SOUTHEASTERN GEOLOGICAL SOCIETY

THIRTEENTH FIELD TRIP

MIOCENE - PLIOCENE PROBLEMS OF PENINSULAR FLORIDA

by

H. K. Brooks
E. C. Pirkle
R. C. Fountain

Special Papers

by

T. H. Patton
S. D. Webb

Edited by

H. K. Brooks and J. R. Underwood, Jr.
Southeastern Geological Society
P. O. Box 1634
Tallahassee, Florida

Joe Banks, President
Ronald D. Perkins, Vice-President
J. R. Underwood, Jr, Secretary-Treasurer

February 24-25, 1967
In the interest of objectivity in evaluating the stratigraphic and paleontological data we will see on this field trip, the written text of this guide has been kept to a minimum. The sedimentological characteristics of the formations to be seen on the trip are described in detail in the inserted reprint of Pirkle et al. (1965) entitled Hawthorne, Bone Valley and Citronelle Sediments of Florida. Only the data and comments on correlation and environment believed to be essential by the person leading the discussion at each stop are contained in the road log with the measured stratigraphic section. Because many are not aware of the great amount of information available on the environmental and correlation significance of new occurrences of land vertebrate fossils, this information is synthesized in papers by T. H. Patton and S. D. Webb.

Several years ago Pirkle (1956) recognized the complexities of the stratigraphy of the materials referred to the Hawthorne Formation. We now know that Hawthorne-type materials range in age from Lower Miocene to Pliocene. I have suggested that when valid lithologic criteria have been established for distinguishing mappable formations of these strata, the Hawthorne should be used as a group name (Brooks, 1966). The youngest formation in the Hawthorne Group would be, of course, the Bone Valley Formation as presently used by most authors in the Bone Valley area (not as used by Riggs and Freas, 1965).

Associated with the Ocala Arch, we will see Hawthorne-type materials that are Lower Miocene, Upper Miocene, and Pliocene in age. The Middle Miocene is absent over much of the uplifted area. This will be discussed at STOP ONE at the Devil's Millhopper and again at STOP FIVE north of Ocala. Off the Arch in such localities as Brooksville, Bartow, and Fort Meade, Middle Miocene materials of Hawthorne type will be observed. Until such time as mappable formations are properly distinguished, confusion in interpretation of the stratigraphy and structure of north and central Florida will persist.

It is in the interest of a better understanding of these important and challenging stratigraphic problems that this field trip is being conducted.

\(^1\)Department of Geology, University of Florida.
SELECTED REFERENCES:


INTRODUCTION

In recent years knowledge of the Mid-Tertiary land vertebrate faunas of Florida has increased to the point where information currently available in the scientific literature has become hopelessly out of date. From the standpoint of the number and geographic location of new sites, the number and diversity of previously unrecognized taxa, and the increasingly longer segment of geologic time sampled, data have accumulated to an unprecedented degree. This introductory article should provide the reader with some idea of the extent and importance of these faunas, as well as their relationships with other North American fossil vertebrate sequences.

Before 1965, most of our knowledge of pre-Pliocene land vertebrates in Florida was based on material collected from a single locality, the Thomas Farm Quarry in Gilchrist County. Isolated and mostly fragmentary specimens had been collected elsewhere, but with few exceptions, notably at Quincy and Midway (Simpson, 1932) and near Ashville (Olson, 1963), did they add appreciably new information. Further, before Olson's (1963) recognition of an apparently Late Miocene (Barstovian) locality near Ashville, the combined faunas represented a time span ranging through only a portion of the Middle Miocene (Hemingfordian). As a result of recent discoveries, however, we now have a sequence of vertebrate faunas ranging in age from Late Oligocene to Late Miocene (and beyond: see S. D. Webb, this guidebook). More importantly, we have greatly extended our concept of life as it existed on the Florida land mass in the geologic past.

OLIGOCENE

The most remarkable find to date has been the discovery of an Oligocene vertebrate fauna in a small sinkhole deposit in a roadcut on Interstate Highway 75 near Gainesville. This is the oldest Cenozoic land vertebrate fauna in eastern North America and has revealed the former presence in Florida of an extensive and surprisingly diversified assemblage of terrestrial vertebrates. On the basis of the taxa represented, the writer regards this fauna as Late Oligocene (Whitneyan) age. Aside from its paleontologic importance, it bears significantly on the interpretation of geologic events in central Florida during the Cenozoic (see Discussion).

A preliminary list of fossil vertebrates from the I-75 locality includes the following forms:

ELASMOBRANCHII

Galeocerdo, tiger shark
Carcharinus, bull shark
Carcharodon, white shark
Isurus, mako?

1Florida State Museum, University of Florida, Gainesville.
ELASMOBRANCHII (cont.)

Negaprion, lemon shark
Odontaspis, sand shark
myliobatid ray

AMPHIBIA

Bufo, toad
Scaphiopus, spadefoot toad
salamander

PISCES

Diodon, puffer
Sphyraena, barracuda
Sciaenidae, drum

REPTILIA

Floridemys, dwarf tortoise
Pseudemys, pond turtle
Boidae, 3 kinds of boid snakes
Colubridae, a new genus of racer
?Amphisbaenidae, lizard

AVES

assorted fragments of bird bones

MAMMALIA

bat
heteromyid or geomyid rodent
eomyid rodent
eumyid rodent
Daphoenus, dog-like carnivore
?Paleogale, mustelid
Mesohippus, small horse
peccary
oreodont (2 kinds)
protoceratid
Nanotragulus, deer-like artiodactyl

The inclusion of the shark and fish fauna is presently questionable. Certainly it did not accumulate simultaneously with the terrestrial vertebrate fauna, but more likely was mixed in the upper sediments of the sinkhole deposit during transgression of an estuarine environment. This conclusion is supported by the presence of a bar of fossil oysters just above the sink deposits. We are presently attempting to determine whether any of the shark or fish material is residue from the surrounding Ocala Limestone.

MIocene

We now have land vertebrate faunas in Florida representing portions of the Early, Middle, and Late Miocene. With the notable exception of the prolific Thomas Farm Quarry, the scattered but increasingly common Miocene localities have yeilded little but isolated, often fragmentary, bones and teeth. Fortunately, however, many of these remains are sufficiently taxonomically diagnostic so that their geochronologic position can be fairly accurately determined.
Because many of the fossil-bearing deposits are localized sinkhole fillings in the Ocala and Suwannee limestones, there is seldom recourse to more "classical" biostratigraphic procedures in arriving at age correlations. In virtually every case reliance is placed almost entirely on faunistic data. However, in view of the ever-increasing precision in interregional biostratigraphic correlation between vertebrate faunas of the North American Tertiary, this appears to be the most reliable approach. It is hoped that some future work will be directed towards achieving finer correlations between terrestrial and marine fossil sequences in the Gulf Coastal Plain.

**Early Miocene**: Of particular significance is the recognition of an apparently Early Miocene vertebrate locality northeast of Brooksville, in Hernando County. This age assignment was based on a comparison by the writer of Brooksville material with specimens from Great Plains faunas housed in the American Museum of Natural History. With the material presently at hand, it is difficult to reach a more precise conclusion; it can be stated only that the taxa are more advanced than corresponding Late Oligocene forms, yet more primitive than those from the Middle Miocene. Since the Thomas Farm Fauna is regarded by the writer to be of early Middle Miocene age (see discussion below), the Brooksville fauna becomes the only Early Miocene fauna in Florida for which there is much evidence. To date, the Brooksville site has yielded alligator, canid, tapir, rhinoceros, and oreodont remains.

**Middle Miocene**: Most of the sparsely productive Miocene localities in Florida are of Middle Miocene (Hemingfordian) age. These include sites in Alachua, Gilchrist, and Marion counties, as well as those farther north in Leon and Gadsden counties. This circumstance is attributable to the fact that central Florida (on the Ocala Arch) was a positive area with respect to sea level during the Middle Miocene. Off the arch, the Middle Miocene is represented by marine Hawthorne sediments (see discussion by H. K. Brooks, this guidebook).

The most important Miocene vertebrate locality in Florida and the most productive vertebrate quarry in eastern North America is the Thomas Farm deposit in Gilchrist County. Since its discovery, this quarry has produced a continuous harvest of valuable skeletal material, now comprising an extensive fauna of quite varied aspect. Physical and faunal evidence indicates that the fossil-bearing sediments accumulated in a sinkhole formed in the underlying Ocala Limestone (for contrasting opinions on this subject, see Purú and Vernon, 1964; and Patton, 1964). The writer has previously discussed some of the problems attendant to vertebrate biostratigraphy in Florida (Patton, 1964):

"The inferred geologic conditions under which the Thomas Farm deposit accumulated and certain aspects of its lithostratigraphic and biostratigraphic correlation are still in dispute. Much of the difficulty arises from the unusually complex nature of Cenozoic stratigraphy and fossil occurrences in peninsular Florida. Solution of the Suwannee and Ocala limestones which underly most of the fossiliferous deposits in this region, has been active since Miocene time. Numerous sinkhole, cave, and fissure deposits have accumulated at varying times throughout this period, so that study of a series of adjacent sink or fissure deposits in one small geographic area (even within a few acres) might reveal faunas representing a total time span ranging from the Miocene to the Recent. Obviously the isolated nature of the deposits makes physical correlation, even in a small area, difficult at best. Most of the deposits are contained within extremely small catchment basins; the sediments are usually locally derived, and reflect the influences of local climate,
topography, and source lithology. As a result, lithostratigraphic correlation of such deposits over a broad geographical area becomes a formidable, if not impossible, task. In any attempt at correlation, therefore, reliance has to be placed at the outset on faunistic data. A complication to this approach lies in the rather strong ecologic bias one encounters from one deposit to another. In many localities, the restricted areal extent of the fossil deposits favors the interment of a fauna representing only one ecotope, so that within a given area one fauna may reflect a spring or pond association while adjacent ones may represent sink or marsh environments. As a consequence of such limited sampling, it is often difficult to achieve a clear picture of the broad ecologic associations of animals in one region at a given time. Furthermore, the presence within one solution complex of closely situated deposits yielding faunas of totally disparate ages and reflecting perhaps quite different climatological and environmental conditions introduces the additional problem of separating temporally isolated faunas. In terms of biostratigraphy and zoogeography, this presents to the paleontologist a dilemma wherein he must decide what associations he may attribute to ecological influences and which are the result of historical and/or evolutionary events. This type of stratigraphic picture stands in strong contrast to the generally more classical configurations of Western North America."

The age of the Thomas Farm deposit usually has been considered to be Late Arikareean (late Early Miocene). White (1942) believed it to be somewhat older, but based his thesis on paleogeographical arguments (concerned with the extent, depth, and length of existence of the so-called Okefenokee Trough) that are disputed by many workers. Romer (1948), on the basis of general faunal make-up, and Bader (1956), using evidence based on horse data, agree on a Late Arikareean assignment. Wood (1964) states that the Thomas Farm rhinoceroses suggest a Late Arikareean or Early Hemingfordian age for the deposit. In a study of artiodactyls from the Miocene of Texas and Florida, the writer (Patton, 1966) concluded that the fauna was of Hemingfordian age.

The Thomas Farm Fauna includes the following forms:

**AMPHIBIA**

- Scaphiopus cf. holbrooki, spadefoot toad
- Leptodactylus abavus, robber frog
- Bufo praevis, toad
- Hyla goini, tree frog
- Gastrophrynus cf. carolinensis, narrow-mouthed toad
- Rana miocenica, frog
- Rana buccella, frog
- Rana cf. pipiens, leopard frog
- Notophthalmus robustus, salamander
- Siren hesternus, siren
- Batrachosauroides dissimulans, salamander

**REPTILIA**

- Leiocephalus sp., gridiron-tailed lizard
- Iguanidae, 3 indeterminate species
REPTILIA (cont.)

Gekkonidae, gen. et sp. indet.  
Eumeces sp., skink  
Cnemidophorus sp., racerunner  
Peltosaurus sp., slow-worm lizard  
Anguidae, gen. et sp. indet.  
Pseudoepicrates stanolseni, tree boa  
Ogophis pauperrimus, ground boa  
Calamagras floridanus, ground boa  
Anilioides minuatus, ground boa  
Pseudocemophora antiqua, colubrid snake  
Paradoxybelis floridanus, vine snake  
Golubridae, gen. et. sp. indet.

AVES

Phalacrocorax subvolans, cormorant  
Promilio floridanus, kite  
Promilio epileus, kite  
Promilio brodkorbi, kite  
Boreortalis laesslei, chachalaca  
Rhegminornis calobates, shore bird  
Columbidae, 2 undescribed species of doves  
Coraciiformes, 2 undescribed species, one a barbet, and one  
representing a new family  
Compsothyliidae, gen. et sp. indet., wood warbler  
Other passerine birds present

MAMMALIA

Soricidae, undescribed species of shrew  
Suaptenos whitei, bat  
Miomystis floridanus, bat  
Several undescribed species of bat present  
Mesogaulus, sp. indet., rodent  
Sciuridae, undescribed species of ground squirrel  
Proheteromys magnus, pocket mouse  
Proheteromys floridanus, pocket mouse  
Cricetidae, undescribed species of New World mouse  
Cynodesmus iamoniensis, coyote-sized dog  
Tomarctus cananus, coyote-sized dog  
Enhydrocyon spissidens, small dog  
Amphicyon longiramus, large dog-like bear  
Absobondaphoenus bathygenus, small dog  
Aelurodon johnhenryi, bear-sized dog  
Oligobunis floridanus, large mustelid  
?Micomusia, sp. indet., weasel-like mustelid  
Leptarctus ancipidens, badger-like mustelid  
Anchitherium clarencei, large conservative horse  
Parahippus blackbergi, small advanced horse  
Parahippus leonensis, large advanced horse  
Floridaceras whitei, larger rhinoceros  
Diceratherium (Menoceras) barbouri, small rhinoceros
MAMMALIA (cont.)

Desmatohyrus olseni, peccary
Nothokemas floridanus, camel
Floridatragulus dolichanthereus, long-snouted camel
Floridatragulus barbouri, long-snouted camel
Prosynthetoceras texanus, advanced protoceratid
Blastomeryx floridanus, small deer
Machaeromeryx gilchristensis, small deer

Fossil vertebrates from Quincy and Midway are considered to be slightly younger than those from Thomas Farm. A new locality near Newberry has produced the remains of a large carnivore, a large oreodont, and a chalicothere (a rather ponderous herbivore with bizarre, clawed feet).

Late Miocene: No definitely recognizable Late Miocene vertebrate deposits have yet been found in Central Florida. The nearest localities of this age are located in North Florida (near Ashville) and South Georgia (near Statenville). A new site on Highway 441 near Zuber (Stop Five), which is judged to be Late Miocene on the basis of stratigraphic and invertebrate paleontological evidence, has produced very fragmentary remains of turtle, alligator, dugong, and a small deer, but is presently of little use in dating the deposit in which they are found. It is hoped that this shortcoming will be remedied with further collecting.

For a discussion of the fossil vertebrates from Ashville, refer to Olsen (1963).

The lack of terrestrial vertebrate faunas in Central Florida during the Late Miocene is attributed to the fact that the Late Miocene strand line lay generally farther north. In this connection it is significant that the fossils from Stop 5 occur in a basal conglomerate representing the earlier part of a transgressive sequence in this area.

DISCUSSION

Perhaps the most important aspect of recent discoveries in Florida vertebrate paleontology has been the revelation of a large and remarkably varied terrestrial fauna in a place and at a time when such a fauna was assumed by many to be composed of waning and/or relictual populations spottily distributed between the mainland and a large continental island (for exposition of this hypothesis, see White, 1942). This former conclusion is obviously no longer tenable. We recognize instead a widespread and more or less continuously distributed set of mainland populations with open access to other such populations. There is no evidence for the presence of island populations. Dispersal between Florida populations and those elsewhere, especially in Texas and the Great Plains, was relatively free, as witnessed by the extreme similarity in the faunas of Florida and those from the Texas Coastal Plain. Only a few ecological filters existed between Texas and Florida, and, as a whole, the faunas of the Gulf Coastal Plain comprised, and evolved as part of, a distinct biotic province.

Of particular interest to those more zoologically inclined is the now-recorded presence of many forms previously thought to be restricted to western faunas. These include groups of early rodents, carnivores, different kinds of oreodonts, a chalicothere, and some previously undescribed reptiles. Combined with those taxa already described from Florida, we now have fossil vertebrate faunas comparable in diversity to those from the better-known
fossil provinces in Western United States, a circumstance only recently considered not too probable.

From a geological standpoint, these faunas not only are useful in determining the extent of dry land at a given point in time, but serve also in the dating of certain structural events in Florida's geologic past. The existence during the Miocene of a Suwannee Trough, separating Central Florida from the mainland by a marine seaway, seems out of the question. There is entirely too close a similarity between faunas on both sides of the supposed Trough to allow for a physical barrier of this extent.

H. K. Brooks (1966), in discussing the geological history of the Suwannee River, comments on dating the uplifts of the Ocala Arch:

"The Arch did not exist during the Eocene and earlier. That the Arch was first uplifted and eroded somewhat prior to early late Miocene time is proven by the absence of the Oligocene from the crest of the Arch, but, more significantly, the main body of the lower Miocene Tampa Formation is missing also."

With the discovery of a definite Late Oligocene fauna from Alachua County, we now are able to extend the period of emergence of this area and to more accurately pinpoint the time of first uplift of the Ocala Arch.


PLIOCENE LAND VERTEBRATE LOCALITIES IN FLORIDA

1. Occidental Mine, White Springs
2. Lulu
3. Santa Fe
4. Gainesville Localities
5. Newberry & Haile Localities
6. Archer
7. Mixon’s Bone Bed
8. Emathla
9. Dunnellon Localities
10. Bone Valley Localities
11. Tampa Bay
12. Manatee Co. Dam Sites
13. Sarasota Localities

Figure 1.- Pliocene land vertebrate sites in Florida.
PLIOCENE TERRESTRIAL DEPOSITS OF PENINSULAR FLORIDA

S. D. Webb

INTRODUCTION

Our knowledge of terrestrial deposits in Florida and the associated fossils is increasing at an explosive rate. The past five years have seen the number of land vertebrate sites double; moreover, the related stratigraphic data are becoming more sophisticated and more detailed.

The Cenozoic rocks of Florida provide a remarkably complete and detailed record of the evolution of the area from a shallow shelf to a peninsula. The terrestrial sequence in Florida is of particular interest because it contains the only succession of land vertebrate faunas in eastern North America.

The purpose of this contribution is to summarize the evidence bearing on the evolution of the Florida peninsula and its land vertebrates during the Pliocene. Together with the work of Brooks, Pirkle, and Patton, this constitutes a progress report on a rapidly growing body of knowledge of the emergence of the peninsula.

DISTRIBUTION OF SITES

The localities in Florida that contain Pliocene land vertebrates are indicated in Figure 1. The only other such sites east of the Mississippi River occur near the mouth of the Ashley River in South Carolina. The localities shown in Figure 1 actually represent a much larger number of fossil sites, groups of which have been clustered on this map. In particular the Bone Valley District contains a large number of land vertebrate sites that are grouped together in Figure 1.

The distribution of Pliocene land vertebrate sites approximates the mapped area of outcrop of the Bone Valley and "Alachua" formations (Vernon and Puri, 1964). Two surface extensions of terrestrial Pliocene deposits beyond the mapped areas should be noted, however. One such extension is the long northern tract that runs through Columbia, Suwannee, and northern Gilchrist counties and connects the mapped deposits of Hamilton and Gilchrist counties. The other major addition is the westward extension of the Bone Valley Formation to localities at low elevation in Manatee and Sarasota counties.

NATURE OF THE SEDIMENTS

The sediments containing terrestrial vertebrates of Pliocene age are of two fundamental types: phosphatic sand and sandy montmorillonitic clay.

1Florida State Museum, University of Florida, Gainesville
Unworked Pliocene land vertebrates have been found in no other kinds of sediments in eastern United States.

The best example of the sandy clay deposit is Mixon's Bone Bed, one and one-half miles northeast of Williston in Levy County. This locality is also the type of Sellards's Alachua Clay (later broadened to Alachua Formation). The clay, usually orange or red but blue in an unweathered state, filled a sinkhole in the Ocala Limestone. Presumably the abundant mastodons, giant ground sloths, alligators, bone-crushing dogs, and several kinds each of rhinoceroses, camels, horses and turtles, including several articulated specimens, were trapped in a sinkhole pond. There is no evidence of any marine influence at this site.

Such clay deposits, especially fossiliferous ones, are not nearly as common as the phosphatic sand. At the McGehee Site, a few miles north of Newberry in Alachua County, similar (though in part somewhat sandier) red clay deposits are interbedded with coarse phosphatic sand. At this site, both kinds of sediments contain Pliocene land vertebrates. The vertebrate fauna at this site, however, also includes an estuarine component, and the geometry and textures of the sediments also indicate an estuarine-fluvial situation.

The most common occurrences of Pliocene land vertebrates are in gray phosphatic sand. In the Bone Valley District Pliocene land vertebrates occur only in an upper phosphatic unit of reworked clastic materials (Pirkle, Yoho and Webb, in press). It is to this unit that the term Bone Valley Gravel (Matson and Clapp, 1909) is most aptly applied. Large areas of these reworked Pliocene deposits accumulated under terrestrial conditions. The significance of estuarine and shallow marine components is still to be evaluated.

Northward from the Bone Valley District, occurrences of the Pliocene phosphatic deposits are irregular. This is evidently a function of their position relative to the Ocala Arch. Instead of resting on the more or less regular surface of the Hawthorne Formation, as in the Bone Valley District, they fill parts of a rugged karst surface developed principally during Miocene time on Eocene and Oligocene limestones. These more northerly Pliocene phosphatic sands accumulated predominantly in irregular depositional basins and straths under fluvial conditions. This is well exhibited in a large number of sites where poorly-sorted cross-bedded sands are complexly interbedded with clay lenses. Frequently the coarsest channel deposits include large phosphate and chert boulders, rounded fragments of limestone, and water-worn fragments of large land vertebrates.

REFINED AGES OF THE FLORIDA PLIOCENE SITES

It is a curious fact that all of the Florida Pliocene land vertebrate sites appear to be Middle Pliocene (Hemphillian in the North American land mammal age terminology of Wood et al., 1941). Some of the sites included in Figure 1 cannot be assigned with full confidence to a subepoch within the Pliocene; however, in these cases the probability is that they are Middle Pliocene. The absolute time span of the Hemphillian based on potassium-argon dates from a considerable number of volcanic ashes interbedded with mammal-bearing sediments in western United States is from about 10 to 4 million years before the present (Evernden, et al., 1964).

It is now possible to resolve the age determination of certain Hemphillian sites in Florida even further. It is clear, for example, that the McGehee Site is early Hemphillian, whereas the Bone Valley land vertebrates (at least at several productive sites) are late Hemphillian. A more detailed discussion of this matter will be published later.
SEAL LEVEL FLUCTUATIONS

Deposits containing Pliocene land vertebrates occur at three principal elevations. The most common occurrences are from about 100 to over 150 feet above sea level, usually in fluvialite deposits of gray phosphatic sand. Such localities are particularly abundant in the upper part of the Bone Valley sequence and also in Alachua County. In north central Florida these high level localities are exclusively fluvialite or sinkhole deposits. Where marine vertebrates are associated they can usually be shown to be reworked from nearby outcrops of the Hawthorne Formation. Whether the Bone Valley deposits carrying Pliocene land vertebrates are exclusively fluvialite is presently unknown. A program of detailed stratigraphic work now being carried out in the Bone Valley Area by the University of Florida (Pirkle, Yoho, and Webb, op. cit.) should give effective results.

Another group of localities occurs at elevations of about 70 to 100 feet. The best known of these localities are the McGehee Site in Alachua County and Mixson's Bone Bed in Levy County. While both of these localities occur at about the same elevation, the McGehee Site clearly reflects an estuarine influence, whereas the Mixson Site does not (Webb, 1964).

A third most interesting group of Pliocene land vertebrate localities occurs at elevations very near present sea level. It generally has been supposed that terrestrial vertebrates of Pliocene age found at low elevations, as in the Alafia and Peace rivers, washed down from the Bone Valley District and were redeposited during the Pleistocene. Certainly this is the proper explanation for many such deposits where water-worn Pliocene fossils are found alongside un worn Pleistocene specimens, but at the Manatee County Dam Site about 12 miles east of Bradenton there is evidence of primary deposition of Pliocene land vertebrates at low elevation. There fragile and articulated specimens of Pliocene land vertebrates (along with more water worn specimens of the same age) occur in place in a single coarse phosphatic member of the Bone Valley Formation. No fossils of any age other than Pliocene occur at this horizon. The base of the bed ranges in elevation from 6 to 10 feet above present sea level. In the same deposit with the terrestrial vertebrates, which include mastodons, numerous horses, tapirs and camels, is a considerable variety of marine and estuarine vertebrates (Webb and Tessman, ms.). This evidence shows that the sea dropped to about its present level during part of the Middle Pliocene.

Alternatively, a structural explanation might be offered for the low elevation of these Pliocene land vertebrates. Cooke (1945), in particular, postulated a Plio-Pleistocene downwarp of west central Florida, pointing out that the Gulf Coast of Florida is a submerged coast and that Citronelle-like sediments occur near Tampa at elevations as low as present sea level. However, solid evidence of a Late Pliocene of younger deformation that could produce a net vertical movement of at least 80 ft. has not yet been presented. Vernon's (1951) contours within the Ocala Formation do not support such deformation for the area, nor do Cathcart's (1963) contours on the Hawthorne Formation. If any of the high level shorelines are older than Pleistocene, their unwarped character attests to Florida's Cenozoic stability. It seems most probable that some of the low elevation land vertebrate sites represent direct evidence of a pre-Middle Pliocene drop in sea level.
ZOOGEOGRAPHY

The history of Florida's emergence as a peninsula is clearly reflected in its terrestrial faunas. Beginning in the Oligocene and increasingly through the Late Cenozoic an abundance of terrestrial vertebrates, many of them closely related to taxa in western United States, extended their ranges into Florida. In the Miocene and especially in the Pliocene reptiles with semiarid preferences (Auffenberg and Milstead, 1965), grasslands rodents (Webb, 1966) and a diversity of grazing ungulates (Patton, 1964, and Webb, 1964) appeared in the peninsula. Their presence clearly indicates that there were episodes when grasslands and savannah were widespread and when the climate was relatively dry.

Although the peninsula has maintained close faunal ties with the rest of the United States since its origin, it has also functioned during the same period as a tropically directed cul de sac in which organisms that became extinct in contiguous areas could maintain themselves under more favorable conditions. In the Middle Pliocene of Florida, for example, one finds a burrowing rodent (Mylagaulus kinseyi) that is most closely related to species known elsewhere in the Middle Miocene, and, similarly, a bizarre "slingshot-horned" ruminant (Synthetoceras) that represents the last record by several million years of its family (the Protoceratidae). As the record of terrestrial vertebrates becomes more complete and our stratigraphy more refined, such relics will become increasingly evident.
REFERENCES CITED


------, 1966, A relict species of the burrowing rodent Mylagaulus from the Pliocene of Florida: Jour. Mamm., v. 47.

------, and N. H. Tessman, ms, A Pliocene vertebrate fauna from Manatee County, Florida.

ROAD LOG

FIRST DAY, February 24, 1967

With stratigraphic sections, appended data and comments. (Note: SR in log means State Road)

Assemble in front of Floyd Hall, Department of Geology, University of Florida, Gainesville, at 8:00 A.M. Note the abrupt scarp to the south. South and west of Gainesville on the Ocala Arch an erosional limestone plain has developed at an elevation of 90 to 120 ft. The present level to which the land surface is being lowered by solution is about 60 ft. elevation. The main campus of the University of Florida is at the erosional, southwest margin of the Okefenokee Terrace at an elevation of about 160 ft. It is underlain by Miocene and Pliocene clastic sediments. Proceed north on Newell Drive.

Intersection of Newell Drive and University Avenue. Turn left (west) on University Avenue (SR 26). Continue past 34th Street and large shopping center.

Hogtown Creek. This creek and its tributaries have dissected the Okefenokee Terrace in northwest Gainesville. About a half mile to the southwest, this creek flows into a prairie from which there are no surface outlets. Westward from Gainesville to the Suwannee and Waccasassa rivers there are no surface streams in the area of the limestone plain.

Turn right (northwest) on SR S26A.

Bear right (north) on SR S329, Devil's Millhopper Road.

Intersection of SR 232 (39th Avenue). Continue north on S 329.

Road bends around small pond. Note the small pond is an incipient sink hole depression.

Road curves to left (west).

Turn right (north) on paved road.

Turn left (west) on dirt road.

Comments by H. K. Brooks

Pirkle, et al. (1965) were justified in referring units 1 through 15 to the Hawthorne Formation. The identifiable fossils in unit 5 are Lower Miocene, Tampan in age. Above the hard dolomitic limestone (unit 14) forming the ledge just above the spring line in the sinkhole are materials of two different ages and origins. One consists of phosphatic sand, sandy clay and calcareous clayey sand containing poorly preserved Upper Miocene marine invertebrates. The degree of consolidation of these 'Hawthorne-type' sediments should be compared with the underlying similar but highly consolidated sediments. Marine mollusk borings occur in the limestone underlying the unconformity. The other material exposed in the Millhopper, and also in places resting on unit 14, is a coarse phosphatic gravel, sand and clayey sand of fluvial origin. Pliocene land vertebrates have been collected by H. K. Brooks and students from these Hawthorne sediments. The fossils collected are gavial teeth and a tooth and cannon bone of Nannippus sp. (horse). The type section of the Hawthorne Formation in the abandoned Simmons' Pit near Magnesia Springs east of Gainesville (Sec. 31, T. 10 S., R. 22 E.) is probably of terrestrial origin (Pirkle, 1956). These phosphatic deposits are probably Pliocene in age as are the similar deposits at the Devil's Millhopper and the Gainesville Airport.

<table>
<thead>
<tr>
<th>Mileage</th>
<th>Dist. from Previous Entry</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2</td>
<td>Return to Millhopper Road, SR S 329.</td>
</tr>
<tr>
<td>7.4</td>
<td>Millhopper Road, turn left (east).</td>
</tr>
<tr>
<td>7.1</td>
<td>Road curves to right (south).</td>
</tr>
<tr>
<td>8.1</td>
<td>Road bends around small pond.</td>
</tr>
<tr>
<td>8.5</td>
<td>Turn left (east) on SR S 232 (39th Avenue).</td>
</tr>
<tr>
<td>9.0</td>
<td>Creek is a tributary of Hogtown Creek.</td>
</tr>
<tr>
<td>9.6</td>
<td>Turn left (north) on dirt road.</td>
</tr>
<tr>
<td>10.3</td>
<td>Road bears to right (east).</td>
</tr>
<tr>
<td>10.7</td>
<td>Small stretch of pavement.</td>
</tr>
<tr>
<td>10.8</td>
<td>Dirt road again.</td>
</tr>
<tr>
<td>11.4</td>
<td>Road bears left. Note: Pine-palmetto flatlands at elevation of 180 ft.</td>
</tr>
<tr>
<td>12.0</td>
<td>Turn left (northwest) on U.S. 441 at Paradise.</td>
</tr>
<tr>
<td>12.8</td>
<td>Turn right (north) on SR 121, cross Atlantic Coastline Railroad. Proceed north to Brooker.</td>
</tr>
<tr>
<td>16.0</td>
<td>Intersection SR 121 and SR S 329; bear right (northeast) on SR S 329.</td>
</tr>
<tr>
<td>Mileage</td>
<td>Distance</td>
</tr>
<tr>
<td>---------</td>
<td>----------</td>
</tr>
<tr>
<td>17.6</td>
<td>1.6</td>
</tr>
<tr>
<td>19.1</td>
<td>1.5</td>
</tr>
<tr>
<td>21.8</td>
<td>2.7</td>
</tr>
<tr>
<td>22.3</td>
<td>0.5</td>
</tr>
<tr>
<td>23.3</td>
<td>1.0</td>
</tr>
<tr>
<td>24.7</td>
<td>1.4</td>
</tr>
<tr>
<td>25.1</td>
<td>0.4</td>
</tr>
<tr>
<td>25.5</td>
<td>0.4</td>
</tr>
<tr>
<td>25.8</td>
<td>0.3</td>
</tr>
<tr>
<td>27.5</td>
<td>1.7</td>
</tr>
<tr>
<td>29.3</td>
<td>1.8</td>
</tr>
<tr>
<td>30.5</td>
<td>1.2</td>
</tr>
<tr>
<td>31.5</td>
<td>1.0</td>
</tr>
<tr>
<td>32.5</td>
<td>1.0</td>
</tr>
<tr>
<td>33.4</td>
<td>0.9</td>
</tr>
<tr>
<td>35.1</td>
<td>1.7</td>
</tr>
<tr>
<td>35.5</td>
<td>0.4</td>
</tr>
<tr>
<td>35.7</td>
<td>0.2</td>
</tr>
<tr>
<td>37.8</td>
<td>2.1</td>
</tr>
<tr>
<td>39.1</td>
<td>1.3</td>
</tr>
<tr>
<td>40.6</td>
<td>1.5</td>
</tr>
<tr>
<td>42.5</td>
<td>1.9</td>
</tr>
</tbody>
</table>
45.5 3.0  Waldo.
46.0 0.5  Bear right just before overpass on SR 24.
53.0 7.0  Fairbanks city limits.
53.5 0.5  Downtown Fairbanks.
55.0 1.5  Gainesville city limits.
55.3 0.3  Blinker light, Sperry Rand Corporation. Turn left (east).
55.8 0.5  Blinker light, stop signal, turn left (east).
56.1 0.3  Pull off to right for **STOP** 3. Section is in artificially deepened valley of Little Hatchet Creek at the north end of the airport runway, Section 23, T. 9S., R 20 E. Elevation of road is about 142 ft. The following stratigraphic section was measured by H. K. Brooks.

<table>
<thead>
<tr>
<th>UNIT</th>
<th>DESCRIPTION</th>
<th>THICKNESS (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Quartz sand, fine to medium, non-indurated, pale yellowish orange to limonitic.</td>
<td>2.0</td>
</tr>
<tr>
<td>7</td>
<td>Quartz sand, medium to coarse, occasional discoidal quartz pebble, partially indurated with about 10% clay matrix, mottled with red and ocher iron stains.</td>
<td>6.5</td>
</tr>
<tr>
<td>6</td>
<td>Quartz sand, fine to medium grained, non-indurated, light gray.</td>
<td>2.0</td>
</tr>
<tr>
<td>5</td>
<td>Quartz sand, fine grained, minor clay matrix, buff.</td>
<td>7.5</td>
</tr>
<tr>
<td>4</td>
<td>Sand and clay interbedded, clay beds pale green.</td>
<td>5.3</td>
</tr>
<tr>
<td>3</td>
<td>Sand and clay, matrix, fine to medium, 30% phosphate particles, light gray to greenish gray.</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>Pebble conglomerate in fine sand and clay matrix, graded bedding, light gray to greenish-gray. Fauna consists of reworked marine dugong ribs and an indigenous Pliocene terrestrial and river fauna. H. K. Brooks and associates, especially K. Utrary and R. L. Mckenney, Jr. have collected portions of an articulated river dolphin (long nosed porpoise) Goniodelphus sp., jaw and teeth of gavial, and a tooth of Nannippus sp.</td>
<td>2.5</td>
</tr>
<tr>
<td>Unit</td>
<td>Unconformity</td>
<td>Thickness</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>-----------</td>
</tr>
<tr>
<td>1</td>
<td>Clay, abundant small phosphate grains, green to gray.</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**TOTAL THICKNESS . . . 29.8 feet**

Comments by H. K. Brooks

Careful study of the sequence above the basal conglomerate containing the Pliocene land and river vertebrate fauna reveals no stratigraphic break. It is believed the total sequence is a Pliocene fluvial deposit. Unit 7 is probably the B horizon of a paleosol profile. The underlying phosphatic clay, Unit 1, may be Upper Miocene (Miccosukee Formation).

Puri and Bishop (Puri and Vernon, 1964) have referred these deposits to the Fort Preston Formation. This cannot be correct. On the basis of information now available, Units 2 to 8 should be referred to the Bone Valley Formation (use of the Alachua Formation should be abandoned as Pirkle, 1956, has suggested).

Note the relatively low preconsolidation of the green clays in the Pliocene sequence. Pocket penetrometer readings are $1 - 1.5$ tons/ft.$^2$. The preconsolidation overburden is only 32 feet.

---

56.7 0.6 Turn around and return to SR 24.
57.0 0.3 Turn left (south) on SR 24.
58.0 1.0 Municipal Airport entrance on left.
58.9 0.9 Junction SR S 232; stoplight; proceed south on SR 24.
60.7 1.8 Blinker light; intersection S 232.
61.1 0.4 Stoplight; cross University Avenue, and continue on SR 331.
61.9 0.8 Railroad.
62.0 0.1 Blinker; junction S 329A; continue on SR 24 and SR 331.
63.4 1.4 Paynes Prairie off to left.
64.2 0.8 Junction SR 329; turn left (southwest) on SR 329. Turn left (south) on U.S. 441.
Paynes Prairie is a large solution depression planed to about 60 ft. above sea level. Within historic times the depression contained a lake with an outlet to Orange Lake, Orange Creek, the Oklawaha River, and the St. Johns River.

City limits of Micanopy.

Junction SR 234 and SR S 25A. Continue southeast.

'Lake' off to right is usually a dry prairie.

Marion County line. Hills are underlain by 'Hawthorne' and in lower areas there are outcrops of Ocala Limestone.

Orange Lake on left (east); note orange groves. Outcrops in road cuts are 'Hawthorne Formation.'

McIntosh city limits.

Intersection of SR S 320.

Road cut 'Hawthorne Fm.'

Good view of Orange Lake on left (east).

Intersection with SR 318.

Bear left on U.S. 441 South.

Horse ranches on right. Because of the phosphate in the 'Hawthorne', this area is becoming an important thoroughbred breeding and training area.

U.S. 301 Junction.

Road to Lowell; 12 miles to Ocala.

Ocala Limestone in road cut to right. Note solution pipes.

Ocala Limestone in road cut on right.

STOP 4. Proceed to NW wall of quarry to observe some interesting structural features. Note large sinkhole fillings by road at south side quarry. Fillings are reddish-brown.

Proceed south to top of hill; park beyond intersection with Martin Road. STOP 5. Intersection of U.S. 441, U.S. 301 and Martin Road, SW corner of Section 1, SE corner of Section 2, NE corner of Section 11 and NW corner of Section 12, T. 14 S., R. 21 E. Elevation at top of hill is more than 160 ft. Composite stratigraphic section exposed in the road cuts and in the large quarry to the southwest measured by H. K. Brooks.
<table>
<thead>
<tr>
<th>UNIT</th>
<th>DESCRIPTION</th>
<th>THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Sandrock, phosphatic, clayey, hard, residual from weathering of a phosphatic clayey sand.</td>
<td>13.5</td>
</tr>
<tr>
<td>14</td>
<td>Sand and clays, stratified, clays pale yellowish-gray irregularly bedded with sand, grains and pebbles of phosphorite abundant at top, silicified oysters, penetrometer reading is 2.5 tons/ft.²</td>
<td>2.0 - 3.0</td>
</tr>
<tr>
<td>13</td>
<td>Conglomerate, clay pebble in a clay matrix, yellowish-gray, contains land vertebrate remains at base.</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td><strong>Unconformity</strong></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Clay, pure, blocky at base becoming plastic upward, pale olive, penetrometer reading is 5 tons/ft.² at the base, becoming irregularly less consolidated upward to 2 1/2 tons/ft.² This unit appears to have undergone chemical change (&quot;weathering&quot;) in relationship to the unconformity. By standing across the road one can see this unit slumped into a solution depression whereas the overlying Unit 13 above the unconformity is undisturbed.</td>
<td>6.0 - 14.0</td>
</tr>
<tr>
<td>11</td>
<td>Sand, very fine, slightly clayey, yellowish-gray.</td>
<td>0.0 - 2.0</td>
</tr>
<tr>
<td>10</td>
<td>Clays and silicified clays, pure clays blocky, light olive-gray.</td>
<td>0.0 - 6.0</td>
</tr>
<tr>
<td>9</td>
<td>Limestone and clay, stratified, abundant <em>Carolina floridana</em>.</td>
<td>1.5</td>
</tr>
</tbody>
</table>

(Section in roadcut southwest of intersection)

| 9    | Limestone and clay, stratified, abundant *Carolina floridana*, olive-green.                                                                                                                      | 1.5       |
| 8    | Clay, slightly sandy, blocky, olive-green, penetrometer reading where fresh, in excess of 5 tons/ft.²                                                                 | 2.0       |
| 7    | Limestone, dense, hard, brecciated, off-white, abundant fossils of the *Orthavulax pugnax* fauna. Base covered.                                                                                   | 2.5       |
(Section in south wall of large quarry to southwest of intersection)

7
Limestone, hard, dense, highly fossiliferous, abundant oysters at base, very pale orange. 7.5

6
Conglomeratic limestone, hard, clasts of lithified ferruginous sandstone and chert; fossiliferous. 6.0

5
Conglomerate, sand and clay, calcareous, abundant fossils. 1.5

4
Sand, fine to medium, minor clay, very pale orange to pale yellowish-orange. This unit is discontinuous. Another pocket can be seen on the northwest wall of the quarry. 0.0 - 8.0

Unconformity - karst surface.

3
Limestone, calcarenite, very fine grained matrix, chalky, blocky, sporadic Lepidocyclina ocalana, Amusium sp., Pecten sp.; color is off-white to very pale orange; locally replaced to large chert nodules. 29.0

2
Limestone, bioclastic calcarenite; alternating beds, 1.5 to 3 feet thick, of coarse porous 'Williston-type limerock' with chalky, white, fine-grained Amusium and Pecten beds. 25.0

1
Limestone, bioclastic calcarenite, with casts of gastropods and pelecypods; abundant Lepidocyclina ocalana; differential solution has locally resulted in high porosity; yellowish-orange. 12.0

TOTAL THICKNESS 109.0

Comments by H. K. Brooks

Units 1 to 3 are Late Eocene, Jacksonian in age. They are the Ocala Limestone of C. W. Cooke. Dr. Harbans Puri will discuss the basis on which the Florida Geological Survey differentiates formations in this limestone sequence.

Unit 4 is a sand and sandy clay that occurs in solution depressions in the Ocala Limestone. Inasmuch as this unit grades upward into the conglomerate and limestone containing a Lower Miocene marine fauna, Tampan in age, it is believed that these sands are Miocene. The Oligocene is missing.
Units 5, 6, and 7 contain an Orthaulax pugnax fauna. The lithology is limestone, so these units are properly referred to the Tampa Formation. Units 9 through 12 are also Lower Miocene and the lithology is that of the Devil's Millhopper-type Hawthorne.

The semiconsolidated marine clay and sand of Units 13, 14, and 15 are distinctly unconformable with the underlying unit. Fossil evidence is meager at this locality, including only a few scraps of land vertebrates and silicified oysters. Evidence from elsewhere indicates that these semiconsolidated Hawthorne-type deposits are Upper Miocene in age (Miccosukee Formation). See paper by T. H. Patton.

---

Continue south on U.S. 441.

97.9  5.8  Ocala city limits.

99.3  1.4  Intersection U.S. 27; continue south on U.S. 441 and U.S. 27.

102.0 2.7  Underpass.

106.8 4.8  Cross Florida Barge Canal. The abandoned "bridge" dates from the Roosevelt administration.

109.0 2.2  Ocala Caverns developed in Ocala Limestone. The hills in this area are capped by sands and clays.

111.5 2.5  Intersection U.S. 301, U.S. 27, and U.S. 441. Continue straight ahead on U.S. 441 and U.S. 27 to Leesburg.

114.1 2.6  We will soon leave the erosional limestone plain, elevation 90 to 120 feet.

114.7 0.6  Low rolling hills underlain by sand, gravel and clay can be seen ahead.

116.1 1.4  Citronelle Formation consisting of coarse clayey sands and gravels in road cut.

118.1 2.0  Intersection SR 42. Continue south on U.S. 441 and 27.

120.4 2.3  Orange groves on hills to left.

122.8 2.4  Badly weathered Citronelle in road cut to right.

124.2 1.4  Lady Lake.

128.7 4.5  Intersection with SR 466A, Fruitland Park.

129.0 0.3  Outcrop to right consisting of sands and clayey sands with interesting sedimentary structures. Flecks of kaolin are allegedly feldspar (weathered) grains. In fresh exposures of Citronelle there is no evidence of feldspar. The flecks
have developed from fragmentation of clay stringers.

130.1 1.1 Leesburg city limits.
131.3 1.2 Holiday Inn to left, headquarters for overnight stop.

END OF FIRST DAY

SECOND DAY, February 25, 1967

<table>
<thead>
<tr>
<th>Mileage</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.8</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Lake Harris is on left. This is a portion of the Central Lake District of Florida. The Oklawaha River has its headwaters in this lake. Bugg Springs is about 3/4 mile to the southwest. It is one of the largest springs in the state. The top of the Ocala Limestone in this area is 20 to 30 feet above sea level. The structural high trending toward Cape Canaveral has been called the Sanford High. In Bugg Springs sand and clayey sand of the Citronelle Formation rest unconformably on the middle portion of the Ocala Limestone.

15.5 11.7 View of the central high hills, underlain by coarse sand, gravel and kaolinitic clay. We are entering main part of the Lake Wales Ridge.

16.5 1.0 Intersection SR 99. Continue south on U.S. 27.

24.2 7.7 Citrus Tower on left. A beautiful view of the landscape can be seen from the top of any of these hills.

25.3 1.1 Bear right to intersection of SR 50.

25.5 0.2 Junction SR 50. Turn left (east) on SR 50.

27.2 1.7 View of landscape of Lake Wales Ridge. This area contains many solution depressions, and has practically no surface drainage.

28.5 1.3 Turn right (south) on dirt road.


29.7 0.6 Return to SR 50 and turn left (west).
32.7  3.0  Join U.S. 27 by turning left (south) just beyond underpass.
48.0  15.3  Polk County.
56.0  8.0  Intersection with I-4.  Continue southeast on U.S. 27.  (Possible rest stop).
61.8  5.8  Intersection SR 547.  Continue south on U.S. 27.
64.2  2.4  Haines City city limits.
64.5  0.3  Intersection SR S 17.  Continue southeast on U.S. 27.
65.4  0.9  Junction U.S. 17 and U.S. 92.  Turn south to U.S. 17.
65.7  0.3  Join U.S. 17 and U.S. 92, turn right (west).
70.2  4.5  Lake Alfred city limits.
72.5  2.3  Turn left (south) and continue on U.S. 17.
74.8  2.3  Intersection SR 544.  As we proceed west and southwest, the landscape has less relief.
76.5  1.7  Bear left (east) in downtown Winter Haven.
76.6  0.1  U.S. 17 bears right.  Continue south on U.S. 17.
78.7  2.1  Stop light.  Continue south on U.S. 17.
79.8  1.1  City limits of Eagle Lake.
82.7  2.9  Junction.  Temporary campus of Polk Jr. College on left.
84.4  1.7  Abandoned phosphate mines to right.
86.2  1.8  Valley of the Peace River.
87.2  1.0  Bartow city limits.
87.4  0.2  Bear left on U.S. 17.  Continue south.
88.1  0.7  Junction SR 60.  Stop light, continue south on U.S. 17.
93.7  5.6  Blinker light at Homeland Road (SR S640) intersection, turn right (west).
95.6  1.9  Turn left (south) on dirt road.
96.9  1.3  The booster matrix pump seen here is a 20" x 20" G.I.W.  (Georgia Iron Works) L.S.A.  46" (maximum impeller side opening) pump.  The power is delivered to the pump by a 1500 horsepower constant speed (514 rpm) synchronous motor.
Approximately 1600 yards per hour of phosphate matrix at 35% solids are being pumped through this pipeline (20" O.D., 19 - 1/4" I.D.) from the mine to the wet processing plant. The pumping rate is 18,000 gallons per minute. The pipeline distance varies between 26,000 and 27,000 feet.

97.4 0.5 Pull off road and stop. STOP 7. SW corner, NW 1/4, NE 1/4, SE 1/4, Section 7, T. 31 S., R. 25 E. Mine of International Minerals & Chemical Corporation in Tiger Bay Mine Complex. The ground elevation is 155 ft. The stratigraphic section was measured by R. C. Fountain, International Minerals & Chemical Corporation.

<table>
<thead>
<tr>
<th>UNIT</th>
<th>DESCRIPTION</th>
<th>THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Quartz sand, very fine, subrounded, some clays and organic material. Roots and root relics are present in the soil profile.</td>
<td>4.0</td>
</tr>
<tr>
<td>7</td>
<td>Quartz sand, fine, nearly structureless, containing a minor amount (-2%) of +1/16 in diameter quartz and very minor white, rounded and weathered phosphate grains (-1%). An occasional discoidal quartz pebble is present. The vuggy appearance of the slightly indurated sand in this unit is due to voids which exhibit the outline of phosphate grains which have been leached out.</td>
<td>4.5</td>
</tr>
<tr>
<td>6</td>
<td>Clay, highly leached, orange mottled, thinly bedded with thin (2 - 6 in.) indurated sand layer at base.</td>
<td>0.5</td>
</tr>
<tr>
<td>5</td>
<td>Clayey quartz and phosphate sand, (phosphorite-ore), thin bedded coarse (pebble) to medium-grained subangular quartz interbedded with thin (1 in.) light green clay laminae. The predominance of coarse phosphate grains diminishes near the top of this unit, and there is a pronounced increase in the intensity of weathering (leaching).</td>
<td>4.5</td>
</tr>
<tr>
<td>4</td>
<td>Clay, weathered, orange mottled, green, thin bedded montmorillonitic clay.</td>
<td>0.5</td>
</tr>
<tr>
<td>3</td>
<td>Quartz and phosphate sand, (phosphorite-ore), extremely coarse, intensely cross-bedded phosphate and quartz. The phosphate grains are up to 1 in. in diameter and are well rounded; color ranges from black to near white. Bone fragments, turtle shell fragments and shark's teeth are</td>
<td></td>
</tr>
</tbody>
</table>
abundant. One tooth from a Pliocene rhinoceros, *Teleoceras sp.*, was collected near the base of the coarse upper portion of this unit. Small stringers of gray-green clay containing white phosphate grains are noted near the bottom.

2

The lower 3-4 ft. of this unit is composed predominantly of fine- to medium-grained rounded phosphate grains and quartz. Cross-bedding is pronounced.

Unconformity.

1

Clayey quartz and phosphate sand (phosphorite-ore), fine-to medium-grained, clayey sands composed predominantly of subrounded to subangular quartz and rounded and polished phosphate grains. Phosphate grains make up 30 - 40% of total matrix. The color of the phosphate grains in the sand-size fraction ranges from glossy black to light brown and gradationally to tan and cream. A minor percentage of amber colored translucent grains are also present. Light green montmorillonitic clays are randomly distributed throughout this unit and exhibit no distinct bedding characteristics. Some light green, hard clay balls are locally noted here. Animal borings, including *Callianassa sp.*, occur throughout and into the upper surface of this unit.

| TOTAL THICKNESS | 27.5 |

WATER LEVEL

Discussion by R. C. Fountain

The Central Florida phosphate district is located in southwestern Polk and south-eastern Hillsborough counties. The deposits occur in a thin blanket of sediments on the southern flank of the southward plunging Ocala Arch, and range in age from Middle Miocene through Pleistocene. Abundant vertebrate and invertebrate fossils occur in the section.

The most popular theory of the origin of these phosphate deposits was summarized by Altschuler, Cathcart and Young (1964, p. 1) and cited by Riggs and Freas (1965, p. 2) as follows: "The Bone Valley Formation is a shallow-water marine and estuarine phosphorite of Pliocene age...(It)...is an excellent example of marine transgression during which the phosphate was derived, by reworking, from the underlying, weathered, Hawthorn Formation."
The section at Tiger Bay Mine consists of a series of sand, clayey sand, and phosphorite of Miocene and Pliocene age. The lowermost unit exposed just above the water level (unit 1) is a light green to cream, clayey, phosphorite containing 15.5% \( \text{P}_2\text{O}_5 \). This unit contains animal borings throughout, including those attributed to Callichinassa sp., a marine crustacean. This horizon probably underwent weathering in early Pliocene time which removed original calcium carbonate and some calcium phosphate, causing superegene enrichment of the phosphate ore. Some minor carbonate is still present. This unit is probably Upper Miocene in age.

An unconformity separates the lowermost horizon from the next sequence of sand, phosphate and clay which is the Bone Valley Formation of Pliocene age. The lower 3-4 feet (unit 2) of the Bone Valley Formation consists of cross-bedded, medium-grained, phosphate-bearing quartz sand probably deposited in an estuarine environment. Overlying these sands is approximately 6 feet of cross-bedded, coarse, rounded phosphate pebbles and interbedded sand. Sharks teeth, turtle shell fragments, horse teeth (Hippotherium plicatile), and one rhinoceros tooth (Teleoceras sp., amphibious, fresh water) were collected from the base of this pebble zone. The degree of rounding and polishing of the phosphate pebbles and the fragmental character of the turtle shells, together with the sharpness of some of the sharks teeth and the undamaged appearance of the rhinoceros tooth, indicate that there are two generations of sediments present. The phosphate has been intensely reworked, probably in a fluvial environment, and is thought to be derived from the underlying Miocene sequence. The Pliocene sequence (units 2 to 8) here appears to represent a change from a near shore or estuarine environment to a fluvial environment. Subsequent leaching (Pleistocene to Recent) has destroyed many of the original sedimentary characteristics in the upper portion of the Pliocene Bone Valley Formation.

During the mining operation here another unconformity, characterized by a weathered surface which evidently has been intensely oxidized, was noted lower in the section. This break is believed to represent the boundary between rocks of Middle Miocene age and those of Upper Miocene age. The sequence underlying this proposed unconformity consists of a light tan to cream, fossiliferous, phosphatic dolomite limestone. The Middle Miocene is now approximately 5-10 feet below water level. To the east of the measured section, on the spoil banks, orange to cream carbonate rocks excavated from below the lowermost unconformity can be seen.

Included here are some basic physical and chemical data on several of the horizons in this section.
### PHYSICAL AND CHEMICAL DATA

<table>
<thead>
<tr>
<th>Depth Below Surface (Feet)</th>
<th>Tyler Mesh</th>
<th>Weight %</th>
<th>% P₂O₅</th>
<th>Insoluble Residue</th>
<th>BPL</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.0 - 20.0 (Unit 3)</td>
<td>+ 16</td>
<td>60.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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| 23.5 - 24.0 (Unit 1)        |            |          | 20.0    |                   | 43.4|

| 24.0 - 27.5 (Unit 1)        | + 16       | 2.6      |         |                   |     |
|                            | + 20       | 0.4      |         |                   |     |
|                            | + 28       | 2.6      |         |                   |     |
|                            | + 35       | 7.9      |         |                   |     |
|                            | + 48       | 22.1     |         |                   |     |
|                            | + 65       | 30.0     |         |                   |     |
|                            | + 100      | 22.1     |         |                   |     |
|                            | + 150      | 8.6      |         |                   |     |
|                            | - 150      | 3.7      |         |                   |     |
| **Total**                  |            | 100.0    | 15.5    | 53.2              | 33.3|

### BIBLIOGRAPHY


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Turn around and return to the Homeland Road (SR S 640).
Turn left (west) on Homeland Road.

Road curves to right (north).

I.M.C. Area 12 Mine, Noralyn Complex. The road is built on debris or tailings of quartz sand.

Virginia Carolina mine west of road, I.M.C. mine east of road.

Office of International Minerals & Chemical Corporation. Turn into parking lot. Lunch is courtesy of I.M.C.

Return to Homeland, via Homeland Road, and turn right (south) on U.S. 17.

Fort Mead.

Turn left (east) on U.S. 98.

Peace River.

Turn left (north) on Pool Branch Road.

Virginia Carolina Peace River Mine. Note the land reclamation program.

Pool Branch; cross bridge and park. \underline{STOP 8.} Pool Branch Vertebrate Site, SW 1/4; NW 1/4, Section 13, T. 31 S., R. 25 E., Polk County, approximately 2 miles northeast of Fort Meade. Elevation of land surface is 90 - 100 ft. Section measured by E. C. Pirkle, S. D. Webb and W. H. Yoho.

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**UNIT** | **DESCRIPTION** | **THICKNESS (Feet)**
---|---|---

**Surface Blanket of Quartz Sand**

5 | Surface sands, loose. Very fine to medium. White to gray, locally dark from presence of finely divided organic matter | 1.7

Sp1. 1 = Spot sample selected 1.0 ft beneath upper surface of unit.

**Pleistocene Reworked Sediments**

4 | Clayey sand with local occurrences of a conglomerate of phosphorite at base. Stringers and small lenses of phosphate gravel are present in the sands, especially in the lower half of the unit. Gray to buff to dark brown. |
The quartz sand is very fine to very coarse. Quartz granules and a few discoid quartz or quartzite pebbles are present in the sediments.

Most of the phosphate particles are white.

This zone occurs disconformably over the underlying sediments of Unit 3. Along the south side of the drainage ditch numerous Pleistocene land-vertebrate fossils, including an articulated skeleton of *Equus fraterculus* (Pleistocene horse), have been taken from the lower part of this zone. (These Pleistocene fossils will be described at a later date by S. D. Webb).

**Sp1. 2** - Spot sample of dark brown clayey sand collected at a depth of 2.5 ft. beneath the upper surface of the unit. Sample taken directly beneath Sp1. 1.

**Sp1. 3** - Spot sample from conglomerate of phosphorite.

**Phosphatic Sediments of Bone Valley District**

3

Mixture of quartz sand, phosphorite and clay. This unit is characterized by an abundance of brown, sand-size phosphorite. Pebble-size phosphorite is rare.

Stringers and small lenses of light green clay are present through the unit. The clay stringers are more numerous toward the top of the bed.

The quartz sand is fine to medium.

Most of the phosphorite is brown, orange-brown and white. However some tan and amber grains are present.

Bones of sirenians are common. A completely articulated skeleton of a sirenian was taken from the materials. The skeleton was embedded in sediments 3 - 4 ft. above the base of the unit. (That specimen, excavated under the direction of S. D. Webb, has been placed in the collections of the Florida Museum).

The contact between this unit and underlying Unit 2 is sharp and distinct. The nature of this contact is currently under study and debate.
Spl. 4 - Spot sample selected about 0.6 ft down from the upper surface of the unit in slightly hardened, brown material.

Spl. 5 - Spot sample taken 1.5 ft. down from upper surface of unit in light colored, almost white sediments containing a few light green clay stringers. There is a purple tint to some of the materials.

Spl. 6 - Spot sample collected 3.9 ft. below the upper surface of the unit in a zone mottled gray, green and yellow-brown.

Spl. 7 - Spot sample from site 3.5 ft. above base of unit where articulated sirenian skeleton was extracted from the sediments. Sediments are tan and yellow-brown. Locally there is a purple tint. Faint horizontal bedding.

Spl. 8 - Spot sample selected 0.25 ft. above base of unit.

2

Mixture of quartz sand, clay and phosphorite. There is much less quartz sand in this unit than in overlying Unit 3. Furthermore, the clay content of some of the sediments is significantly higher.

This unit contains both pebble-size and sand-size phosphorite. Most of the pebbles and grains are white, cream and light tan. There are minor amounts of brown, orange-brown and amber grains.

Locally the materials have the appearance of weathered bedrock. Pinnacles of bedrock of Unit 1 extend into the sediments. At some sites boulders of bedrock, or boulders of material similar to bedrock, are present within the sediments. At some exposures, sediments surrounding the pinnacles and boulders are horizontally laminated.

Lenses of silicified oyster shells are present. Such a lens was seen in this unit directly beneath the articulated sirenian skeleton of the overlying Unit 3.

The quartz sand is very fine to medium.

Spl. 9 - Spot sample taken 0.25 ft. below upper surface of unit in light gray to white sediments.
Spl. 10 - Spot sample collected 1.3 ft. below top of unit in materials that contain scattered white phosphate pebbles as much as 1 in. in longest dimension. No visible bedding.

Spl. 11 - Spot sample selected just beneath Spl. 10 in a zone that is more yellow-brown in color and that has faint suggestions of horizontal bedding.

Spl. 12 - Spot sample taken 2.5 ft. below top of unit in a zone that has a relatively high clay content and that contains a lense of silicified oyster shells.

Spl. 13 - Spot sample collected 3.6 ft. below top of unit in material that has indistinct horizontal laminations.

Bedrock of the Hawthorne Formation

Bedrock. Whitish to pale yellow dolomite or dolomitic limestone. In some places the bedrock is silicified. Locally, fossil impressions of marine mollusks are abundant. (It is on the basis of such fossils that this Hawthorne bedrock usually is dated as middle Miocene. Relationships of the bedrock to the overlying sediments of Unit 2 are under study. Current ideas differ).

Minor amounts of quartz sand and amber to orange and brown phosphorite are present disseminated through the bedrock and in stringers and small lenses within the bedrock.

The clastic quartz sand is very fine to fine.

Only 11 in. of this unit is exposed at the site of this section. 0.9

Spl. 14 - Spot sample of Hawthorne bedrock.

Depth to water in canal . . . 22.9
Chemical and sedimentary analyses of selected samples from the stratigraphic section. Data and comments submitted by E. C. Pirkle:

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<th>Fe₂O₃</th>
<th>Total Heavies</th>
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Although probably not readily apparent, the types of values in the tables accompanying this section constitute an important aid, or in a sense, valuable tools in studying both regional and local problems of the sediments. As examples, studies involving grain sizes of the quartz sand and the uniformity of the quartz sand distribution are of much value when considering origins of the surface sands. In addition,
size distributions of the quartz sand grains, when considered with clay content, mica content, heavy mineral percentages, heavy mineral associations, and other values, take on much interest in determining whether phosphatic sediments are depositional in origin or residual concentrations resulting from weathering in situ.

Heavy mineral analyses, considered with data in these tables, may be quite significant in determining the relationships of reworked concentrations of Pliocene and Pleistocene phosphorites to Miocene concentrations of phosphorites. Likewise the heavy mineral data can be applied to problems of the origin of the surface sands. From these few examples it is evident that the uses of the types of data given in the tables are essential to reliable stratigraphic studies.

END OF FIELD TRIP.

Bus will return to Gainesville.