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PLIOCENE THREE-TOED HORSES FROM LOUISIANA, WITH COMMENTS ON THE CITRONELLE FORMATION

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CONTENTS

I. ABSTRACT

Teeth and metacarpals of early Pliocene (latest Hemphillian land-mammal age) three-toed (hipparionine) horses are described from the Tunica Hills of West Feliciana Parish in east-central Louisiana. An upper molar pertains to *Nannippus minor*, known from the Hemphillian of Central and North America, and two teeth and two distal metacarpals pertain to a recently described species of *Cormohipparion*, *C. emsliei*, known only from Pliocene (latest Hemphillian and Blancan land mammal ages) sites in peninsular Florida. The material represents the first record of Pliocene non-marine fossils from Louisiana, as well as the first record of a fossil horse from the state other than Pleistocene *Equus*. Found in surface stream gravels, the horses probably were derived from the otherwise almost nonvertebrate-bearing Citronelle Formation.

II. INTRODUCTION

Fossil land mammals of pre-Pleistocene age are exceedingly rare in Louisiana. In January of 1985, the senior author was shown a large collection of late Pleistocene (Rancholabrean land-mammal age) vertebrate fossils from the Tunica Hills of Louisiana (Fig. 1) by Dr. A. Bradley McPherson of Centenary College, Shreveport. McPherson and Mr. Bill Lee of Baton Rouge had collected fossils from that area since about 1981. Among the standard assemblage of Rancholabrean taxa (*e.g.* mastodon, horse, ground sloth, tapir and bison) were an upper molar and distal metacarpal of very small horses collected by them in 1983, which were quite different from the common large *Equus* of the fauna. In 1986 McPherson and Lee collected two more teeth and another distal metacarpal of a small, primitive horse. These five specimens are, thus far, the only record of a pre-late Pleistocene fauna among the hundreds of vertebrate fossils that have been found in the Tunica Hills area. They indicate the presence of terrestrial or near-shore early Pliocene deposits in Louisiana. The purpose of the present study is to describe this material and to discuss its implications for Louisiana biochronology and stratigraphy.

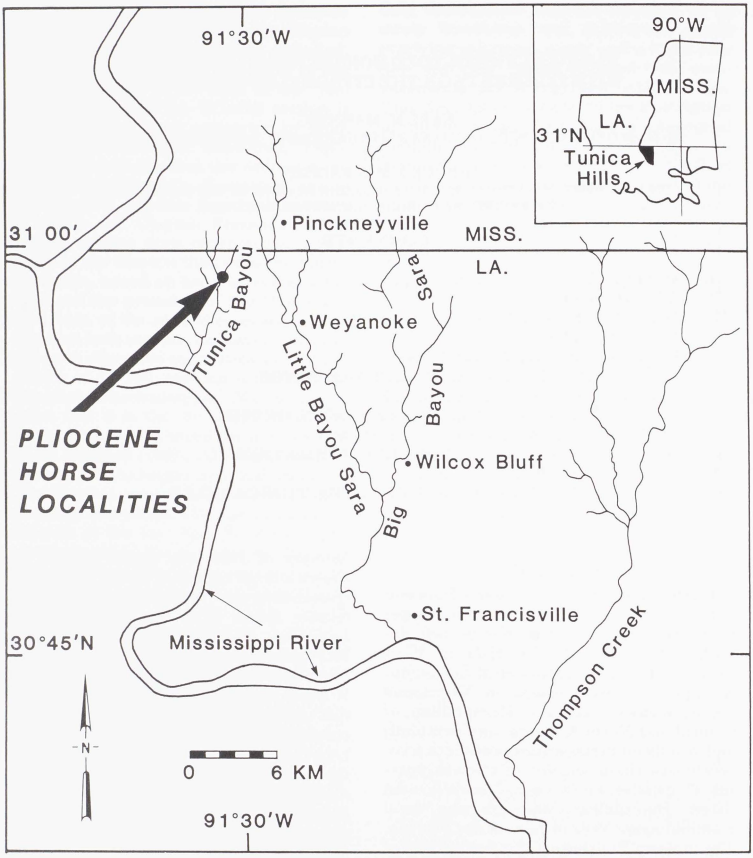

Figure 1. Location of the Pliocene horse sites and the Tunica Hills, West Feliciana Parish, Louisiana and Wilkinson County, Mississippi. Modified from Givens and Givens (1987, fig. 1) and Alford *et al.* (1983, fig. 1).

III. ACKNOWLEDGMENTS

The authors are especially grateful to Dr. A. Bradley McPherson of Shreveport and Mr. Bill Lee of Baton Rouge for permission to describe these specimens. Without their persistant collecting efforts in the Tunica Hills, the material would never have come to light. Dr. Richard C. Hulbert, Jr. (University of Florida, Gainesville) kindly allowed us the use of a then unpublished manuscript on Coastal Plain horses that was critical to the present study and also provided useful discussion of our

identifications. Dr. Frank Whitmore (U.S. Geological Survey, Washington, D.C.) graciously permitted one of us (EMM) to examine the fascinating Mauvilla fauna of Alabama. Dr. Richard Kesel (LSU Department of Geography and Anthropology, Baton Rouge) examined the sites where the specimens were found, and provided useful information on the stratigraphy of the area. Dr. Whitney J. Autin (Louisiana Geological Survey, Baton Rouge) reviewed the manuscript, and provided many helpful comments. The manuscript was also reviewed by Dr. Judith A. Schiebout (LSU Museum of Geoscience, Baton Rouge). This is University of Florida Contribution to Paleobiology number 321.

IV. ABBREVIATIONS

Fossil collections referred to in the text are: CCVC - Centenary College Vertebrate Collection, Biology Department, Centenary College, Shreveport LA; UF - Vertebrate Paleontology Collection, Florida State Museum, University of Florida, Gainesville, Florida.

V. SYSTEMATIC PALEONTOLOGY

Class MAMMALIA Linnaeus, 1758
Order PERISSODACTYLA Owen, 1848
Family EQUIDAE Gray, 1821
Subfamily EQUINAE Gray, 1821
Genus CORMOHIPPARION
Skinner & MacFadden, 1977

CORMOHIPPARION EMSLIEI Hulbert, 1987
Figures 2 c-f, 3, Table 1

Distribution: Early Pliocene (latest Hemphillian land-mammal age) of the upper Bone Valley Formation, Polk Co., central peninsular Florida; late Pliocene (late Blancan land mammal age), of the Pinecrest beds, Macasphalt Shell Pit, 3 km N of Fruitville (type locality), Sarasota Co., west-central peninsular Florida; and the Tunica Hills area, West Feliciana Parish, east-central Louisiana.

Referred Louisiana specimens: CCVC 1628, right P^3 or P^4; CCVC 1627, right P_2; CCVC 86 and CCVC 535, distal ends of MC III. (Casts of the first three specimens are deposited in the UF and LSU Museum of Geoscience collections.)

Site location: South border of sect. 62 and northern half of sect. 78 (irregular sections), T1S, R4W, Tunica 7 1/2 min. Quad., Tunica Bayou, Tunica Hills area, NW part of West Feliciana Parish, east-central Louisiana (Fig. 1). From surface stream gravel, probably derived from the Citronelle Formation (see discussion below).

Age. Early Pliocene (latest Hemphillian).

Discussion: The dental pattern in the Louisiana specimens exhibits the diagnostic characters listed in Hulbert (1987). The parastyle and mesostyles are grooved on the anterior side. The fossette borders are richly plicated with a count of 4-5 + 4-1. The pli caballin consists of a large fold with five secondary folds. The hypoconal groove is moderately deep. The protocone is elongate with a concave lingual side. The tooth is in middle wear and seems moderately hypsodont (Table 1).

The lower tooth, a right P_2, exhibits a diagnostic anterior extension of the metaconid that connects to the posterior portion of the paraconid. The protoconid and hypoconid are flattened and there is a prominent pli caballinid. Although the size of the Louisiana sample is smaller than the type from the Blancan, it falls within the size range published by Hulbert (1987) for the large sample from the late Hemphillian upper Bone Valley Formation.

There are two distal metacarpals, CCVP 86 (Fig. 3) and 535, from the Tunica Hills that seem to be referable to *Cormohipparion emsliei* based on the primitive (hipparionine) aspect of the distal tuberosities (26.9 and 28.9 mm) being greater than the width of the distal articular keel (26.4 and 27.3 mm; see Hussain, 1975) and similar proportions to that of probable *C. emsliei* metapodials from the Bone Valley.

Because North American horse species are generally widespread in geographic distribution, the occurrence of *C. emsliei* in only Florida and Louisiana suggests that it is an unusual, regional endemic species of the late Cenozoic Gulf Coastal savanna.

Genus NANNIPPUS Matthew, 1926
NANNIPPUS MINOR (Sellards, 1916)
Figures 2 a-b, Table 1

Distribution: Early Pliocene (late Hemphillian) of Central and southern North America.

Referred Louisiana specimen: CCVC 585, left M^2.

Site, age and stratum: See description above for *Cormohipparion emsliei*.

Discussion: The tooth (Fig. 2, Table 1) is too small to be allocated to *Cormohipparion*

TABLE 1
Measurements (in mm) of the teeth of Pliocene three-toed horses from the Tunica Hills.

Specimen No.	Element	Greatest antero-posterior length (excluding cement)	Greatest transverse width (excluding cement)	Height (upper-mesostyle; lower-paraconid)
		Cormohipparion emsliei		
CCVC 1628	RP^3 or P^4	18.8	17.0	37.5
CCVC 1627	RP_2	20.6	9.0	30.4
		Nannippus minor		
CCVC 585	LM^2	16.5	15.0	35.7

emsliei. Although broken on the occlusal surface, the parastyle and metastyle seem unconstricted. The fossettes are moderately plicated (3-3-4-2). There is a well developed pli caballin. The protocone is elongate with a concave lingual border. This tooth, which is in middle wear stage, seems too low-crowned to be referable to *Nannippus peninsulatus* (senior synonym of *N. phlegon*). It falls within the large end of the observed range and has a dental pattern consistent with that of *Nannippus minor* (MacFadden, 1984; Hulbert, 1987).

VI. AGE OF THE TUNICA HILLS HIPPARIONINES

The presence of the two hipparionines *Cormohipparion emsliei* and *Nannippus minor* suggests a latest Hemphillian, or early Pliocene, age for the sub-Pleistocene stratum of the Tunica Hills. This is based on: 1) the age of the upper Bone Valley Formation of Florida, the only other place where these two taxa are known to co-occur; and 2) the primitive stage of evolution of *C. emsliei* from Louisiana, which is of similar size to the Bone Valley occurences of this species (and smaller than the Blancan specimens). The biochronology of the upper Bone Valley fauna is well established (*e.g.*, MacFadden, 1986) and probably represents a time interval between 5.4-4.5 myr ago, or early Pliocene, using the time-scale of Berggren *et al.* (1985).

VII. STRATIGRAPHIC PROVENIENCE

The Tunica Hills have long been known for their rich fossil flora (see review in Givens and Givens, 1987), freshwater mollucks (Richards, 1938) and vertebrates (see reviews in Domning, 1969 and Lowery, 1974). Recent work has shown that nearly all of the vertebrates have derived from low level (T1) terrace deposits of late Pleistocene age (Givens and Givens, 1987). No older vertebrates have previously been reported from the area.

The fossil horse material described here was found loose in the surface stream gravel along Tunica Bayou (Fig. 1), as are most vertebrate fossils from the Tunica Hills. *In situ* recovery of vertebrates is uncommon and the discovery of even partially articulated material (such as the partial mastodon skeleton figured in Lowery 1974, p. 519) is extremely rare. Even when found in place, most vertebrate material consists of isolated, often badly stream worn, elements in channel gravel or sand.

The outcrops exposed in the area of Tunica Bayou where the horse material was found consist of reworked loess, sand and thin gravel stringers typical of much of the Tunica Hills Pleistocene. One of the Pliocene horses, CCVC 1628, was even found in the same area as Rancholabrean (late Pleistocene) mammals reported by Domning (Arata and Domning MS, *in* Domning, 1969, p. 393). The Rancholabrean fauna found in the stream beds of the Tunica Hills probably derives from the slumping of this material into the bayous, with the gravel-sized fraction concentrated later at the stream surface. The composition of the loess in the area, containing stringers of sand and fine gravel, suggests that it is reworked colluvium, and is not *in situ* (Fisk, 1938; Delcourt and Delcourt, 1977; Alford, Kolb and Holmes, 1983). If this is the case, then the Pleistocene vertebrate fauna may have been reworked

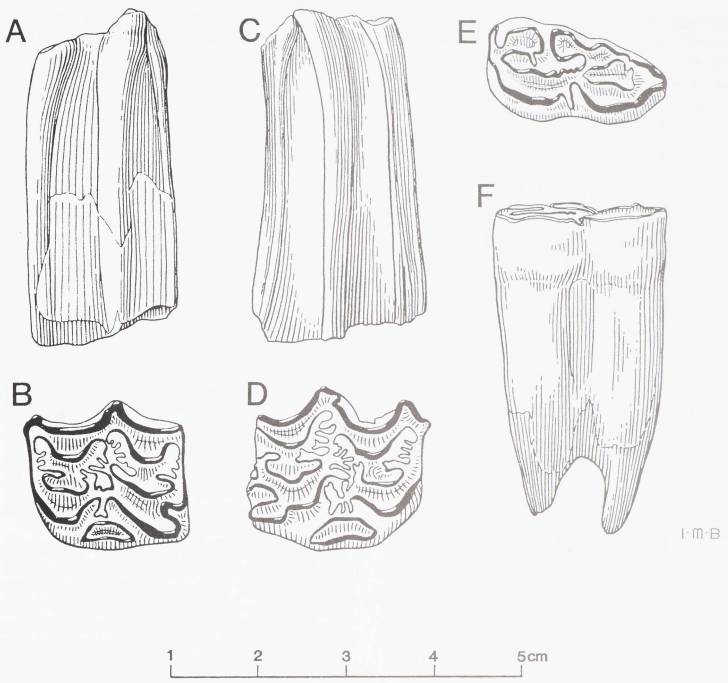

Figure 2. *Cormohipparion emsliei* (C-F) and *Nannippus minor* (A-B) from the early Pliocene of the Tunica Hills, West Feliciana Par., La. A-B: CCVC 585, left M^2, lateral and occlusal views. C-D: CCVC 1628, right P^3 or P^4, lateral and occlusal views. E-F: CCVC 1627, right P_2, in occlusal and lateral views.

twice. Specimen wear (including nearly rounded cobbles of mastodon bone) tends to corroborate this hypothesis.

Because the hipparionine horses described here are of Pliocene age (based on distribution of the species elsewhere, particularly Florida), they must have originally derived from a bed *below* that in which the much larger Rancholabrean fauna was buried. Because of the relatively unworn state of the fossils described here (despite evident reworking), it is unlikely that they were derived from a very distant source. The underlying Pascagoula Formation is known to be of late Miocene age (see sect. X) and, therefore, it is most likely that the Pliocene horses were derived from the Citronelle Formation, which is the bed usually underlying the Pleistocene beds in the Tunica Hills.

It is worth noting that while Rancholabrean fossils have been found in nearly every major drainage of West Feliciana Parish (Tunica Bayou, Kimball Creek, Little Bayou Sara, Bayou Sara, Thompson's Creek, etc.), Pliocene vertebrates are only known from a small area on Tunica Bayou. This possibly suggests a limited, local source bed.

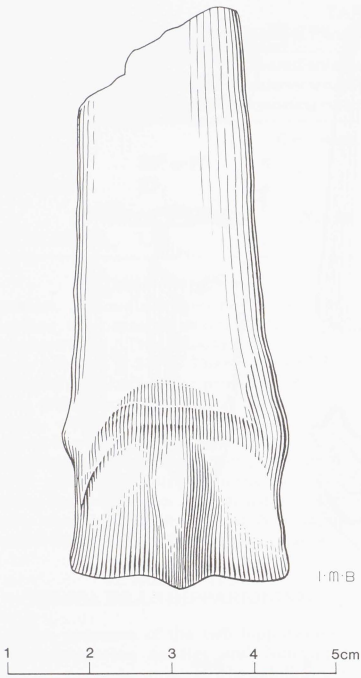

Figure 3. *Cormohipparion emsliei* from the early Pliocene of the Tunica Hills. CCVC 86, dorsal view of distal metacarpal III.

VIII. PLIOCENE TERRESTRIAL VERTEBRATES OF THE GULF AND ATLANTIC COASTAL PLAIN

Unlike Miocene terrestrial vertebrates, which have an extensive, if spotty, record from the southeastern North American Coastal Plain (see review in Tedford and Hunter, 1984), non-marine Pliocene vertebrates are well represented only in Florida and North Carolina. Considering the extensive surface exposures of Pliocene sediments in the area, it is surprising that Pliocene terrestrial faunas are not better known. The better known coastal Pliocene faunas are both earliest Pliocene (latest Hemphillian land mammal age), whereas later Pliocene (Blancan land mammal age) Coastal Plain faunas are unknown outside Florida. The following brief review of Pliocene terrestrial vertebrates from the Coastal Plain discusses the principal localities of this age.

Texas - Although late Hemphillian and Blancan faunas are well known from the High Plains Ogallala Group of the north Texas panhandle (see review in Schultz, 1977), and Blancan fossils are recorded from the Basin and Range bolsons of western Texas (Akersten, 1972), Pliocene terrestrial vertebrates have not been recorded from the Texas coastal plain. This is surprising in light of the extensive record of Miocene terrestrial vertebrates of the Texas coastal plain (Quinn, 1955; Wilson, 1956; Patton, 1969; Patton and Taylor, 1971; Forsten, 1975; Prothero and Manning, 1987, etc.). The Goliad Formation has, at times, been identified as Pliocene, but vertebrate faunas of the Goliad are of middle to late Miocene (late Barstovian/ early Clarendonian) age (Prothero and Manning, 1987).

Louisiana and Mississippi - Until the present report, no Pliocene terrestrial fossils had been reported from either state (see review in Domning, 1969). The Miocene terrestrial vertebrate record from these states is little better, limited as yet to a single pair of gomphothere tusks from the middle Miocene part of the Fleming Formation of western Louisiana (Arata, 1966).

Alabama - "Middle Pliocene" terrestrial vertebrates have been reported from southwest Alabama (Isphording and Lamb, 1971; Thurmond and Jones, 1981); but this age assignment was based on an outdated correlation of the Hemphillian. Except for the latest faunas, the Hemphillian is now generally considered to be of late Miocene age (Tedford, *et al.*, 1987). This Mauvilla, or Mobile, Local Fauna (see Whitmore *in* Isphording and Lamb, 1971, p. 776 and Isphording and Flowers, 1983 pp. 71-72; Tedford and Hunter, 1984, p. 144) can be dated as early (or middle) Hemphillian, rather than late, on the basis of the presence of *Synthetoceras* cf. *tricoronatus* in assocation with advanced rhinocerotid taxa. A middle Hemphillian

age has been indicated by Tedford and Hunter (1984 p. 144). With the Mauvilla Local Fauna reassigned to the late Miocene, Alabama also has no Pliocene terrestrial vertebrates.

Florida - Unlike Gulf Coastal states to the west, Florida has an extensive Pliocene terrestrial vertebrate record. An excellent late Hemphillian fauna has long been known from the fluvio-deltaic upper part of the Bone Valley Formation, extensively exposed in the phosphate mines of central peninsular Florida (see review in MacFadden and Webb, 1982). Several Blancan faunas, *e.g.*, the Haile XVA site (Robertson, 1976) and Santa Fe River localities have been reported from peninsular Florida (see MacFadden and Waldrop, 1980). Unlike the Gulf Coastal states to the west, Florida also has an extensive early Pliocene marine fossil record, in the upper Choctawhatchee Group. The difference relative to Louisiana, for example, is due to the distance of Florida away from the clastic-dominated delta facies of the Mississippi River.

Despite extensive surface exposures of Pliocene sediments on the Atlantic Coastal Plain (Cronin, *et al.*, 1984), Pliocene terrestrial vertebrates in this area are also generally poorly represented.

Georgia - Voorhies (1974) reported the occurrence of a possible early Pliocene (latest Hemphillian) *Nannippus minor* from upland gravel beds in central Georgia.

North Carolina - A relatively large early Pliocene (latest Hemphillian) terrestrial vertebrate fauna is known from the Yorktown Formation at Lee Creek Mine, near Aurora. The fauna has been listed (R. Eschelman *in* Tedford and Hunter, 1984, pp. 138-139), but has not yet been fully described.

In summary, the horses described here are the only Pliocene terrestrial vertebrates presently known from the Gulf Coastal Plain west of peninsular Florida.

IX. COMMENTS ON THE CITRONELLE FORMATION

Extent - As originally studied by Matson (1916), the Citronelle included reddish and orange sands and gravels in a belt along the northcentral Gulf Coast from western Louisiana to the western Florida panhandle. Matson named the beds for outcrops near the city of Citronelle, in southwest Alabama. The outcrop area has now expanded across the Gulf and Atlantic Coastal Plain. Doehring (1958, p 773) included "a belt of up to 100 miles wide which extends for 1,500 miles from the Nueces River in south Texas to the vicinity of Washington, D.C."

Sediment - Citronelle clastics vary, but they are dominated in outcrop by quartz sand and chert gravel (Matson, 1916, p. 174). The sand and gravel is gray-white when fresh (Rosen, 1968), but weathers to pink, red, or orange as its iron cement oxidizes to ferric hydroxide (Parsons, 1967). Generally, these clastics are only slightly consolidated. Sedimentary structures such as channels, cut and fill, scour surfaces, and cross-bedding are locally common in the Citronelle (Autin, *et al.*, 1986, p. 420). Interbedded with the coarse clastics are minor beds of silts and clays (Parsons, 1967, pp. 41 and 44).

Paleoecology - Early work on these beds suggested that they might be glacial "drift" (Hopkins, 1872; Lerch, 1892) or marine (McGee,1891; Harris and Veatch, 1899), but most workers in this century have agreed that the Citronelle is predominately of fluviatile origin. It has been described as "...an alluvial plain built up by braiding, coalescing streams crossing a gently sloping coastal plain." (Parsons, 1967, p 49). This interpretation has been supported by more recent work (Smith and Meylan, 1983, p. 430). The presence of two Pliocene horses with very high-crowned (grazing type) teeth in the Tunica Hills suggests that at least the upland part of the Citronelle must have had nearby grasslands during deposition. There are considerable changes in the Citronelle from north to south. Clastics are generally coarser to the north and finer to the south, and the southern deposits are party estuarine (Matson, 1916, p. 187). Matson noted that the varying sediment types suggested that the source streams varied considerably in both direction and velocity (1916, p. 187). Some beds suggest flood deposits while others suggest quiet pond deposition.

Source - Derivation from northern glacial outwash (*e.g.*, Fisk, 1939), or an area west of the Mississippi (Clendenin, 1896, p.196),

or an ancestral Mississippi drainage (Russell, 1987), have all been suggested but mineralogical analysis points strongly to a southern Appalachian source area, at least for Citronelle deposits in Mississippi and Alabama (Rosen, 1968 and 1969; Isphording, 1976; Isphording, 1983; Isphording and Flowers, 1983; Smith and Meylan, 1983). The later work tends to support an earlier hypothesis of a southern Appalachian source area (Brown, 1967). The Citronelle heavy mineral suite differs from both that of late Pleistocene glacial terrace sediment and that of modern Mississippi River sediment (Rosen, 1968 and 1969). Middle Paleozoic invertebrates found in chert pebbles from central Gulf Coast Citronelle gravels (and reworked into Pleistocene gravels) may also derive from the southern Appalachians (Rosen, 1968, p. 10; Smith and Meylan, 1983, p. 424).

Relationship to the Coastal Plain Sequence - As emphasized by Doehring (1958), unlike the underlying Coastal Plain beds, the basal Citronelle is often strikingly unconformable. While most Coastal Plain sediments rest only on the next older bed, the Citronelle often overlies much older units. On the eastern flank of the Sabine Uplift in northwest Louisiana, the Citronelle overlies Eocene beds. This distinctive unconformity, in addition to it nonmarine origin, suggests that the Citronelle is not part of the typical Coastal Plain sequence. Contrary to Doehring (1958), this does not mean that the Citronelle is part of a Pleistocene sequence.

Relationship to Pleistocene Beds - There has been tremendous confusion about the relationship of the Citronelle to overlying Pleistocene beds. This is mostly due to the fact that many of the Pleistocene beds incorporated large amounts of Citronelle sand and gravel during deposition (Isphording and Lamb, 1971, p. 775). As a result, they often look very similar and contain similar lithologies. This makes contacts difficult to discern and resulting maps and thickness estimates of the Citronelle suspect. Doehring (1958, p. 778) states that some Citronelle outcrops have been mapped as Williana Terrace, and Rosen (1968) noted that parts of Matson's mapped Citronelle outcrop was included by Fisk (1939) as Williana, Bentley, and even Montgomery terrace deposits. That the Citronelle was not contemporaneous with the Williana has been indicated by Russ (1976, p. 1081), who noted that the Williana surfaces cut into the Citronelle in the Red River area of Louisiana.

Fossils - Despite its enormous surface exposure, the Citronelle has produced very few fossils. There are probably several reasons for the scarcity of fossils. High energy gravels often destroy any contained fossils. Shallow braided streams generally preserve fewer vertebrates than do deeper channels. Leaching during the weathering process may have dissolved some fossils, though Matson noted that even some unweathered beds he examined were non-fossiliferous (1916, p. 186). The major exception is the plant material described by Berry (1916) from unweathered clays in southwest Alabama. He described well-preserved leaves, seeds, and nuts of at least 18 species, revealing a coastal flora similar to that of coastal Alabama today, with abundant bald cypress and live oak. He suggested that the plants lived near a quiet, coastal lagoon, which was protected by a barrier beach. Although it has been argued that the plants are from a bed below the Citronelle (Roy, 1939; Carlston, 1950), more recent work (Stringfield and LaMoreaux, 1957, p. 746; Isphording and Flowers, 1983, p. 68) has corroborated the view that the plants occur in the Citronelle. No *in situ* vertebrate material is known from the Citronelle Formation.

X. AGE OF THE CITRONELLE

Flora - Matson (1916) based his Pliocene age assignment on the floral determinations made by Berry (1916, published at the same time as Matson's paper) as well as the fact that the Citronelle is overlain by Pleistocene sediment. Berry suggested a late Pliocene age (1916, p. 195) because some Citronelle plants are not present in the Pleistocene. It must be added that, at the time, no Pliocene floras from North America were available for comparison.

Doehring (1958) suggested that the plants might be of early Pleistocene, rather than Pliocene, age. This argument appears to have been part of an effort to place the Citronelle in the same depositional system as the overlying Pleistocene

deposits. Doehring considered the Citronelle a pre-glacial Pleistocene deposit. Doehring's age assignment of Berry's flora has been contested by Stringfield and LaMoreaux, who included a confirmation of Berry's Pliocene date by R. W. Brown of the USGS (1957, p. 746). On the other hand, a study of pollen from the middle and upper Citronelle Formation from western-most Florida by Estella Leopold indicated a Quaternary age (Marsh, 1964, p. 83).

Underlying Beds - A maximum age for the Citronelle can be obtained from the age of the youngest underlying beds. As noted by Matson (1916, p. 172), the Citronelle lies unconformably upon the Pascagoula Formation in Mississippi. A small invertebrate fauna from the Pascagoula in southeastern Mississippi was reported by Mincher (1941), who compared its age to that of the *Arca* zone in Florida, now thought to be of late Miocene (planktonic foraminiferal zone N17) age (Akers, 1972, p. 14). In southwest Alabama, the Citonelle overlies a sand and clay bed (possibly the Ecor Rouge Member of the Catahoula Formation), which contains the previously mentioned Mauvilla Local Fauna (Isphording and Flowers, 1983, pp. 69-71) of late Miocene age. Thus, in at least two places, the Citronelle overlies late Miocene (late Hemphillian and probably Messinian European stage) sediments.

Overlying Beds - A minimum age for the Citronelle can be obtained from the age of the overlying beds. Several authors have noted Pleistocene beds overlying the Citronelle (Matson, 1916; Mayer, 1932, p. 34; Parsons, 1967; Rosen, 1968; Isphording and Lamb, 1971, p. 775; Russ, 1976; Isphording and Flowers, 1983; etc.). Stringfield and LaMoreaux (1957, p. 746) note that the Citronelle is overlain by the oldest Pleistocene marine terrace in Florida.

Correlation - The above data argue strongly for a Pliocene age for at least part of the Citronelle, as originally proposed by Matson (1916). It has been suggested (Tedford and Hunter, 1984, Fig. 4.) that the Citronelle may be a lateral equivalent of several early Pliocene transgressive beds in Florida, *i.e.*, the Jackson Bluff Formation of the panhandle, the uppermost Bone Valley Formation of the central peninsula, and the Tamiami Formation of the south. The similarity of horse taxa described here with those of the Bone Valley corroborate these correlations.

XI. THE CITRONELLE FORMATION IN THE TUNICA HILLS

As elsewhere in the Gulf Coast, the Citronelle Formation has often been confused with both older and younger beds in Louisiana. As a result, much basic geologic data on the unit (outcrop distribution, thickness, and even stratigraphic terminology) in the state is equivocal.

Hilgard (1860) included Citronelle beds in the Tunica Hills of Louisiana and Mississippi as part of a Quaternary unit that he identified as "Orange Sand." In a later work (1869), he grouped Citronelle material with Eocene sediment under the same name. Hopkins (1872) included Citronelle material as part of a "Northern Drift." McGee (1891) included Citronelle beds in his Lafayette Formation, a unit he considered to be a pre-Pleistocene marine bed. Lerch (1892) included Citronelle sediment in beds he identified as "Drift." Harris and Veatch (1899) included Citronelle beds with Eocene sediment in their usage of McGee's "Lafayette." They considered the Lafayette to be a late Pliocene coastal deposit. Matson (1916), in the original description of the Citronelle, described the bed in the Tunica Hills area as "Yellow and red sands and clays, locally gray where unweathered. Much gravel near the landward margin and in valleys of principle streams."

Parsons (1967) noted that the Citronelle overlies silts and clays in Louisiana, but did not identify these beds. Brown and Guyton (1943) identified these underlying beds as Pascagoula Formation. Parsons noted (1967, pp. 37-38) that the basal Citronelle contact in the Tunica Hills area could be either a sharp unconformity or a transitional zone.

Rosen (1968, 1969) studied the mineralogy of the Tunica Hills Citronelle in detail, and noted that it is the principal aquifer of the Baton Rouge area.

Because many Pleistocene beds (particularly the gravels) in the Tunica Hills are derived from reworked Citronelle, it is dif-

ficult to draw a boundary between the two. Many people have included nearly all of West Feliciana Parish in the Citronelle outcrop area (Matson, 1916; Parsons, 1967; Rosen, 1968). The presence of late Pleistocene (Rancholabrean) vertebrates in bayous across the parish (as well as the presence of extensive loess outcrop) shows this to be incorrect. While Citronelle may underlie much of the parish, most of the surface exposure is clearly of late Pleistocene age or younger. Recent geologic work, such as the geologic map of the state by the Louisiana Geological Survey (Snead and McCulloh, 1984), unites the Citronelle with the Williana and highest Bentley terraces simply as "High Terraces," avoiding the boundary problem entirely. It is worth noting that, as yet, no early Pleistocene (Irvingtonian land mammal age) vertebrates have been recovered from the Tunica Hills. An early Pliocene/late Pleistocene unconformity may exist in much of the area. The present description provides strong evidence for a nearly Pliocene age for the Citronelle Formation in east-central Louisiana, based on the presence of biochronologically diagnostic late Hemphillian horses.

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