H. princeps*, re-

ferring it to *Neohipparion*. He considered *H. ingenuum*, *H. plicatile*, and *H. venustum* (from South Carolina) as differing from all other North American species, and referred these, only, to the genus *Hipparion*, all others (save one or two doubtful types) to *Neohipparion*. Supposedly distinctive characters were: more hypsodont teeth, stronger styles, more elaborate folding of fossette borders, small and nearly circular protocones. On this view of special affinity to the Old World *Hipparions* Joleaud based certain paleogeographic speculations adequately discussed and refuted by Matthew (1924, p. 173). Gidley's views were

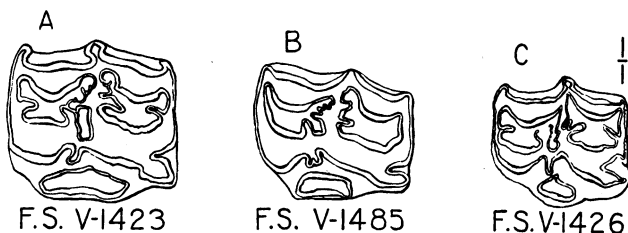


Fig. 20. Various species of *Hipparion* from Florida. A, *Hipparion phosphorum*, type. B, *Hipparion plicatile*, referred. C, *Hipparion ingenuum*, referred. Natural size.

paraphrased by Osborn (1918) without comment, but he agreed with Lucas in rejecting *H. princeps* as abnormal. Matthew (1924, p. 173) states that the protocones are oval to lenticular, as in *H. gratum* and most Old World species, and that exceptional hypsodonty is typical rather of *H. gratum*. He concludes that the Florida *Hipparions* belong to the *H. gratum* group and are conspecific with western species. He has more recently stated that the Florida species belong to his new subgenus *Nannippus*.

#### "*Hipparion princeps*" (Leidy, 1890)

I agree with Lucas in considering this as an abnormal *Equus* tooth. Although Gidley expressed an opposite opinion, it does agree in every respect save the separate protocone with some true *Equus* teeth from Florida. The protocone is united not far below the worn surface, and no other specimen has been discovered in Florida, although *Equus* teeth occasionally approach this condition. It was found in Pleistocene or Recent beds.

#### *Hipparion ingenuum* (Leidy, 1885)

This is the common species in Florida. It is of medium size, the protocone oval, its long diameter averaging about one-third the entire

anteroposterior diameter of the crown. In some cases, especially where less worn, the ends of the protocone are angulate as in *H. lenticulare*. The protocone is never circular, as stated by Gidley, unless very obliquely worn. The enamel folds vary greatly in the available specimens, but are about as in *H. gratum* and its allies, perhaps rather more complex on an average than in *H. gratum* itself. The crowns are extremely hypsodont. It is probable that the slender metapodial described by Lucas belongs to this species, although it may belong to *H. plicatile* as he supposed. The species appears to be referable to *Nannippus* Matthew.

#### **Hipparion plicatile** (Leidy, 1887)

There is no sharp demarcation in the isolated teeth between this species and the last, but they are probably distinct. Upper cheek teeth now referred to this species average about 10% larger than in *H. ingenuum*. The protocone may be similar in form, but is usually more elongate, more flattened on its internal side, and on the average larger relative to the whole tooth, its long diameter nearly half the anteroposterior diameter of the crown. The complication of the enamel is only partially distinctive. No subsequently discovered tooth is as complex as the type. Several others have a double, but none a triple, pli caballin, and a double pli caballin does occur rarely in *H. ingenuum*. Like the latter this agrees rather closely with western species and lends no support to Gidley's view of 1907. It is in some respects intermediate between the *gratum* and *affine* groups, some specimens resembling more the one, some the other, although better material would doubtless fix its relationships.

#### **Hipparion minor** Sellards, 1916<sup>1</sup>

Sellards described this species on the basis of three upper cheek teeth, one (the type) from the Bone Valley at Brewster and two from the Alachua. The species is apparently rare. The characters given by Sellards are its small size, complicated enamel pattern, and ellipsoidal protocone. The last two characters are well within the range of variation of *H. ingenuum* or *plicatile*, but the size, apparently 20 to 25% smaller than *ingenuum*, appears to be distinctive. So far as this isolated material goes, resemblance is clearly to the subgenus *Nannippus*.

<sup>1</sup>Matthew (ms.) suggests preoccupation of the name by *H. minus* Pavlow. The similarity is unfortunate but not a basis for renaming the species under the accepted recommendations in nomenclature.

**Hipparion phosphorum**, new species

TYPE.—F.S.G.S. V1423. Left upper cheek tooth, probably M<sup>2</sup>.

HORIZON AND LOCALITY.—Lower Pliocene, Bone Valley Formation, mine of American Cyanamid Company, Brewster, Polk County, Florida.

DIAGNOSIS.—A *Neohipparion* of the *H. (N.) affine* group. Size medium. Crown very long, moderately curved. Outer border flattened, with sharply defined styles. Protocone relatively very large, elongate, flattened internally. Pli caballin single. Fossettes contracted, borders complex, pli protoloph and pli hypostyle present.

This species is totally unlike those previously known from Florida. It clearly belongs in the subgenus *Neohipparion* and is close to *H. affine*, *H. whitneyi*, and *H. occidentale*, but nevertheless is so distinct even as an isolated specimen that reference to an established species is impossible. From both of the first two mentioned species it differs in its smaller size, relatively larger and more elongate protocone, flatter outer border, and more complex fossette borders. The complexity of enamel pattern is closely paralleled in *H. occidentale*, but the size is smaller, the fossettes more contracted, the protocone larger and flatter, the hypocone smaller.

In view of the general faunal relations of the Florida Pliocene, the presence of a true *Neohipparion* of this stage of evolution was to be expected. The specific distinction is explicable as due to climatic or other differences in facies or perhaps to the wide geographic separation.

F.S. V-282

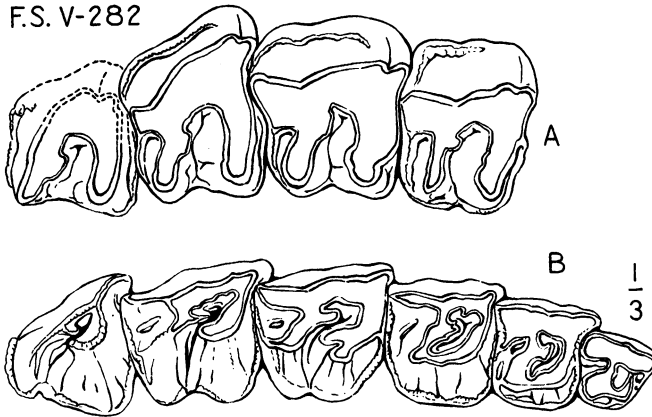


Fig. 21. Pliocene rhinoceroses from Florida. A, *Aphelops longipes*, right P<sup>4</sup>-M<sup>3</sup> from Brewster, crown view. B, *Teleoceras proterus*, right P<sup>2</sup>-M<sup>3</sup> from Mixson's bone bed. B redrawn after Leidy and Lucas. One-third natural size.

**RHINOCEROTIDÆ**

Leidy (1884, 1890) described two rhinoceroses from the Mixson bone bed, *Rhinoceros proterus*, based on a last upper molar, and *R.*

*longipes*, based on a canine and two metacarpals. Cope (1892) referred both species to *Aphelops*. Lucas (in Leidy and Lucas, 1896) considered *R. proterus* as synonymous with *Aphelops fossiger* and *R. longipes* as synonymous with *Aphelops malacorhinus*, both Republican River species. Osborn (1904) considered *Aphelops longipes* as possibly distinct from *A. malacorhinus* and referred to the other species as *Teleoceras fossiger* var. *proterus*. The two species are here provisionally recognized as *Aphelops longipes* and *Teleoceras proterus*.

Rhinoceroses occur in Florida chiefly in the Alachua Formation near Williston and the Bone Valley Formation near Brewster. The species appear to be identical, but at the former locality *Teleoceras proterus* is more abundant, and at the latter *Aphelops longipes*.

#### ***Teleoceras proterus* (Leidy, 1885)**

Lucas (in Leidy and Lucas, 1896) has described and discussed this species in some detail on the basis of specimens from the Mixson bone bed, including examples of most of the upper teeth, some of the lower teeth (less positively identified), and numerous isolated or fragmentary skeletal parts. He concluded that the distinctions from *Teleoceras fossiger* were "slightly smaller molars, having thinner crests; a better development of the cingulum on pm<sup>3</sup> and <sup>4</sup>, bones of the feet averaging a little heavier and more rugose." He also points out that the crests tend to unite at a higher level in the Florida specimens.

Hitherto undescribed specimens from the pits of the American Cyanamid Company at Brewster reveal the presence of this genus and probably species in the Bone Valley Formation. The only upper jaw (F.S.G.S. V4036) is that of a young individual with dm<sup>3-4</sup> and M<sup>1</sup>, rather poorly preserved. So far as preserved, these teeth agree very closely with homologous teeth from the Mixson bed figured by Leidy and Lucas. There also are known an isolated M<sub>2</sub> (Am. Mus. No. 20473) and right lower jaw with M<sub>1-3</sub> (Am. Mus. No. 20467). These do not at all resemble some of the lower teeth referred by Lucas (Leidy and Lucas, 1896, Pl. x, figs. 1-2), but I believe that these teeth actually belonged to the other species, *Aphelops longipes*, and that only one of the Mixson specimens there figured (Pl. x, figs. 9-10) belongs to *T. proterus*. This tooth agrees in size and other characters with M<sub>1</sub> of the Bone Valley material. Like the upper teeth, these lowers agree very closely with *Teleoceras fossiger*, the only definite distinctions being the smaller size and the relatively slightly greater depth of the crown below the closure of the valleys internally.

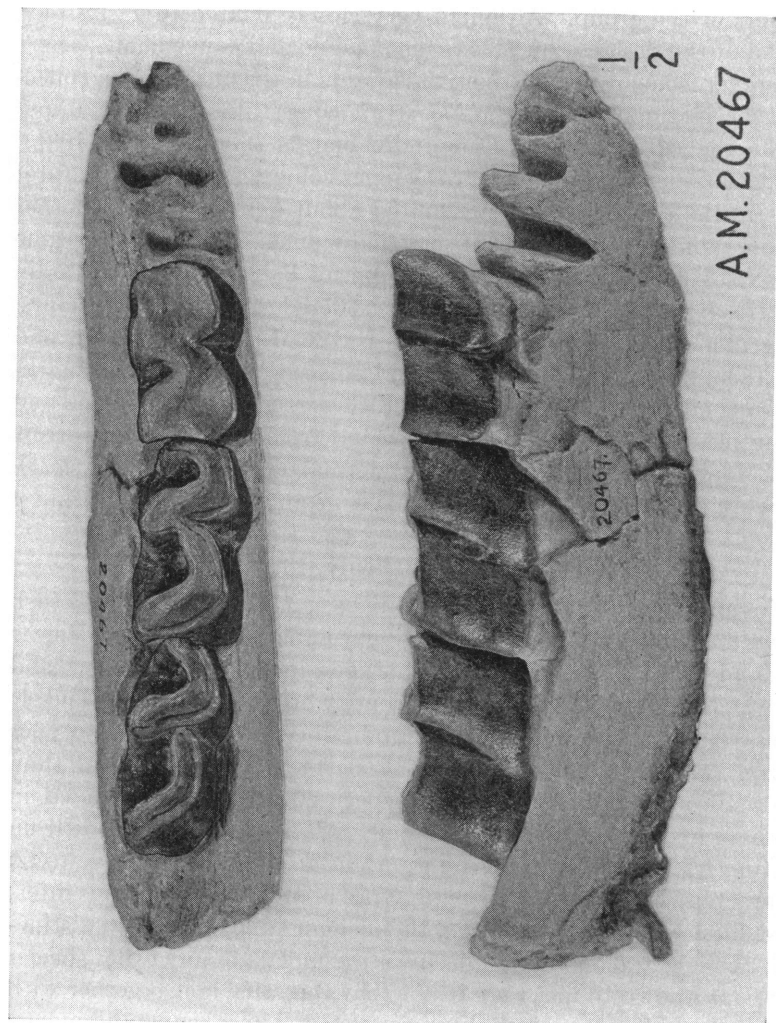


Fig. 22. *Teleoceras proterus*. Referred right lower jaw with  $M_1$ -3 from Brewster, crown and external views. One-half natural size.

The majority of the known specimens agree fairly well with the best upper dentition described by Leidy and Lucas (1896, Pl. VIII, figs. 7-12; U.S.N.M. No. 3165), which may be taken as typical and as fixing the characters of the group. Although very closely related to *T. fossiger*, retention of the designation *proterus* is possible and convenient. There are, however, some rather distinctive variants in the old Alachua collection in the National Museum. No. 3197, consisting of all the upper cheek teeth, separate but of one individual, is smaller (about 10%), somewhat lower crowned. On  $P^{3-4}$  the inner columns are more separate; on  $M^2$ , on the contrary, they are united about half way up. Another variation, represented by parts of three individuals, is of about the same size as No. 3165, but has the inner columns of  $P^{3-4}$  more separate, as in No. 3197. Both of these may well be considered as individual variants.

A still more peculiar form is seen in U.S.N.M. No. 3191 (Leidy and Lucas, 1896, Pl. IX, fig. 15), a broken and isolated  $M^2$ . It has a remarkably strong crista, well developed antecrochet, crochet highly folded and reaching nearly to the crista but separated from it by a very narrow fissure. Lucas considered this as an abnormal *T. proterus* (or *fossiger*). It is highly distinctive but not identifiable as an isolated specimen.

#### ***Aphelops longipes* (Leidy, 1890)**

This species rests on a rather insecure basis. The types, a lower tusk and two metacarpals, are hardly distinguishable as to species. Lucas (Leidy and Lucas, 1896) described topotypes, including a few teeth and bones which he claimed to show the identity of *A. malacorhinus* and *A. longipes*. This conclusion is not acceptable. The very poor topotypes of *longipes* are not closer to comparable parts of *A. malacorhinus* than are those of other and clearly distinct species of this group included in *Aphelops* or even in the quite separate genus *Peraceras*. Nor, aside from suggesting relationships to the *malacorhinus* group, do they serve to fix the characters of the species. The presence of a strong continuous internal cingulum with cusps closing the median valley would be distinctive, as these characters do not occur in the molars of any other species of *Aphelops* known to me, were it not that this very fact together with other structural features strongly suggests that Lucas' supposed molars are really premolars. The internal parts of  $M^{1-2}$  are missing in the type of *A. malacorhinus* with which he made comparison.

This problem is to some extent resolved by the discovery of three specimens in the Bone Valley, which, while presenting some difficulties of their own, are greatly better than any rhinoceros material previously



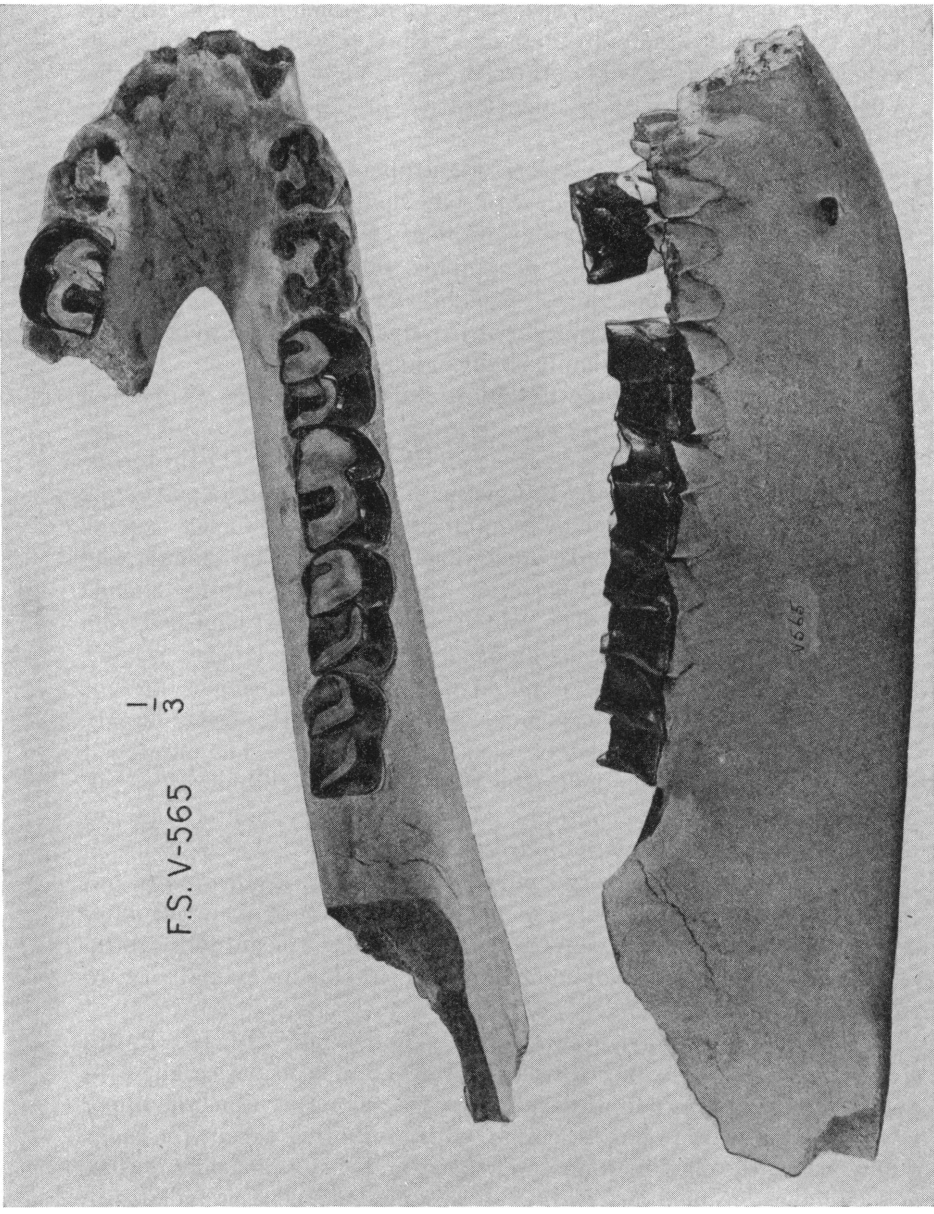


Fig. 23. *Aphelops longipes*. Partial lower jaw with right P<sub>4</sub>-M<sub>3</sub> and left P<sub>3</sub> from Brewster, crown and right lateral views. One-third natural size.

discovered in Florida. These specimens, all of which are from the pits of the American Cyanamid Company at Brewster, have not previously been described, although one of them (F.S.G.S. V565) and part of another (V646) were figured without identification or description by Sellards (1915, figs. 37, 38, 39).

One of these, F.S.G.S. V282, is a right upper jaw  $P^4-M^3$ . It may be referred to *A. longipes*, although with some doubt. It clearly belongs to the same group and to the same evolutionary level; its size is the same, its age is about the same, the geographic separation is less than 120 miles, and (assuming that Lucas' "molars" are premolars)  $P^4$  is generally similar except for the interruption of the cingulum on the hypocone, a feature of doubtful and probably slight significance.

$P^4$  is a large quadrate tooth, slightly broader than long. There is a posteroexternal cingulum and an anterior, internal, and posterior cingulum continuous save for a short space on the hypocone. The protocone is not differentiated from the protoloph. There is no crista and only a slight swelling in the position of the antecrochet. The crochet is small but distinct. The molars have somewhat longer external cingula and equally distinct anterior and posterior cingula, but the internal cingula are very feeble or absent. The protocone is faintly distinguished from the protoloph on  $M^1$ , not at all on  $M^{2-3}$ . As on  $P^4$ , the crochet is very small but distinct, and there is no crista. The antecrochet is present on  $M^1$ , although very inconspicuous, vestigial on  $M^2$ , absent on  $M^3$ . The median valley is completely open and uncrested. The parastylar fold, feeble on  $P^4$ , is better defined on  $M^{1-2}$ . This part is broken off on  $M^3$ .  $M^3$  is trapezoidal in basal contour. The crowns are moderately brachyodont, about as in *A. malacorhinus*.

The upper teeth are very similar to those of *A. malacorhinus*, but the crochets are much less prominent, the valleys more open, the antecrochet less distinct on  $M^{1-2}$ . As in *A. malacorhinus*, the anterior orbital border is above the posterior end of  $M^1$ , and the choanæ extend forward to the middle of  $M^2$ .

There are two good lower jaws, F.S.G.S. V565 with left  $P_4-M_3$ , right  $P_3$  and roots of other teeth, and F.S.G.S. V646 with right  $M_{1-3}$  and left  $M_{1-2}$ . These doubtless represent the same species as the upper jaw just described, and agree closely with each other except for slight differences in the cingula of no importance, and very slight difference in molar dimensions due partly to differences in wear. The premolars are nearly equal to the molars in length and increase in size from  $P_2$  to  $P_4$ .  $P_2$  (roots) is unreduced.  $M_1$  and  $M_2$  are about equal in size,  $M_3$  smaller.

There are variable external cingula on all the cheek teeth. The crowns are much lower than in *Teleoceras proterus*. The jaw is relatively slender, with a nearly straight lower border.

Reference of these specimens to *A. longipes* is further supported by the close agreement between  $M_{1-2}$  of the lower jaws just described and two lower molars from the Mixson locality figured by Leidy and Lucas (1896, Pl. x, figs. 1-2). These were referred to *Teleoceras proterus* by Lucas, but they probably belong to *A. longipes*.

#### TAGASSUIDÆ

##### ?*Prosthennops* sp.

A peccary is represented in the Pliocene collections by the proximal end of a left metatarsus (Amer. Mus. No. 20474) acquired by Dr. Matthew in 1924 from the American Cyanamid Company mines at Brewster.

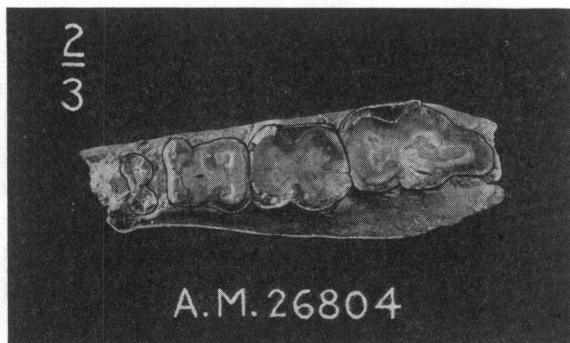


Fig. 24. ?*Prosthennops* sp. Part of upper jaw with badly worn  $M_{1-3}$  from Mulberry, crown view. Two-thirds natural size.

It is smaller than that of *Mylohyus* or *Platygonus*. The third and fourth metatarsals are completely coössified proximally, incompletely medially. The proximal facets are strongly curved. The fifth metatarsal is preserved as a small nodule, fused to the fourth proximoposteriorly. These characters led Matthew (ms.) to refer it to *Prosthennops*, in which, however, this part is otherwise unknown. A jaw fragment (Amer. Mus. No. 26804) was derived from the mines of the Phosphate Mining Company at Mulberry and presented by Mr. J. T. Bullwinkel. The three molars are badly worn but appear to indicate a peccary of about the size of *Prosthennops rex* (Marsh).

### CAMELIDÆ

Leidy (1886B, p. 12) named three species of camels from supposed Pliocene beds in Florida: *Auchenia major*, *A. minor*, and *A. minimus*. The types were all isolated astragali. Cope (1892) listed the species as *Pliauchenia major*, *P. media*, and *P. minor*, erroneously transferring *minor* to the smallest species and introducing the name *media* for Leidy's true *minor*. Leidy and Lucas (1896) referred the species to *Procamelus*, returned to the name *minimus* for the smallest form, but retained Cope's *medius* for the medium-sized animal originally named *minor*. The name *Pliauchenia minima* should properly have been used by Cope according to his understanding of the smallest species, but this name was later given to an entirely different animal by Wortman.

The types are all astragali from Mixson's bone bed in the true Alachua Clays. A number of skeletal parts are also known from this locality, as well as most of the dentition of the largest form and a few isolated teeth of that of medium size. With increasing knowledge of polyphyly in the later Tertiary camels, it is found to be almost impossible to determine the generic affinities of any species without complete knowledge of the dentition and of associated metapodials. Such knowledge is lacking in the Florida material. The revision of the later western camels now in progress by Mr. Frick furthermore makes any detailed comparison of the present species premature.

The size distinctions of the types and the natural grouping of homologous specimens (astragali) into three species are well established. The type astragalus of "*Auchenia major*" measures 99.5 mm. in external length and 66 mm. in distal width. Corresponding measurements for the type of "*A. minor*" are 67 mm. and 46 mm., and for the type of "*A. minimus*" 50 mm. and 33 mm. Taking the National Museum collection as a whole, there are nine measurable specimens of the largest form, 99–103 mm. in external length and 64–70 mm. in distal width. Another specimen of the medium-sized animal agrees almost exactly with the type. The four good specimens of the smallest forms are 50–55.5 mm. in external length and 33–35 mm. in distal width.

Camels are very rare in the Bone Valley. The only specimen known to me is an indeterminate proximal phalanx, mentioned by Sellards (1916, p. 100).

#### ?*Megatylopus major* (Leidy)

There are a number of isolated skeletal parts surely referable to this species. The proportions of the feet are suggested by the following measurements of proximal phalanges in the National Museum:

	Length	Proximal width	Minimum width
Fore foot	106	49.5	28.5
Hind foot	121	46.5	27.5

The cheek dentition of the largest form, including the upper deciduous molars, has been described and figured by Leidy and Lucas (1896). This relatively good documentation will doubtless permit of positive

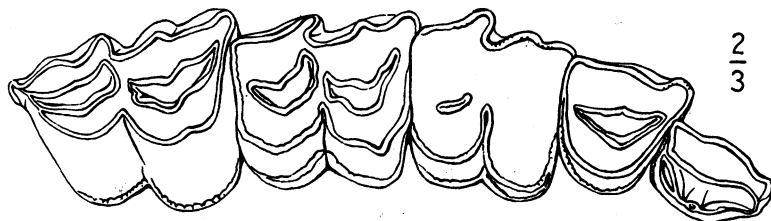


Fig. 25. ?*Megatylopus major*. Right upper P<sup>3</sup>-M<sup>3</sup>, crown view, redrawn after Leidy and Lucas. Two-thirds natural size.

generic assignment with the revision of the Camelidæ. At present, provisional reference to *Megatylopus* is suggested. The teeth and known skeletal parts are of an animal nearly as large as *Megatylopus gigas* and rather similar in proportions. The cheek teeth are more transverse than in *M. gigas*, and the inner crescent of P<sup>3</sup> is complete, although small.

#### ?*Procamelus minor* (Leidy)

Little is surely known of this species beyond the astragalus. An isolated molar and a few fragmentary bones, referred by Leidy and Lucas, are doubtfully placed here and of little value. The true characters of the species and its proper generic assignment are quite unknown.

#### ?*Procamelus minimus* (Leidy)

None of the known teeth are referable to this species, but several limb bones have been placed here. Measurements of proximal phalanges are as follows:

	Length	Proximal width	Minimum width
Fore foot	78.5	23.5	14.5
Hind foot	87.5	22.5	13.5

The limbs were long and slender, as seen especially in a referred metatarsus (Leidy and Lucas, 1896, Pl. xvi, fig. 1). This material offers small chance for comparisons, but it does not exclude reference to *Procamelus*, although affinities may be closer with some of the more slender-limbed forms.

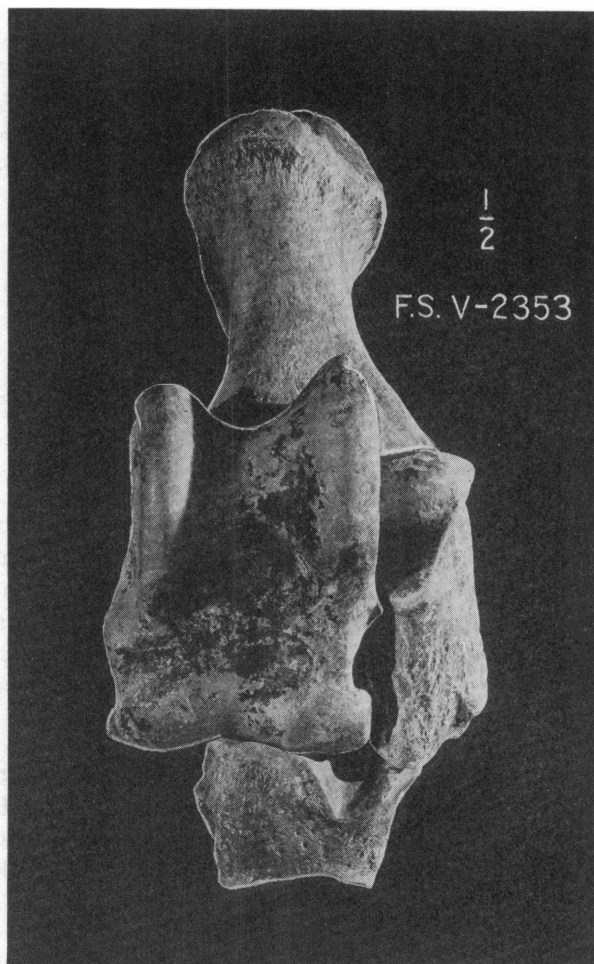


Fig. 26. ?*Megatylopus major*. Left astragalus, calcaneum, and cuboid from Mixson's bone bed, anterior view. One-half natural size.

#### MASTODONTIDÆ

Leidy (1886, p. 11) named *Mastodon floridanus* from the Alachua clays, and a complete description of rich but dissociated materials was given by Leidy and Lucas (1896). The species has been referred to various genera in accord with the numerous changes in mastodont

nomenclature, but it clearly belongs in *Serridentinus* as defined recently by Osborn. Sellards has mentioned the occurrence of the same or closely similar species at various localities in the Alachua and Bone Valley formations (1913, 1915, 1916), and also described (1916, p. 95) a very different type of mastodont from the Bone Valley which he referred questionably to *Mammot progenium* Hay. Frick (1926, p. 169) separated one of Leidy's specimens from *S. floridanus* and made it the type of a

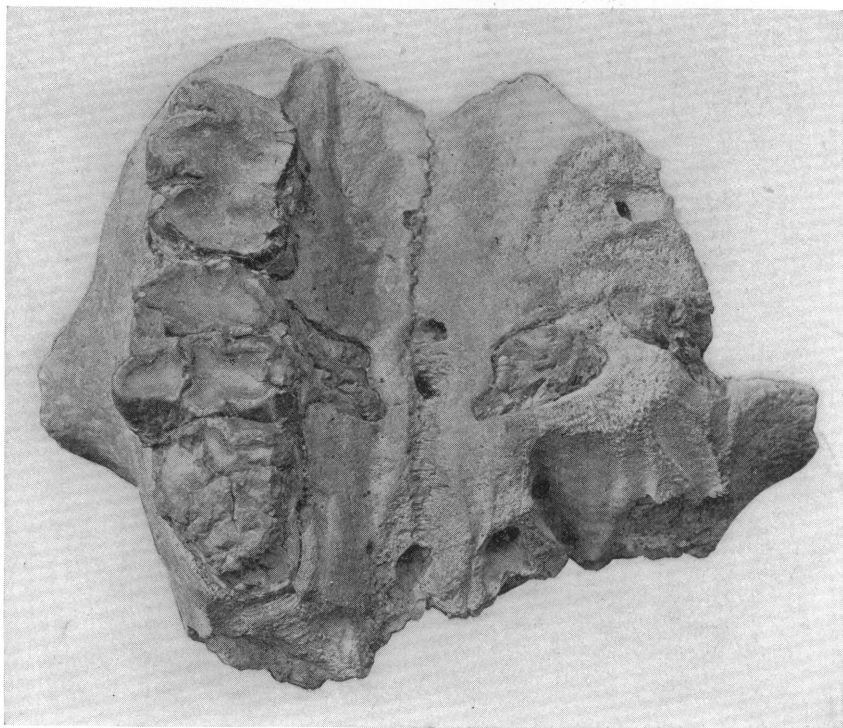


Fig. 27. *Serridentinus brewsterensis*. Palate with broken right M<sup>2.3</sup> from Brewster, crown view. Burdette Loomis Collection.

new species, *S. leidii*. Osborn has recently described two species from the Bone Valley Formation, both referred to *Serridentinus*: *S. simplicidens* (1923) from Lakeland, and *S. brewsterensis* (1926) from Brewster. Professor Osborn's forthcoming memoir will take up the Florida serridentines in detail, so that any attempt at revision or redescription would here be premature. For completeness, however, brief characterization

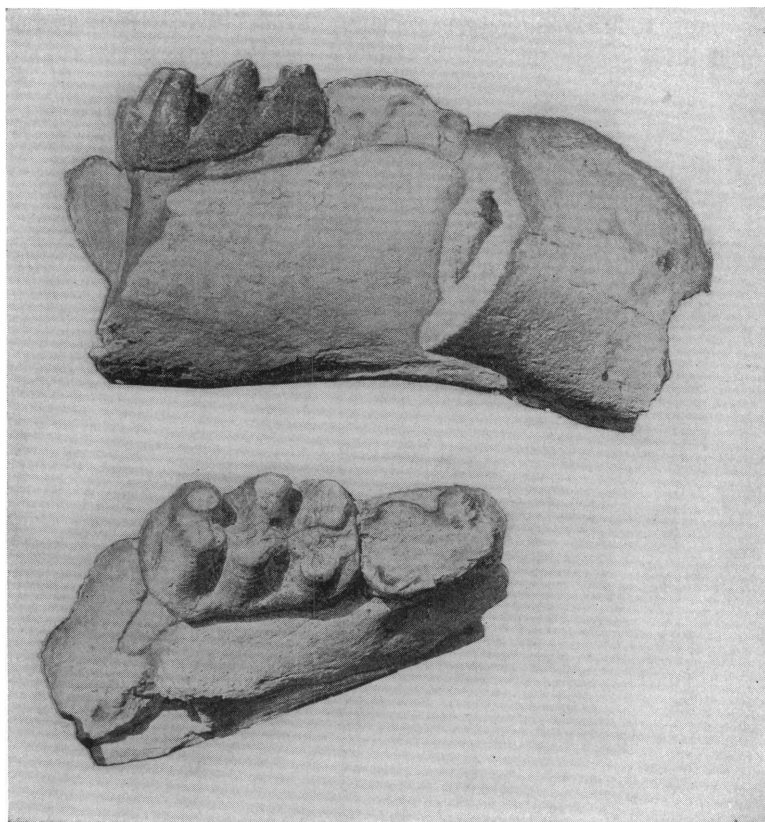


Fig. 28. *Serridentinus brewsterensis*. Partial lower jaw with right and left dm<sub>4</sub> and M<sub>1</sub> from Brewster. Right lateral view of part of same jaw with right teeth. Burdette Loomis Collection.



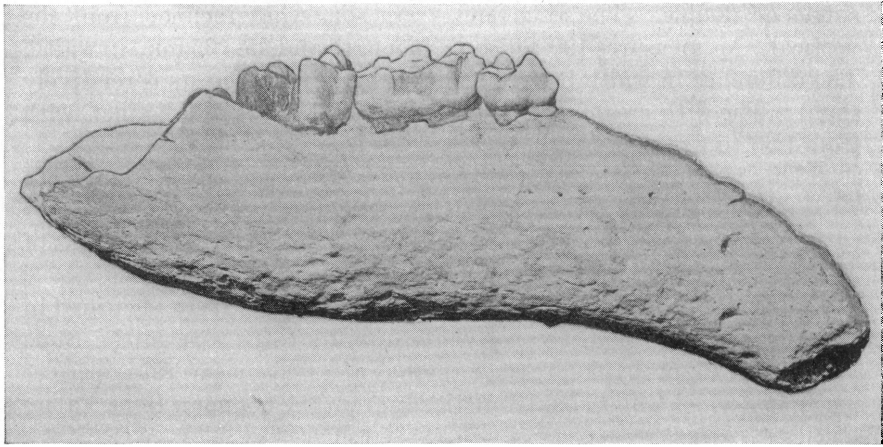
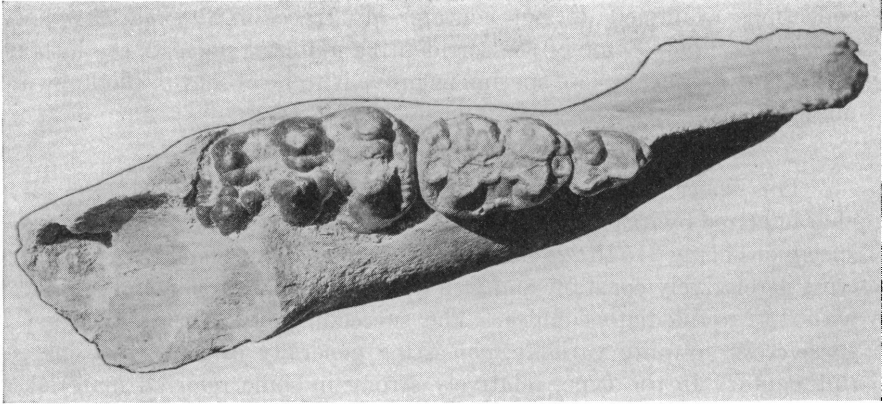


Fig. 29. *Serridentinus brewsterensis*. Juvenile right lower jaw with dm<sub>2</sub>-4, symphysis nearly complete but tusks lacking, from Brewster. Crown and external views. Burdette Loomis Collection.

of the species and description of a new species of another phylum are here given.

The proboscideans of the Alachua and Bone Valley belong to two groups, the Serridentinæ and the Mastodontinæ. The rather rich collections examined do not contain any trace of *Stegomastodon* or *Rhynchotherium*. Some of the serridentine material suggests the latter genus, but more complete specimens prove it to be absent in the known material.

***Serridentinus floridanus* (Leidy, 1886)**

This species, thoroughly described by Leidy and Lucas (1896), is characterized by its relatively large and narrow  $M_3$ , the length of various specimens being 215 to 225 mm. and the width about 85 mm. The fifth crest is relatively constant and well developed, but narrow and usually without intermediate conules. The succeeding heel, or rudimentary sixth crest, is quite variable, consisting generally of one small cusp, rudimentary in the type, relatively strong in some referred material. The ridge-crest conules are generally double, the trefoil-crest conules single or double. The ridge-crests are somewhat inclined from the vertical.  $M_3$  measures 190–205 mm. in length and 95–105 mm. in width. The difference in width between the first and fourth crests is relatively slight. The fifth crest is variably developed, but always distinct, with from two to five cones.

This is apparently a rather progressive species, but certainly not more so than *S. republicanus* of the lower Pliocene. The latter is similar to *S. floridanus* and of the same size, but the rudimentary fifth crest of  $M_3$  is more complex and the trefoil conelets more numerous.

This and *S. leidii* are the only species so far positively identified in the Alachua formation. *S. floridanus* appears to be rare in the Bone Valley, but its probable presence there is attested by several imperfect specimens which differ characteristically from the common Bone Valley species, *S. brewsterensis*.

***Serridentinus simplicidens* Osborn, 1923**

This is a small and simple species, surely distinct from *S. floridanus*. The type  $M_3$  is 135 mm. long and 60 mm. wide and has four complete crests and a rudiment of the fifth. The cones and crests are low and simple, trefoil crests relatively poorly developed.

From its apparently primitive character, it might be supposed that this species is older than *S. brewsterensis*. This is probably not true, however. It was found in the same formation and is indistinguishable in

mode of preservation from the other proboscideans of the Bone Valley. The Hawthorn has yielded no trace of Proboscidea, and derivation from that formation is highly improbable.

**Serridentinus brewsterensis** Osborn, 1926

*S. brewsterensis* is distinguished from *S. floridanus* by slightly smaller size,  $M^3$  measuring 179 mm. by 87 mm., by the absence of the fifth loph on this tooth, and by the relatively small and narrow fourth crest. Several third lower molars from the type locality are probably referable to this species. The sixth crest is absent and the fifth crest is small and consists of four closely appressed cusps, higher on the external side, rather than of two subequal and more separate cusps as in *S. floridanus*.

This species appears to be close to several western species, such as *S. præcursor* or *S. anquirivalis*, which seem, however, to have higher, sharper crests, but is apparently distinct and in an Upper Miocene or Lower Pliocene stage of evolution.

**Pliomastodon sellardsi**, new species

TYPE.—F.S.G.S. V3822 (old number, 6160). Left lower jaw with  $M_{2-3}$ . Right lower jaw of same individual known from photographs, present location unknown. Presented by Anton Schneider.

HORIZON AND LOCALITY.—Lower Pliocene, Bone Valley Formation, pit of American Cyanamid Company, Brewster, Florida.

DIAGNOSIS.—Symphysis elongate, stout lower tusks, alveoli about 50 mm. in diameter near posterior end.  $M_2$  fully trilophodont. Fifth crest of  $M_3$  less developed than in *Mastodon americanus*, ridge-like, more distinct internal cusp and four closely appressed cusps external to it. Cusps more elevated than in *Miomastodon merriami*, less than *Mastodon americanus*, about as in *Pliomastodon mathewi*. Inner side of  $M_3$  strongly convex, outer border straight. First loph distinctly narrower than second, and last two lophs also relatively narrower than in *Mastodon*.

Measurements.— $M_2$ —Length—110 mm.

Width—80 mm.

$M_3$ —Length—164

Width—First loph—85

Second " —95

Third " —88

Fourth " —73

Fifth " —45

Height internal cone of first crest—actual 55, estimated 57.

" " " second " — 56, " 59

This specimen was discovered in the mine of the American Cyanamid Company at Brewster and sent to Sellards, then State Geologist, by the late Anton Schneider, then superintendent of the company.

Sellards (1916, p. 93) published a photograph and brief description of the specimen, pointing out the close resemblance to *Mastodon americanus* but emphasizing the longer symphysis. He did not believe it to be conspecific with *Mastodon progenius* Hay, which is a Pleistocene form and perhaps only an abnormal *M. americanus*, yet provisionally referred it to that species.

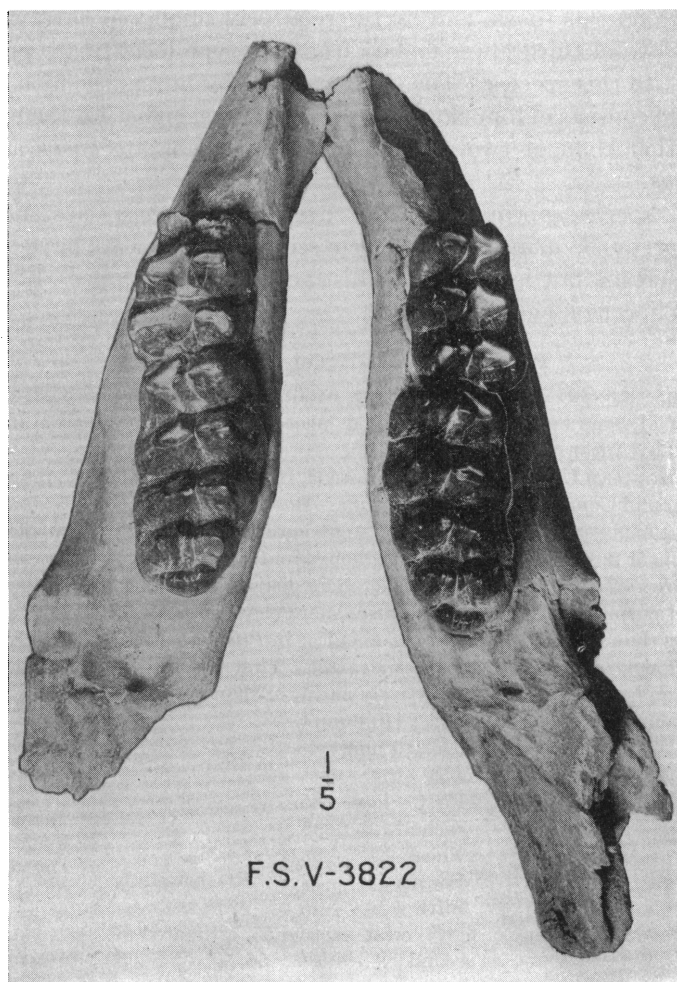


Fig. 30. *Pliomastodon sellardsi*. Type. Lower jaw with right and left  $M_{2-3}$ , crown view. One-fifth natural size. Photograph from Florida State Geological Survey.

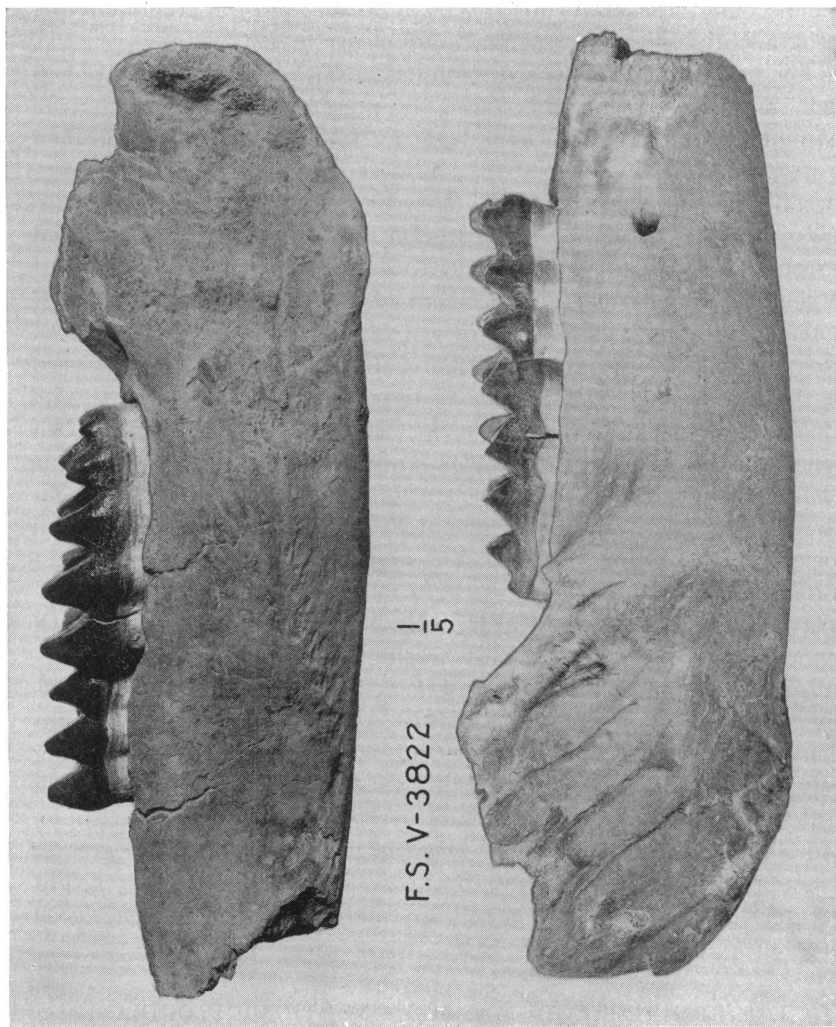


Fig. 31. *Plomastodon sellardsi*. Missing part of type. Right lower jaw with M<sub>2-3</sub>, internal and external views. One-fifth natural size. Photographs from Florida State Geological Survey.

The somewhat better right half of the specimen was returned to Mr. Schneider, at his request, but upon inquiry in 1929 he did not know of its whereabouts, and repeated inquiry has failed to reveal it. The left half constitutes an adequate type, however, and the accompanying photographs of the whole specimen are clear.

The importance of this specimen has never been adequately recognized. In 1915, Sinclair announced the presence of an apparent true mastodontine in the Snake Creek beds, an isolated specimen identified as ?*Mastodon* sp. Matthew (1918) considered this tooth as intermediate between "*M.*" [*Rhynchotherium*] *brevicens* and "*M.*" [*Serridentinus*] *serridens* on the one hand and *Mastodon americanus* on the other, and referred it and the two former species to *Zygolophodon*. It was not until five years after Sellards' announcement of the fact that the presence of the true mastodontines as such in the Lower Pliocene of the United States was clearly recognized (Osborn, 1921). At that time Osborn described *Mastodon matthewi* from the upper Snake Creek and *Mastodon merriami* from the Thousand Creek. In 1922 Osborn placed both species in a new genus, *Miomastodon*, and in 1926 he erected the genus *Pliomastodon* for *M. matthewi*. The status of these genera is not entirely clear, as they are based on fragmentary material of rather doubtful association, but will of course be discussed in Professor Osborn's forthcoming memoir.

The present specimen is far the best yet referred to this group. Of previously described species it most resembles *P. matthewi*, and is therefore tentatively referred to *Pliomastodon*. The  $M_3$  referred to *P. matthewi* is very incomplete, but *P. sellardsi* is about 15% smaller; the incipient fifth crest rises to a prominent internal cuspule rather than being purely cingulum-like, and the fourth crest is relatively narrower, with two definite intermediate cuspules rather than one indefinite cuspule. More complete knowledge of *P. matthewi* will perhaps reveal greater distinctions, but the two species appear to be related. The cusp height is greater than in *Miomastodon merriami* and about as in *Pliomastodon matthewi*.

#### EASTERN TERTIARY MAMMALS NORTH OF FLORIDA

For the sake of comparison with the Tertiary faunas of Florida, a brief review of the other pre-Pleistocene land mammals of the Atlantic coastal region, from the literature only, will be given.

The oldest of these is doubtless *Anchippodus riparius* Leidy, based on one tooth found by a Dr. Knieskern, in the neighborhood of the Shark

River, Monmouth County, New Jersey. Cope considered it as Miocene, believing it to be from the same beds as the lower Miocene mammals mentioned below. Leidy later recognized it as related to *Trogosus* from the western Eocene, an opinion sustained by later students.

Several Miocene mammals were described by Marsh from isolated teeth said to have been found in a single stratum in excavations of the Squankum Marl Company, near Farmingdale, in Monmouth County, New Jersey. *Ammodon leidyianum* is a very large entelodont, comparable in size with *Dinohyus*. It is considered by Peterson as the most advanced of the entelodonts, but is very poorly known. "*Rhinoceros*" *matutinus* was based on a broken  $M_3$ . It is a relatively large form and was referred to *Aphelops* by Hay, an improbable generic assignment. It may be related to *Diceratherium*, in a broad sense. *Tapiravus validus* has not been figured, and its affinities are uncertain. Another species from the upper Miocene or lower Pliocene "east of the Rocky Mountains" was referred to this genus by Marsh, on what grounds does not appear. "*Dicotyles*" *antiquus* is a relatively large pig, of which  $M_2$  and  $M^3$  are known. It has been referred to *Perchaerus*, but it is apparently more advanced than the John Day species of that genus. It may tentatively be referred to the genus *Desmathyus*. This scanty fauna is probably from the Kirkwood, and seems, on the evidence of these mammals, to be of Lower Miocene age. Peterson's belief that it is Middle Miocene appears to me to be based on no conclusive evidence. References to discussions of these specimens may be found in Hay's catalogues.

Mammals of Lower Pliocene aspect have been found at various localities along the Atlantic Coast, but always in equivocal geologic circumstances comparable to those of the so-called Peace Creek in Florida. For the most part these consist of worn or broken teeth of *Hipparion* and *Serridentinus* and are found with Pleistocene mammals. The conditions of collecting and of occurrence amply testify to the probability of admixture, and there is no reason to accept this as evidence of the survival of these two genera into the Pleistocene.

A case in point is the Ashley River deposit, from which Leidy described "*Mastodon*" [*Serridentinus*] *rugosidens* and *Hipparion venustum*. The geology of these deposits as given by Holmes indicates that the Pleistocene sediments are in part reworked from materials of earlier age, and the fauna as given by Leidy obviously includes true Tertiary elements as well as Recent specimens in the supposed Pleistocene fauna. Hay includes *Hipparion* in his Pleistocene list, but excludes *Serridentinus rugosidens*, recognizing the latter as probably Miocene or Pliocene, although he insists that *Serridentinus* is Pleistocene in Florida.

It seems probable that the two teeth recently described by Osborn as *Serridentinus obliquidens* and said to be of Pleistocene age are also inclusions from the Pliocene. They were found in the phosphate beds near Charleston. Hay records a large species of *Parahippus* also from phosphate beds near Charleston. In spite of their supposed occurrence with Pleistocene mammals, it is impossible to assume that these fossils were not derived from much older beds, as their morphology would suggest.

Gidley has described a fauna from near Brunswick, Georgia, which also includes *Serridentinus* and Pleistocene mammals. Gidley referred this mastodont to *S. floridanus*, Hay to *S. rugosidens*. *Mastodon americanus* also occurs here. Again there is ample probability that the *Serridentinus* teeth, along with some marine forms, were derived from older beds. This view was advanced by Hay, although he does not recognize this explanation for similar occurrences in Florida.

It is possible that some of the many isolated teeth found along the Atlantic coast and referred to *Mastodon americanus* or *progenius* belong to *Pliomastodon* and are from Pliocene beds.

The only other record of much importance is that of *Procamelus virginiensis* Leidy found in blue clay while excavating a tunnel beneath the city of Richmond, Virginia. As quoted by Dall, Leidy later referred the species to *Auchenia*, and Cope questioned its Miocene age. Leidy's figures strongly suggest that this is a Pleistocene camel, perhaps of the genus *Tanupolama*. Its Miocene age must be considered as very improbable.



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