MIOCENE PALEONTOLOGY AND STRATIGRAPHY OF THE SUWANNEE RIVER BASIN OF NORTH FLORIDA AND SOUTH GEORGIA

SOUTHEASTERN GEOLOGICAL SOCIETY

Guidebook Number 30

October 7, 1989

MIOCENE PALEONTOLOGY AND STRATIGRAPHY OF THE SUWANNEE RIVER BASIN OF NORTH FLORIDA AND SOUTH GEORGIA

Compiled and edited by
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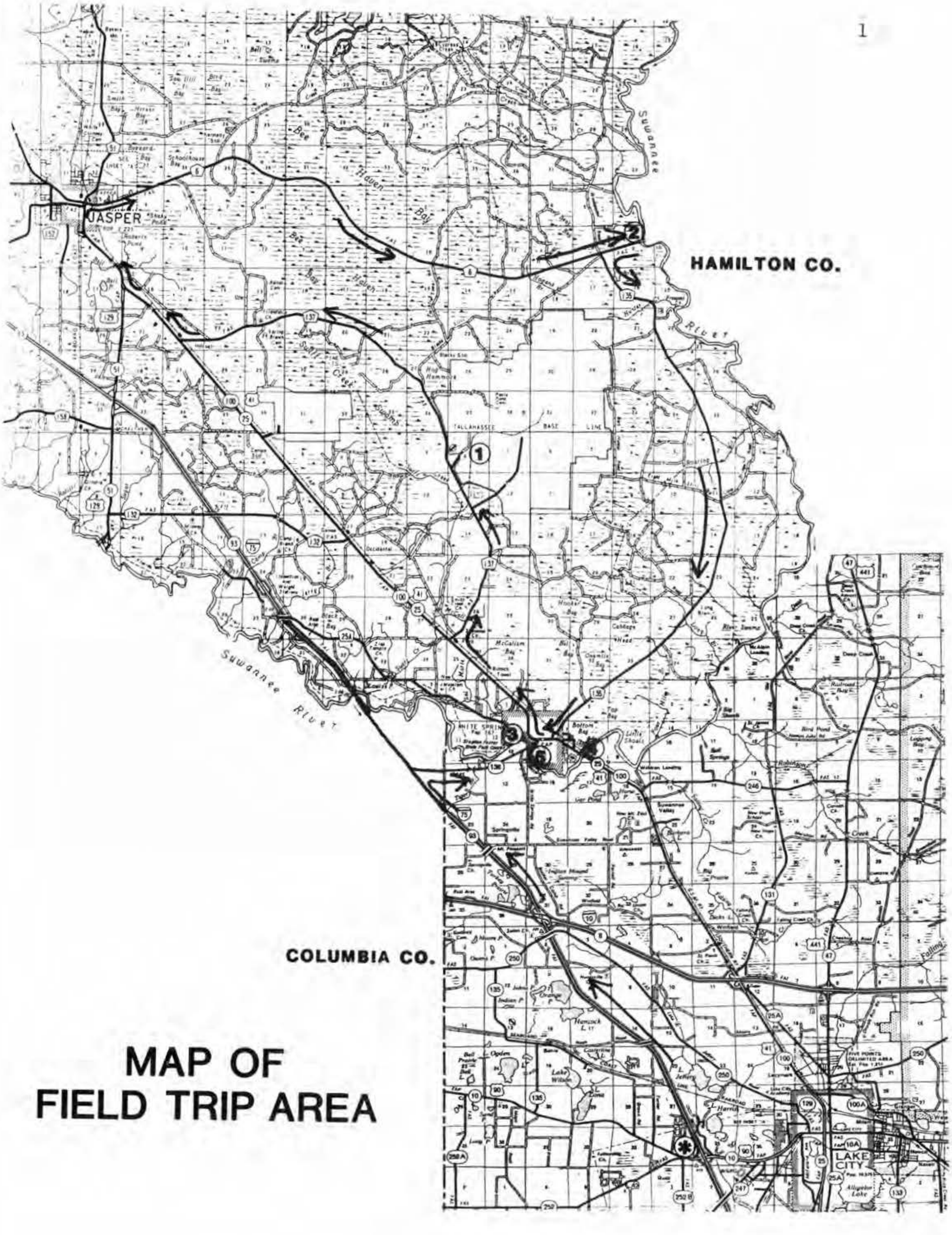
GUIDEBOOK NUMBER 30

A Guidebook for the Annual Field Trip of the
Southeastern Geological Society
October 7, 1989

Published by the
Southeastern Geological Society
P. O. Box 1634
Tallahassee, Florida 32303

TABLE OF CONTENTS



MAP OF FIELD TRIP AREA

ROAD LOG

Total Mileage	Mileage from Last Point	Reference Points
0.0	0.0	Begin at Holiday Inn, Lake City, intersection of I-75 and US 90.
7.3	7.3	Pass under I-10.
12.6	5.3	Turn right (east) on SR 136.
15.8	3.2	SR 136 Bridge over Suwannee River.
16.0	0.2	Turn left (west) on US 41.
19.5	3.5	Turn right (northeast) on CR 137.
23.1	3.6	On right-main office of Occidental Chemical Corporation.
24.3	1.2	STOP 1. Suwannee River Mine of Occidental Chemical Corporation. OXY began mining phosphate in this region in the mid 1960s. We will see their dragline operations, in place sections of the phosphorite-bearing Statenville Formation, and should also have a chance to collect shark teeth and other vertebrate fossils from spoil piles.
		Return to CR 137 and turn right (north).
33.4	9.1	Turn right (northwest) on US 41.
35.4	2.0	Turn right (north) on US 129.
37.8	2.4	Turn right (east) on CR 6 in Jasper.
53.1	15.3	CR 6 Bridge over Suwannee River. STOP 2. Phosphatic sands of the Statenville Formation are exposed on the west bank of the river to the north and south of the bridge. Shark teeth and sea cow ribs and vertebrae are common in these sediments.
		Turn around and proceed west on CR 6.
54.2	1.1	Turn left (south) on CR 135.
69.4	15.2	Turn right (west) on US 41.

71.1	1.7	Turn left (south) into Stephen Foster State Folk Culture Center. Lunch stop.
		STOP 3. After lunch we will take a leisurely walk along the Suwannee River beginning at the boat landing and ending at the old springhouse (about 0.8 mi). We will see exposures of the bone bed and shell bed of the Parachucla Formation, huge dolomitic boulders belonging to an unnamed unit of the Hawthorn Group, and the historic White Sulphur Springs.
		Return to US 41 and turn right (east).
73.7	2.6	US 41 Bridge over Suwannee River. STOP 4. Miocene strata referred to the Porters Landing Member of the Parachucla Formation are well exposed on both banks of the river to the north and south of the bridge. We will walk several hundred yards north along the east bank of the river to examine the sandy sediments that have produced the richest vertebrate fauna in the White Springs area, including several skulls and skeletons of sea cows.
		Turn around and proceed west on US 41.
75.0	1.3	Turn left (south) on SR 136.
75.2	0.2	SR 136 Bridge over Suwannee River. STOP 5. Fossiliferous shell beds of the Porters Landing Member of the Parachucla Formation are well exposed immediately under the bridge on the west bank of the river and on the east bank slightly upstream (south) of the bridge. This unit has produced one of the richest invertebrate faunas known from the Hawthorn Group of north Florida.
		Proceed west on SR 136.
78.4	3.2	Turn left (south) on I-75.
91.0	12.6	Holiday Inn, Lake City, US 90 exit.

PREFACE

This is actually the second field trip of the Southeastern Geological Society (SEGS) to examine the Miocene strata along the banks of the Suwannee River in the vicinity of White Springs. Long-time members of the Society may remember that the twelfth annual field conference of the SEGS met in conjunction with the Atlantic Coastal Plain Geological Association on November 4, 1966 and visited some of the same outcrops we will see today (Brooks, 1966). The primary emphasis of the 1966 SEGS field trip and guidebook was on detailed lithological and chemical analyses of the sediments, and on the geological history of the Suwannee River. The 1989 field trip and papers in this guidebook concentrate primarily on the paleontology, biostratigraphy, and lithostratigraphy of these strata, topics only briefly touched upon during the 1966 trip.

Daryl Domning and Gary Morgan first discussed the idea for the present field trip as long ago as the summer of 1982. At that time two college students had recently discovered a complete skull and partial skeleton of the fossil sea cow Metaxytherium along the banks of the Suwannee River near the U. S. Route 41 Bridge in White Springs (Stop 4 of this field trip). In the summer of 1985 Gary Morgan discovered the first known skull of the extinct sirenian, Dioplotherium manigaulti, in these same strata only a few yards upstream from the locality where the first sea cow was collected. A skeleton of a third extinct sirenian, Halitherium olseni, was found in similar beds on the east bank of the Suwannee River about two miles west of White Springs in December 1961 by S. J. Olsen, C. Hendry, and W. Yon of the Florida Geological Survey. These three extinct sea cows are among the most significant specimens of early Miocene sirenians in North America. Their discovery and paleontological significance has provided the impetus for this field conference.

Thanks to Daryl Domning's gentle but persistent prodding, Morgan set out to determine the age of the sirenian-rich beds along the Suwannee River in the vicinity of White Springs. He quickly discovered that very little had been written on the paleontology and biostratigraphy of these fossiliferous Miocene strata, despite the fact that they are well exposed in the banks of one of Florida's best known and most scenic rivers. In fact, Dall and Harris (1892) discussed the Miocene strata along the Suwannee River near White Springs in their original description of the Hawthorn Formation. Thus, as Huddlestun (1988) has noted, this section may be considered a supplementary stratotype or parastratotype of the Hawthorn.

It is fortunate that the timing of this field trip coincides with the recent publication of two very significant papers on the Miocene stratigraphy of Florida (Scott, 1988) and Georgia (Huddlestun, 1988). These two papers provide a current stratigraphic framework into which the Suwannee River section may be placed. Because the age of these beds is uncertain, we decided to invite several specialists to participate in field studies aimed at a multidisciplinary approach to the determination of the age of the Miocene sediments along the upper reaches of the Suwannee River in southernmost Georgia and northernmost Florida. Special emphasis is given to the beds in the vicinity of White Springs, where most of the fossils have been collected.

Tom Scott provides a current lithostratigraphic framework for the Miocene strata in the Suwannee River region, using data from well cores as well as analysis of the naturally exposed sections. Roger Portell reviews the invertebrate fauna from the fossiliferous shell beds exposed between the U. S. 41 Bridge and the Florida Route 136 Bridge in White Springs. Gary Morgan reviews the fossil record of Miocene vertebrates from the Suwannee River basin, concentrating on the fauna collected in the vicinity of White Springs, but also including a preliminary discussion of vertebrate fossils from the Occidental Phosphate Mine (Stop 1). Finally, Daryl Domning discusses the spectacular sea cow fossils collected in the upper Suwannee River area.

The banks of the Suwannee River provide one of the best naturally exposed stratigraphic sections of early and middle Miocene sediments in the north Florida and south Georgia area. Consequently, the geology of this beautiful river has captured the interest of geologists for nearly a century. We sincerely hope that the present guidebook provides a significant addition to our understanding of the Miocene paleontology and stratigraphy of this region.

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THE LITHOSTRATIGRAPHY OF THE SEDIMENTS EXPOSED ALONG THE SUWANNNEE RIVER IN THE VICINITY OF WHITE SPRINGS

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INTRODUCTION

The sediments exposed along the upper reaches of the Suwannee River in the vicinity of White Springs, Hamilton County range in age from Oligocene to Holocene. The oldest sediments cropping out along the river in this area belong to the Lower Oligocene (Rupelian) Suwannee Limestone (Figure 1). Most of the sediments that will be seen on this field excursion are assigned to the Lower to Middle Miocene (Aquitanian-Serravallian) Hawthorn Group (Figure 1). The Hawthorn Group sediments exposed in the phosphate mines belong to the Middle Miocene (Serravallian) section with a thin zone of Upper Miocene (Tortonian?) reworked sediments which aided in concentrating the phosphorite. The Hawthorn Group sediments are overlain by sediments generically referred to as Pleistocene-Holocene sediments.

The Suwannee Limestone was deposited on a broad, shallow carbonate bank that existed in Florida from at least the Late Cretaceous. Thousands of feet of carbonate sediments formed on the platform. The carbonate bank environment ceased to exist as a result of siliciclastics filling the Gulf Trough (Figure 2) and flooding across the Florida Platform beginning in the Early Miocene.

The Hawthorn Group represents the initial Cenozoic influx of siliciclastic sediments into the previously carbonate-producing environments of the Florida Platform. In northern Florida, these sediments replaced the carbonate sediments more rapidly and completely than in southern Florida. Characteristically, the basal Hawthorn Group in Florida contains more carbonate beds than the younger portion of the group. This holds true for much of the peninsular area with few exceptions. The basal Hawthorn Group along the Suwannee River near White Springs is one of the exceptions.

Phosphate in the form of carbonate-fluorapatite (francolite) granules is virtually ubiquitous in the Hawthorn sediments although concentrations are generally subeconomic. However, an economically significant deposit occurs in the upper Hawthorn Group in the vicinity of the Suwannee River in the North Florida Phosphate District. Occidental currently mines a portion of this deposit north of White Springs in Hamilton County.

LITHOSTRATIGRAPHY

Sediments exposed in the field trip area range in age from Oligocene to Holocene. The oldest sediments exposed belong to the Suwannee Limestone while the youngest are Holocene fluvial deposits along the Suwannee River and its tributaries. Most

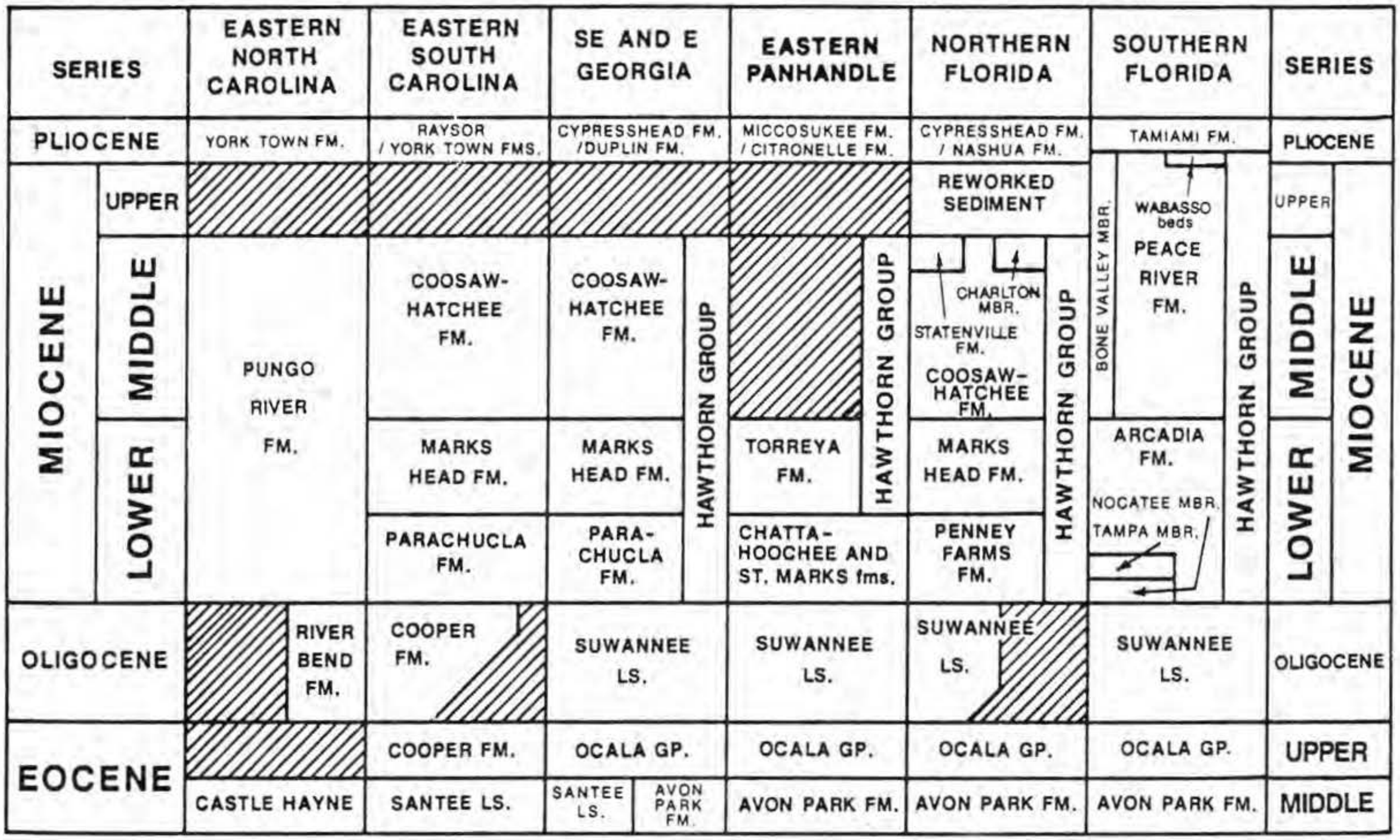

Figure 1 Formational correlations (modified from unpublished C.O.S.U.N.A. Chart, 1985).

exposures seen during the field trip will be Miocene Hawthorn Group sediments overlain by Pleistocene-Holocene deposits.

Oligocene Series
Suwannee Limestone

The Suwannee Limestone forms the oldest rocks exposed in the field trip area. It was named by Cooke and Mansfield (1936) for the limestones exposed along the Suwannee River from the vicinity of White Springs to Ellaville. These sediments had previously been assigned to the Hawthorn Formation or Tampa Limestone. The concept of the Suwannee Limestone has varied between a biostratigraphic unit and a lithostratigraphic one. Carbonate sediments of dissimilar lithologies have been correlated utilizing "Suwannee" fossils and subsequently referred to as the Suwannee Limestone. Also, particularly in southern Florida, the limestone situated below the Tampa Member of the Arcadia Formation, Hawthorn Group has been referred to as the Suwannee due simply to its subjacent position to the Tampa. For this reason, the Gulf Coast Region, Correlation of Stratigraphic Units (COSUNA) of North America chart (Braunstein et al., 1988) utilizes "Suwannee Ls." to indicate a formal unit which may be incorrectly used for some of the limestones referred to as the Suwannee in southern Florida.

The Suwannee Limestone in northern Florida is characteristically a white (N 9) to very pale orange (10 YR 8/2), soft to hard, variably recrystallized, fossiliferous grainstone to packstone. Dolomite occurs in the Suwannee to the west of the field trip area at Ellaville and westward.

As used here, the Suwannee Limestone includes all the carbonates lying on the Ocala Group carbonates as exposed at Ellaville on the Suwannee River. Huddlestun (in review) has proposed that the Suwannee Limestone be restricted to the limestone above the dolomite in the type exposure at Ellaville. He also proposes the name Suwannacoochee Dolomite for the dolomite exposed and the Ellaville Limestone for the basal limestone resting on the Ocala Group limestones. This terminology is utilized on the COSUNA chart but, pending further investigation into its extent in northern Florida, is not currently used by the Florida Geological Survey.

The thickness of the Suwannee Limestone in the Hamilton County area ranges from 20 to 160 feet (Colton, 1978). The Suwannee is absent due to post-depositional erosion immediately east of this area.

The Suwannee Limestone is unconformably subjacent to the Miocene Hawthorn Group. This contact can be seen in a number of exposures along the Suwannee River between White Springs and Ellaville as it undulates above river level at various locations.

Miocene Series
Hawthorn Group

Huddlestun (1988) and Scott (1988) raised the Hawthorn Formation of former usage to the Hawthorn Group in Georgia and

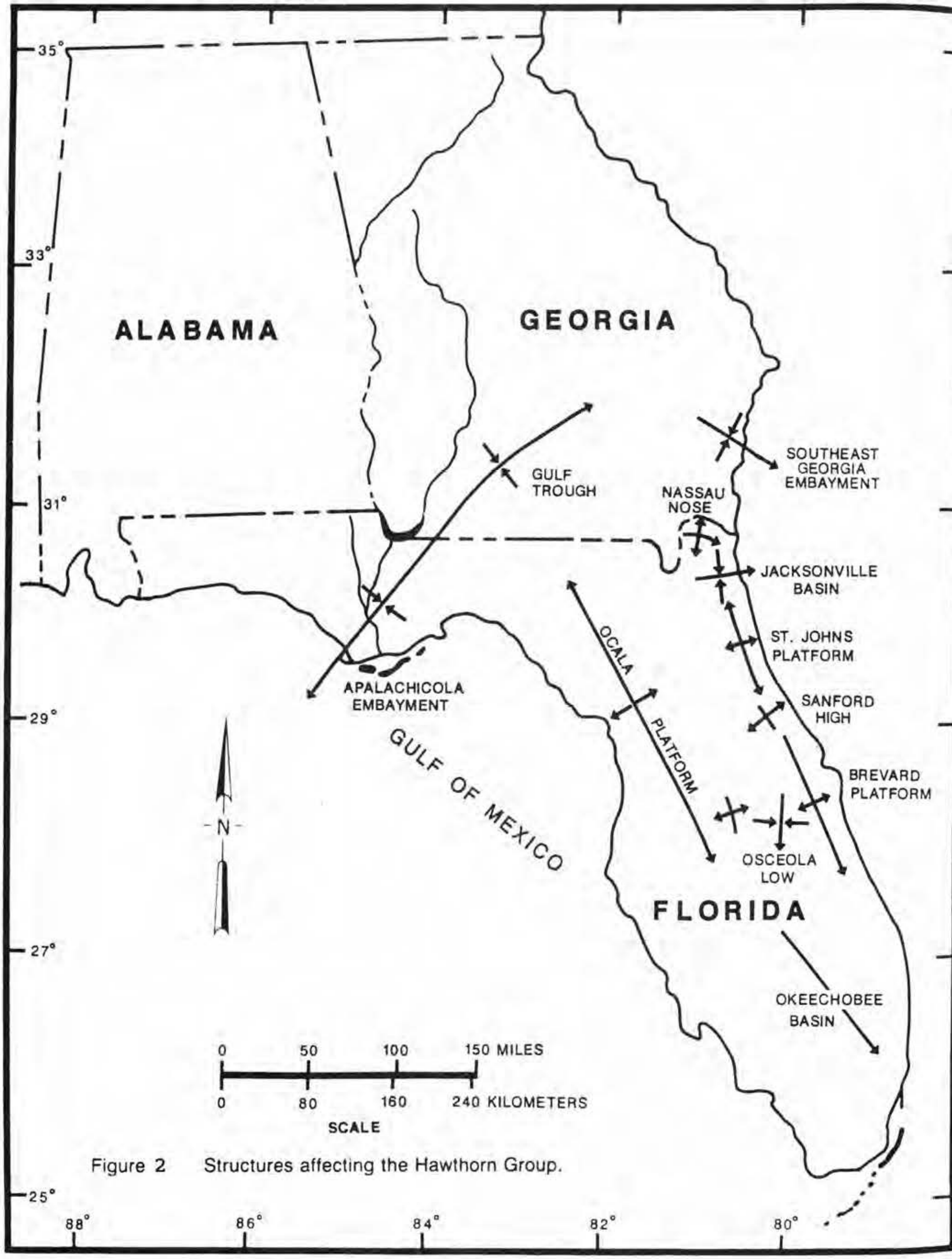

Figure 2 Structures affecting the Hawthorn Group.

Florida respectively. The reader is referred to these publications for more complete descriptions and discussions of the Hawthorn Group.

Five formations comprise the Hawthorn Group in northern Florida. In ascending order these are the Parachucla and its lateral equivalent Penney Farms, Marks Head, Coosawhatchie and the Statenville. In the Suwannee River area, only the Parachucla and Statenville Formations have been definitely recognized. The component units of the Hawthorn Group are best developed in the subsurface to the northeast and east of the outcrop area. Only those formations of the Hawthorn recognized along the Suwannee River will be discussed here. For more detailed information, the reader is referred to Huddlestun (1988) and Scott (1988).

Parachucla Formation

The Parachucla Formation occurs only in limited areas of northern-most Florida. Currently, the only recognized exposures of the Parachucla in Florida occur along a limited stretch of the Suwannee River near White Springs. It has not been recognized in cores in Hamilton and surrounding counties in Florida. Downdip from the outcrop area, to the east, the Parachucla grades into the Penney Farms Formation. The primary lithologic difference between these units is that the Penney Farms contains a significant proportion of carbonate beds interbedded with siliciclastics.

Lithologically, the Parachucla in this area consists of varying admixtures of sand, silt and clay with variable fossil content. The quartz sands are fine to coarse grained and range in color from medium light gray (N 6) to olive gray (5 Y 3/2) in outcrop. The silt and clay content is highly variable. As will be seen on the field trip, two generalized facies of the Parachucla occur in this area. One contains rather abundant mollusks while the other facies has few if any mollusks but contains scattered vertebrate remains (see articles by Domning,Morgan and Portell, this volume).

The thickness of the Parachucla Formation in this area has not been determined at this time. However, from some of the exposures near White Springs, it appears that it ranges to at least 10 feet thick.

The Parachucla lies unconformably on the subjacent Suwannee Limestone. Although the contact has not been observed along the Suwannee River, the Parachucla is unconformably overlain by either undifferentiated Hawthorn Group sediments, by the Marks Head Formation of the Hawthorn Group or by Pleistocene-Holocene sediments. The age of the Parachucla is Early Miocene (Aquitanian) based on planktonic foraminifera (Huddlestun, 1988).

Statenville Formation

The Statenville Formation occurs in a limited area of southern Georgia and northern Florida (Huddlestun, 1988; Scott, 1988). The type section of the Statenville Formation is located

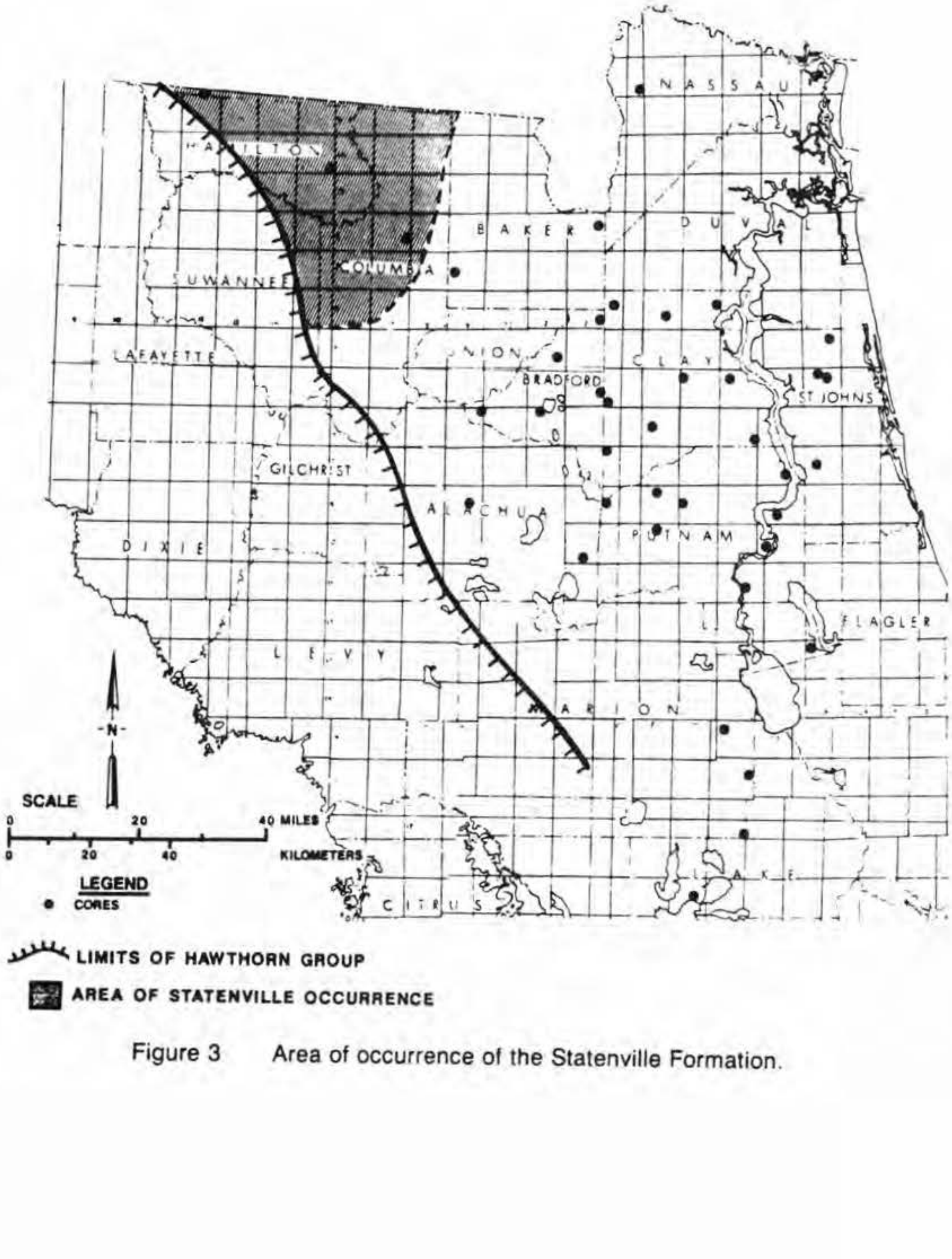

Figure 3 Area of occurrence of the Statenville Formation.

along the Alapaha River in Echols County, Georgia immediately north of Hamilton County, Florida.

The Statenville Formation consists of interbedded sands, clays and dolostone. Quartz sands predominate and are fine to coarse grained with occasional gravel. The sands are variably clayey to dolomitic, poorly indurated, and phosphatic. The sands are often thinly bedded and cross bedded. Colors range from very light gray (N 8) to light olive gray (5 Y 6/1).

Clay beds, which are not often readily apparent in outcrop, are sandy, dolomitic, phosphatic and poorly indurated. The clays are thinly bedded and range in color from yellowish gray (5 Y 8/1) to olive gray (5 Y 4/1).

The dolostones are variably clayey, sandy, phosphatic and poorly to well indurated. The dolostones are best exposed on the Alapaha River to the west of the field trip area and occur as thin beds or lenses interbedded with the siliciclastics.

The areal extent of the Statenville Formation in Florida is limited to portions of Hamilton and Columbia Counties and possibly a small area of Baker County (Figure 3). The thickest recognized occurrence is in a Florida Geological Survey core Betty #1, W-15121, NE1/4, NW1/4, Sec.3, T2N, R12E, Hamilton County where it attains a thickness of 87 feet. Natural exposures are generally less than 20 feet thick.

Huddlestun (1988) suggested the age of the Statenville to be Middle Miocene(Serravallian). A zone of reworked sediments at the top of the Statenville contains a Late Miocene vertebrate fauna. This reworked unit is informally referred to as the Swift Creek member of the Statenville Formation.

The Swift Creek member is readily visible in the phosphate pits in Hamilton County. It is horizontally bedded as compared to the cross bedding in the undifferentiated Statenville Formation. Thicknesses have not been determined at this time.

Pleistocene-Holocene sediments

The Pleistocene-Holocene sediments which are suprajacent to the Hawthorn Group sediments are characteristically quartz sand with varying amounts of clay. These sediments have been characterized as Pleistocene-Holocene based on the lack of lithologic attributes assignable to the Hawthorn Group, the Miccosukee Formation or other recognizable formational entity. These sediments are thought to be composed of terrace and fluvial deposits.

Geologic Structure

Hamilton County, Florida lies on the northeastern flank of the northern end of the Ocala Platform where it plunges toward the Gulf Trough (Figure). The Gulf Trough lies north of Hamilton County in southern Georgia.

The structural setting of this area played an important role in the Miocene phosphogenic episode which occurred in the southeastern United States. This area was the site of phosphogenesis and the subsequent accumulation of phosphorite

(Riggs, 1979, 1984; Miller, 1982; Scott, 1988). For further information concerning phosphogenesis the reader is referred to the references cited above.

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Fossil Invertebrates from the Banks of the Suwannee River at White Springs, Florida

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Introduction

Along the banks of the Suwannee River, between the State Road 136 bridge and the U.S. 41 bridge at White Springs, Hamilton-Columbia counties, Florida, occur exposures of fossil-rich early Miocene sediments. These exposures have captured the interest of geologists since they were first reported by W.H. Dall and G.D. Harris (1892). Dall and Harris, relying upon notes furnished by J.C. Neal, included a section from the area as part of their "Hawthorne beds", a variable mixture of quartz sand, clay, carbonate, and phosphate named for the town of Hawthorne in Alachua County.

After examining the outcrops during their 1913 field season, Vaughan and Cooke (1914) suppressed the name "Hawthorne beds" and placed the exposures within the Alum Bluff Formation. They believed the invertebrate fossils exposed along the river were similar to those found in the Chipola Marl and Oak Grove Sand Members of the Alum Bluff Formation.

Gardner (1926) raised the Alum Bluff Formation to group status and followed Vaughan and Cooke by including the outcrops along the Suwannee River at White Springs within the now raised Chipola Formation. She described several new Chipola species based upon fossils collected in outcrops along the river.

Cooke and Mossom (1929) reinstated the Hawthorne as a formation and placed it within the Alum Bluff Group. Later, Cooke (1936) dropped the Hawthorne Formation from the Alum Bluff Group when he extended the unit into Georgia.

Brooks (1966) made a detailed stratigraphic section of what he termed "Hawthorne" sediments along the north bank of the Suwannee River west of the State Road 136 bridge and correlated the fauna from the lower three beds of his section (Unit 1 of this paper) to the Chipola Formation. Brooks felt these highly fossiliferous units were probably late early to early middle Miocene.

Studies by Huddlestun (1988) and Scott (1988) have led to a refinement of our knowledge of the lithostratigraphy, age, and correlation of the Hawthorne sediments found in Florida and Georgia. Huddlestun (1988) elevated the Hawthorne Formation of Georgia to group status as did Scott (1988) in Florida. Due to the lack of exposures at the type locality at Hawthorne, Florida and because Dall and Harris (1892) referred to the outcrops along the Suwannee River at White Springs as "Hawthorne beds", Huddlestun (1988) proposed this area serve as a parastratotype (supplementary stratotype used in the original definition by the original author to aid in elucidating the holostratotype) for the Hawthorne Group. Huddlestun (1988 and pers. comm. with G. Morgan, 1989) also assigned the fossiliferous outcrops (Unit 1) near White Springs to the Porters Landing Member of the Parachucla Formation based upon lithostratigraphic correlation with similar sediments found in Georgia. The age of this unit at the type locality of Porters Landing, Effingham County, Georgia is considered early Miocene based upon planktonic foraminifera.

For this paper, G. Morgan and R. Portell followed the river between the State Road 136 bridge and the U.S. 41 bridge and observed that these outcrops were laterally traceable but varied in thickness, lithology, faunal content, and faunal preservation. A section was measured along the north bank of the Suwannee River approximately 100 meters east of the State Road 136 bridge (NW1/4, NW1/4, SW1/4, Sec.7, T2S, R16E, White Springs West Quadrangle). There was approximately 5.5 meters of exposed section above water level with the lowest 3.0 meters of fossiliferous section (Unit 1) tentatively identified as the Porters Landing Member of the Parachucla Formation (see Figure 1). At this locality undifferentiated Hawthorne sediments (Units 2,3) overlie the Porters Landing Member of the Parachucla Formation and upstream at Rock Island Shoals, Unit 1 unconformably overlies the Suwannee Limestone.

The invertebrate fossils from Unit 1 were derived from sediments which range from well-sorted, fine quartz sand with minor amounts of clay and phosphate (lower 1.5 meters of section) to a calcareous shelly sand (upper 1.5 meters of section). Occurrence of numerous tan, rolled, waterworn dolomite pebbles with distinct borings were also present throughout this unit.

The intent of this study was to supplement the work of Gardner (1926) and expand the work of Brooks (1966) by presenting a further assessment of the invertebrate fossil fauna found in Unit 1 along the Suwannee River near White Springs. Collections housed at the Florida Museum of Natural History in Gainesville, Florida were used to facilitate this study. These collections represent the field work of Dr. H. K. Brooks and students in 1966 and 1971; J. Harper in 1972; G.

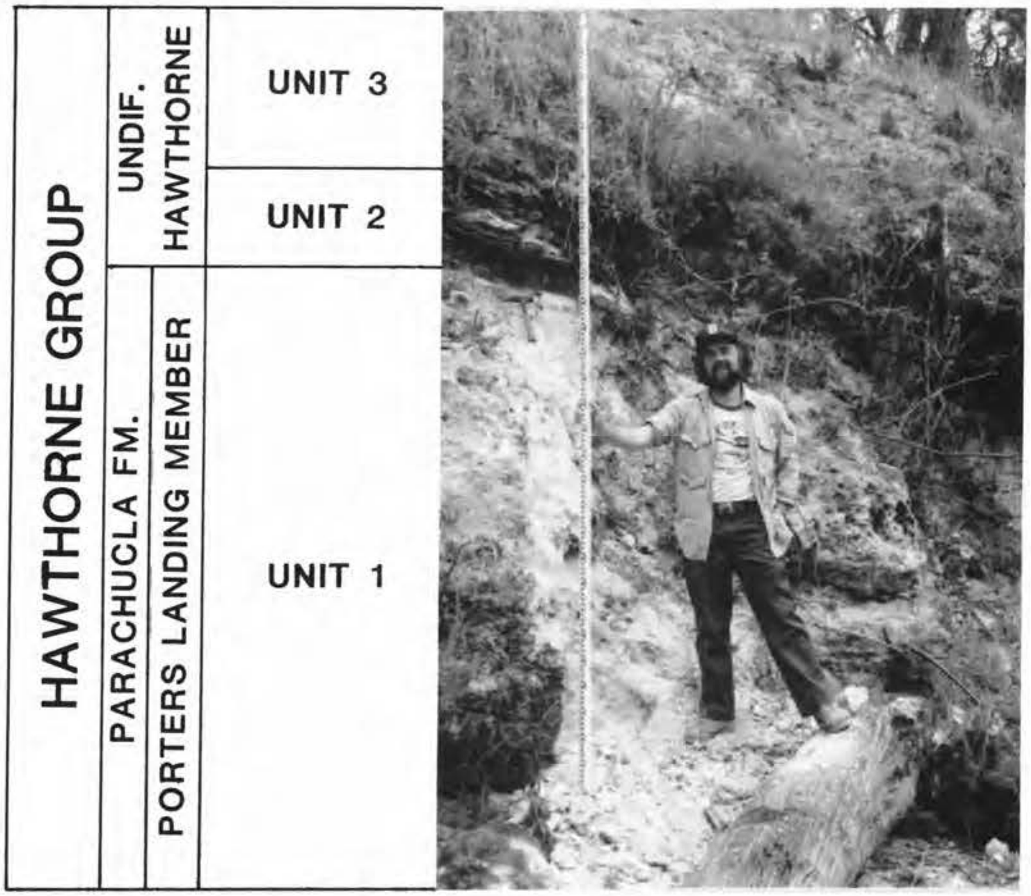

Figure 1. Stratigraphic section measured by G. Morgan and R. Portell. Unit numbers reflect those used in text. Unit 1 is tentatively identified as belonging to the Porters Landing Member of the Parachucla Formation of Huddlestun (1988) and corresponds to Beds 1-3 of Brooks (1966). Units 2 and 3 are assigned to undifferentiated Hawthorne and correspond to Beds 4 and 5 of Brooks (1966). Stadia rod is 4.5 meters in length.

Morgan in 1982; G. Morgan, A. Pratt, A. Poyer, and R. Portell in 1988; and G. Morgan and R. Portell in 1989. G. Morgan will present a companion paper (this volume) that will discuss the fossil vertebrates.

Invertebrate Fossil Fauna

Dall and Harris (1892) and Vaughan and Cooke (1914) briefly mentioned the occurrence of invertebrate fossils within their sections along the Suwannee River at White Springs. Gardner (1926) listed 15 taxa of bivalves and gastropods that occur in the White Springs area. Among these were two new species of bivalves, Anomia suwanneensis and Callocardia albofonte, which she described from the White Springs outcrops. Gardner believed the exposures to be within the Chipola Formation and as such apparently assumed many of the species were identical to those found from the Chipola elsewhere. Probably because of poor preservation of the fossils, Gardner was unsure about many of the specific names she used for the specimens found at White Springs and in her monograph preceded them with a question mark. For this paper the author has chosen to recognize only molluscan species that Gardner positively identified. These include Ostrea normalis Dall, Chlamys acanikos Gardner, Anomia suwanneensis Gardner, and Callocardia albofonte Gardner.

Brooks (1966) described the outcrops near the State Road 136 bridge as containing, "one of the richest faunas ever discovered in the Hawthorne". He reported 23 taxa of molluscs, arthropods, and foraminifera within his lower three beds (Unit 1 of this paper). Upon careful review of Brooks' material, it was found that many of his identifications were incorrect. He identified Anomia suwanneensis Gardner as Carolia floridana Dall and Callocardia albofonte Gardner as Gafrarium gouldia erosum Dall. He also placed specific names on specimens too poorly preserved to do so. For the faunal list of this paper, the author has disregarded Brooks' identifications and re-identified his material.

Recently G. Morgan and R. Portell collected bulk matrix as well as individual fossil specimens from Unit 1 between the State Road 136 bridge to just north of the U.S. 41 bridge. The majority of the invertebrate fossils collected were from under the State Road 136 bridge because of easy access to the outcrops. Most of the fossils near the U.S. 41 bridge have been destroyed by diagenesis with the exception of numerous silicified oysters, several "ghosts" (internal molds composed of sand) of the pecten Chlamys acanikos Gardner, and fragments of echinoids.

Over 65 marine taxa belonging to 6 phyla were recognized from Unit 1 (see Table 1). The phylum Mollusca was the best represented with over 50 species. Three of these were the bivalves Chlamys acanikos Gardner, Ostrea normalis Dall, and Anomia suwanneensis Gardner. In addition to the molluscan fauna, abundant, complete and fragmented specimens of Balanus (acorn barnacle), cf. Gagaria (sea urchin), and Callianassa (ghost shrimp) were also recovered. See Figure 2 for photographs of several representative fossil invertebrates from Unit 1.

The preservation of the fossils varied greatly with the best preserved being the calcitic-shelled organisms such as oysters, pectinids, barnacles, and bryozoans. Most of the aragonitic-shelled organisms were highly leached and many preserved as casts and molds in case-hardened areas of the outcrop. The degree to which these casts and molds could be identified was limited. Generic identifications were based upon silicone rubber casts of the external molds.

Paleoecology

Determining the paleoecology of fossil-bearing units is difficult. Information losses can occur through non-preservation and transportation of organisms after death. The poor preservation of the aragonitic portion of the fauna limited the degree to which paleoecological assessments could be made. The following observations were based primarily on the well-preserved, calcitic portions of the fauna.

Several faunal elements suggested water turbulence of high to moderate energy associated with a relatively hard, stable substrate. These included the bivalves Anomia, Ostrea, Chama, and Mytilus which are normally found attached to the substrate by means of byssal threads or cementation. The relative abundance of Ostrea, coupled with large numbers of Anomia and Chlamys indicated an oyster community. Other common oyster associates found included numerous specimens of Balanus and encrusting bryozoans. Some faunal elements also implied a paleoenvironment of high energy but with a soft, somewhat unstable substrate. Among these were Callianassa (ghost shrimp), cf. Abertella (sand dollar), Chione, Olivella, and a member of the family Pinnidae (pen shell). This assumption of a medium to high energy environment based upon the fauna is further strengthened by the occurrence of numerous, rolled, water-worn dolomite pebbles with distinct borings of the bivalves Lithophaga and cf. Martesia.

No preferred orientations were exhibited by the bivalves nor were they in life position. Relatively few were articulated which indicated transport and/or predation. The disarticulation presumably occurred at or near the site of deposition because of the lack of excessive breakage or abrasion.

In summary, the faunal evidence can be interpreted to indicate a mixing of nearshore, shallow marine environments

Table 1. List of invertebrate fossils recovered from the 2.5 miles of Unit 1 exposed along the Suwannee River from the State Road 136 bridge to just north of the U.S. 41 bridge (Ed Scott Bridge) at White Springs, Hamilton/Columbia Counties, Florida.

PROTISTA
- Sorites sp.

BRYOZOA
- Cheilostome, gen. and sp. A undet.[1]
- Cheilostome, gen. and sp. B undet.

MOLLUSCA

GASTROPODA
- Acteocina sp.
- Anachis sp.
- Bullidae, gen. and sp. indet.[2]
- Calyptraeidae, gen. and sp. A indet.
- Calyptraeidae, gen. and sp. B indet.
- Cypraea sp.
- Ecphora sp.
- Epitonium sp.
- Melongenidae, gen. and sp. indet.
- Naticidae, gen. and sp. indet.
- Olivella sp.
- Scaphander sp.
- Sinum sp.
- Turritella sp. A
- Turritella sp. B
- Vasum sp.
- Vitrinellidae, gen. and sp. indet.

BIVALVIA
- Anomalocardia sp.
- Anomia suwanneensis Gardner
- Arcidae, gen. and sp. indet.
- Arcopsis sp.
- Callocardia albofonte Gardner
- Cardiidae, gen. and sp. A indet.
- Cardiidae, gen. and sp. B indet.
- Carditamera sp.
- Carditidae, gen. and sp. indet.
- Cardium sp.
- Chama sp.
- Chione sp.
- Chlamys sp.
- Chlamys acanikos Gardner
- Corbulidae, gen. and sp. A indet.
- Corbulidae, gen. and sp. B indet.
- Divaricella sp.
- cf. Lima sp.

Lithophaga sp.
Lucinidae, gen. and sp. A indet.
Lucinidae, gen. and sp. B indet.
Glycymeris sp.
cf. Martesia sp.
Mercenaria sp.
cf. Modiolus sp.
Mytilus sp.
Nucula sp.
Nuculana sp.
Ostrea sp.
Ostrea normalis Dall
Panopea sp.
Pinnidae, gen. and sp. indet.
Trigoniocardia sp.
Veneridae, gen. and sp. indet.

ARTHROPODA
CIRRIPEDIA
Balanus sp.

MALACOSTRACA
Callianassa sp.
Callianassa matsoni Rathbun
Decapoda gen. and sp. A indet.
Decapoda gen. and sp. B indet.
cf. Libinia sp.
Paguridea, gen. and sp. indet.

ANNELIDA
polychaete worm tubes

ECHINODERMATA
ECHINOIDEA
cf. Gagaria sp.
cf. Abertella sp.
Echinoidea, gen. and sp. indet.

ASTEROIDEA, gen. and sp. indet.

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[1] genus and species undet. (undetermined) indicates that the material of a particular taxon, although in some cases abundant and well preserved, has not been studied in sufficient detail for a more complete identification.

[2] genus and species indet. (indeterminate) indicates that the material of a particular taxon is insufficient to warrant a more complete identification.

Figure 2. Representative invertebrate fossils from Unit 1. UF numbers represent catalogued specimens housed in the Invertebrate Paleontology Collection, Florida Museum of Natural History.

2.1) Anomia suwanneensis Gardner, interior and exterior of left valve, x1.0, UF25305.

2.2) Chlamys acanikos Gardner, exterior of right valve, x0.95, UF25304.

2.3) Callianassa matsoni Rathbun, exterior of right palm and fixed finger, x1.3, UF25364.

2.4) Lucinidae, exterior right valve, x1.0, UF25308,

2.5) Ostrea normalis Dall, interior and exterior of left valve, x0.9, UF25476.

2.6) Balanus sp., several individuals attached to Chlamys acanikos Gardner, x1.0, UF25311.

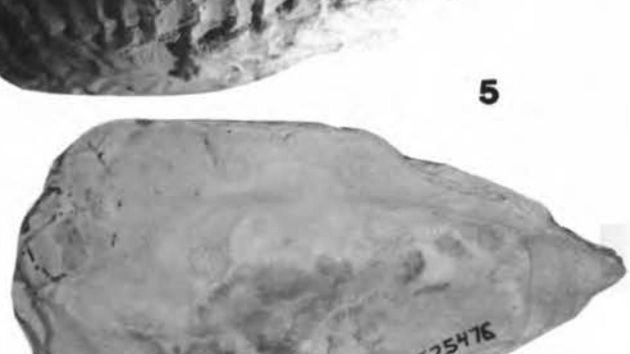
1

3

2

4

5



6

(intertidal to subtidal) with a predominantly quartz sand or sand-lime mud substrate.

Biostratigraphy

Of the well preserved segment of the fauna from Unit 1, only Chlamys acanikos Gardner and Ostrea normalis Dall offer any insight into biostratigraphic correlation. Both bivalves have been reported from numerous Florida and Georgia localities that are correlative with early Miocene formations.

Chlamys acanikos and Ostrea normalis were reported from the Chipola Formation by Gardner (1926). As a result of the abandonment of the Hawthorne between 1914 and 1929, Gardner had to assign these Hawthorne bivalves to the Chipola Formation because it was the only suitable formal stratigraphic unit available at that time. Therefore, these and several other "Chipola species" may be common in the Hawthorne but not found in the Chipola Formation and should not be used to suggest such a correlation (Banks and Hunter,1973). Unfortunately, workers that followed Gardner, (Rathbun,1935; Mansfield,1936; Brooks,1966; Gibson,1987), continued to correlate these fossils and/or associated strata with the Chipola Formation, when in fact, they only occur in the early Miocene portion of the Hawthorne Group.

Chlamys acanikos and Ostrea normalis have been cited from the early Miocene portions of the Hawthorne Group, namely the Torreya Formation of Florida. These reports by Banks and Hunter (1973) include the type locality of the Torreya Formation at Rock Bluff, Liberty County; the Taff Limerock Pit south of Crawfordville, Wakulla County; and Jones' Bluff at Chattahoochee, Gadsden County. Hunter and Huddlestun (1982) later placed these occurrences within the Pododesmus scopelus Assemblage Zone of the lower part of the Torreya Formation, but Hunter (pers. comm.,1989) reports that they do occur higher in the Torreya Formation.

Ostrea normalis and Chlamys acanikos have both been reported from the lower levels at Devil's Millhopper by Dall (1895) and Pirkle, Yoho, and Allen (1965), respectively. Scott (1988) includes this strata within the Penney Farms Formation which is a lateral equivalent to the Parachucla Formation of Huddlestun (1988).

Cooke (1936,1943) reported both bivalves from Hawthorne outcrops along the Savannah River near Porters Landing, Effingham County, Georgia (Huddlestun's type locality for the Porters Landing Member of the Parachucla Formation).

At this time the author believes that the data presented by the preceding authors indicate that these fossils occur in sediments of early Miocene age. The author therefore has chosen to follow Huddlestun (1988) in assigning Unit 1 to the Porters Landing Member of the Parachucla Formation. Huddlestun regarded the Porters Landing Member as being of early Miocene (Aquitanian) age based upon planktonic foraminifera from cores in similar sediments found in Georgia. He suggested that the Porters Landing Member is either upper Zone N4 (upper Globorotalia kugleri Zone) or lower Zone N5 (lower Catapsydrax dissimilis Zone) of Blow (1969) which translates to between 23 and 19 Ma. To date, no planktonic foraminifera have been reported from Unit 1 of the White Springs outcrops but a similar age has been inferred for this unit based upon Huddlestun's correlation.

Acknowledgements

I am grateful to Gary Morgan for assistance with field work and many other aspects of this study. I wish to acknowledge Douglas Jones and Muriel Hunter for reviewing the manuscript and also Burt Carter for providing identifications of some of the echinoderm material. I am thankful to Kevin Schindler for help with preparation and curation of the fossil invertebrates. Ms. Jeri Friedman took the photographs in Figure 2. This paper represents University of Florida Contribution to Paleobiology number 351.

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MIOCENE VERTEBRATE FAUNAS FROM THE SUWANNEE RIVER BASIN OF NORTH FLORIDA AND SOUTH GEORGIA

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INTRODUCTION

Since the late nineteenth century Florida has been known for its wealth of Miocene vertebrate fossils (e.g. Leidy and Lucas, 1896). Indeed, the vast majority of Miocene land vertebrate faunas in eastern North America are found in Florida. The best known of these Miocene faunas, spanning the time period from about 22 to 5 million years ago (Ma), have recently been reviewed and placed within the context of the North American land mammal biochronology (MacFadden and Webb, 1982; Tedford et al., 1987). Many of Florida's richest Miocene vertebrate sites contain large samples of well preserved fossils, but provide little stratigraphic information since they occur in isolated pockets or as fissure or sinkhole fillings in Paleogene limestones. The majority of these well known Miocene faunas are located in the north-central portion of the peninsula, particularly in Alachua, Gilchrist, Levy, and Marion counties.

Only during the last 10 to 15 years has the northernmost portion of the Florida peninsula been seriously explored for vertebrate fossils. Several important faunas have been discovered during this time, including the earliest Miocene (late Arikareean) SB 1A (=Live Oak) Local Fauna in Suwannee County (Frailey, 1978) and the late early Miocene (late Hemingfordian) Brooks Sink Local Fauna in Bradford County (Morgan and Pratt, 1988). Three of these recently discovered faunas, including Brooks Sink and the two new faunas described here, occur in marine geologic units belonging to the Hawthorn Group (Huddlestun, 1988; Scott, 1988). Moreover, several of these faunas contain marine invertebrate fossils and microfossils associated with marine and terrestrial vertebrates, thus allowing for correlation between terrestrial and marine biochronologies.

In this paper, two new vertebrate faunas from the Suwannee River basin are placed on record, the earliest Miocene (Arikareean) White Springs Local Fauna from Columbia and Hamilton counties and the late middle Miocene (early Clarendonian) Occidental Local Fauna in Hamilton County. All vertebrate fossils discussed in this paper are housed in the vertebrate paleontology collections of the Florida Museum of

Natural History (formerly the Florida State Museum), University of Florida, Gainesville (acronym UF).

WHITE SPRINGS LOCAL FAUNA

Daryl Domning and I began collecting vertebrate fossils from the Miocene strata along the banks of the Suwannee River in the vicinity of White Springs beginning in 1981 and continuing until the present. The only significant vertebrate fossils found in the vicinity of White Springs prior to 1981 were the type specimen of the sea cow Halitherium olseni collected in 1961 (Reinhart, 1976) and two shark teeth referred to Carcharodon auriculatus and a new species of small Carcharhinus by Tessman (1969). Collecting trips were made several times each year during periods of low water when the thickest section of Miocene sediments was exposed. These efforts have produced several beautifully preserved skulls and skeletons of sirenians that are discussed in Domning's paper in this volume.

A rich and varied marine vertebrate fauna is found in association with the fossil dugongs from the White Springs fauna. More important from a biostratigraphic standpoint is the rare but regular occurrence of land mammals in these same beds. Two partially articulated specimens of land mammals have been recovered from the White Springs Local Fauna, including a skull, mandibles, and partial skeleton of an oreodont and an associated hind limb of a camel. A small sample of isolated teeth of rodents and a rabbit has proven to be extremely useful for biostratigraphic correlation.

The White Springs Local Fauna is here designated for the earliest Miocene (Arikareean) vertebrate fauna recovered from sediments referred to the Porters Landing Member of the Parachucla Formation (Huddlestun, 1988), exposed along the banks of the Suwannee River in the vicinity of White Springs in Hamilton and Columbia counties, Florida (Fig. 1). Fossils from the White Springs 1A, 3A, and 3B localities (described in more detail below) comprise the White Springs Local Fauna. Vertebrate fossils included in this fauna have been collected along an approximately 10 kilometer stretch of the Suwannee River between Little Shoals 3 km east of White Springs and the Suwannee County line 4 km west of White Springs.

The Suwannee River forms the boundary between Columbia County on the south and east and Hamilton County on the north and west, and thus individual localities may be in either county depending upon which bank of the river they were collected. Despite the distance between localities (about 9 km separate White Springs 1A and 3A) there is little question that the fossils are derived from the same stratigraphic unit, as the primary bone-producing bed has been traced more or less continuously along the banks of the Suwannee River

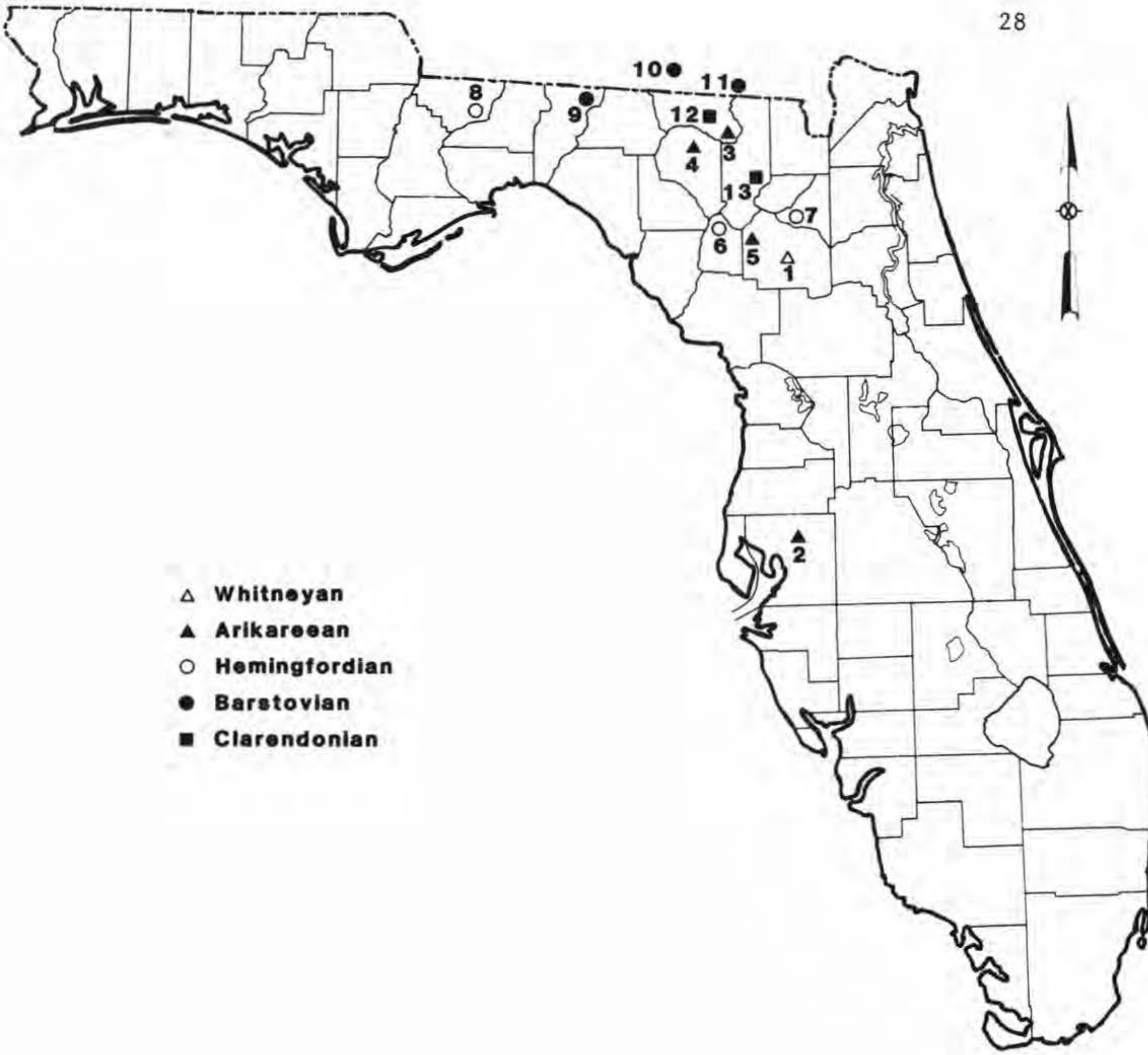

Figure 1. Map of Florida showing vertebrate fossil localities mentioned in text. 1. I-75, Alachua Co., Whitneyan (late Oligocene); 2. Cowhouse Slough, Hillsborough Co., early Arikareean (latest Oligocene); 3. White Springs, Hamilton and Columbia Co., Arikareean (earliest Miocene); 4. Live Oak, Suwannee Co., late Arikareean (earliest Miocene); 5. Buda, Alachua Co., late Arikareean; 6. Thomas Farm, Gilchrist Co., early Hemingfordian (early Miocene); 7. Brooks Sink, Bradford Co., late Hemingfordian (early Miocene); 8. Midway, Gadsden Co., late Hemingfordian; 9. Ashville, Jefferson Co., late Barstovian (middle Miocene); 10. Statenville, Echols Co., Georgia, late Barstovian; 11. Needmore, Echols Co., Georgia, Barstovian; 12. Occidental, Hamilton Co., early Clarendonian (late middle Miocene); 13. Kerr McGee core, Columbia Co., early Clarendonian.

between the productive fossil sites. The various localities included in the White Springs Local Fauna are the same age, but differ from one another in species composition. Detailed map data, field notes, and stratigraphic sections for all of the localities discussed in the text are on file in the Vertebrate Paleontology collection of the Florida Museum of Natural History (FLMNH).

White Springs 1A.--Most of the vertebrate taxa in the White Springs Local Fauna are from the localities designated White Springs 1A and White Springs 3B. White Springs 1A is located on the east bank of the Suwannee River in Columbia County, 200 to 300 m north of the U. S. Route 41 bridge (Stop 4 of this field trip), 1 km southeast of White Springs. While canoeing the Suwannee River in June 1982, two college students, Kim Hyde and Cliff Maxwell, discovered several associated sea cow ribs at the White Springs 1A locality. They alerted the FLMNH of their discovery and an expedition consisting of Ann Pratt, Richard Franz, Cathy Puckett, and myself returned to the site in November 1982 to excavate the specimen (see photographs in Fig. 1 of Domning's paper). The ribs belonged to a partially articulated skeleton composed of a nearly complete skull, partial mandible, and nine cervical and anterior thoracic vertebrae of the dugongid sirenian Metaxytherium (see Domning's paper in this volume). Morgan and Pratt (1983) provide a more detailed discussion of the discovery and excavation of the White Springs Metaxytherium skeleton.

Routine screenwashing of the sediments from the plaster jacket in which the sea cow skeleton was collected produced a rich fauna of nearshore marine vertebrates including rays, sharks, and bony fish, along with an isolated molar of a large species of heteromyid rodent (Proheteromys cf. P. magnus) and the ilium of a small frog. After the discovery of terrestrial vertebrates in these sediments we initiated a program to screenwash matrix samples from this portion of the river in hopes of adding to the land vertebrate fauna, thereby providing a better estimate for the age of these beds using the North American land mammal biochronology (Tedford et al., 1987).

Numerous collecting expeditions have visited the White Springs 1A locality between 1982 and 1989 in search of additional sirenian specimens, as well as for the collection of sediment for microvertebrate analysis. The only known skull of the rare sirenian Dioplotherium manigaulti was discovered at White Springs 1A in July 1985, barely 50 m north of the spot where the Metaxytherium skeleton had been collected three years previously. The terrestrial mammal fauna from the White Springs 1A site now includes a horse, a small shrew, a rabbit, and a number of species of rodents, including three species of heteromyids, a squirrel, an eomyid, a geomyoid, and a possible beaver.

White Springs 3A.--The second locality for the White Springs Local Fauna is designated White Springs 3A. The most important fossil found at this site was the holotype of the sea cow, *Halitherium olseni*, described by Reinhart (1976). This specimen consists of an articulated skeleton, including a complete skull and mandibles, collected in December 1961 by S. Olsen, C. Hendry, and W. Yon of the Florida Geological Survey. A sawfish vertebra (*Pristis* sp.), a shark tooth (*Carcharhinus* sp.), and a barracuda tooth (*Sphyraena* sp.) are the only other vertebrate fossils recovered from this site. White Springs 3B is located on the east bank of the Suwannee River in Hamilton County, 3.5 km northwest of White Springs.

White Springs 3B.--The White Springs 3B locality was discovered by Daryl Domning and Gary Morgan in February 1989. White Springs 3B is located on a small island in the middle of the Suwannee River 2 km southwest of White Springs. The first specimen collected from White Springs 3B was a partially associated skeleton of a small primitive species of camel, including sacrum, femur, both tibiae, two metatarsals, and numerous phalanges. The matrix surrounding the camel limb also contained an isolated molar of the small heteromyid rodent, *Proheteromys* cf. *P. floridanus*. A subsequent trip to this locality by Ellen Dotson, Ann Pratt, and myself in June 1989 yielded the most complete land mammal yet recovered from the White Springs fauna; the skull, mandibles, and partial articulated skeleton of a small species of oreodont. Further screenwashing of sediments from White Springs 3B has produced a very interesting fauna of terrestrial vertebrates, including: a typhlopid snake, two species of boid snakes, a bat, a cricetid rodent similar to *Leidymys*, and several species of the heteromyid rodent *Proheteromys*.

Paleoecology of the Vertebrate Fauna

Table 1 lists the vertebrates known from the three localities referred to the White Springs Local Fauna. The majority of these taxa are from the White Springs 1A site. The fauna consists of 47 species, including 27 marine forms, 18 terrestrial species, and two freshwater taxa. The marine forms include four species of rays, a sawfish, nine species of sharks, nine species of teleost fish, a crocodile, and three species of sea cows. A species of gar (*Lepisosteus*) is represented by a small sample of scales and teeth. Although most gars inhabit fresh water, several species are known to inhabit estuarine habitats. The scales are not clearly referable to any of the modern species of gar, and thus the paleoecology of this species is unclear. Similarly, the single specimen of a small frog is too fragmentary for a positive identification, and it is therefore not possible to determine whether this species was aquatic or terrestrial. The terrestrial vertebrate fauna includes three species of snakes, a shrew, a bat, a rabbit, eight taxa of rodents, a

Table 1. Vertebrates from the earliest Miocene (Arikareean) White Springs Local Fauna, Columbia and Hamilton counties, Florida.

Class Chondrichthyes
- Order Rajiformes
  - Family Myliobatidae
    - *Myliobatis* sp.
    - *Plinthicus* sp.
  - Family Dasyatidae
    - *Dasyatis* spp. (several species present)
  - Family Pristidae
    - *Pristis* sp.
- Order Lamniformes
  - Family Lamnidae
    - *Carcharodon angustidens*
  - Family Carcharhinidae
    - *Carcharhinus* undescribed species
    - *Carcharhinus* sp.
    - *Galeocerdo aduncus*
    - *Hemipristis serra*
    - *Negaprion* sp.
    - *Odontaspis* sp.
    - *Rhizoprionodon* sp.
  - Family Orectolobidae
    - *Ginglymostoma serra*

Class Osteichthyes
  - Family Lepisosteidae
    - *Lepisosteus* sp.
  - Family Sparidae
    - genus and species indet.[1]
  - Family Sciaenidae
    - *Pogonias* sp.
  - Family Scaridae
    - cf. *Sparisoma* sp.
  - Family Sphyraenidae
    - *Sphyraena* sp.
  - Family Balistidae
    - cf. *Balistes* sp.
  - Family Tetraodontidae
    - cf. *Sphoeroides* sp.
  - family indet.
    - three additional teleost fish present

Class Amphibia
- Order Anura
  - family indet.-one species present

Class Reptilia
- Order Squamata
  - Suborder Serpentes
    - Family Boidae
      - genus and species undet.-two species present
    - Family Typhlopidae
      - *Typhlops* sp.
- Order Crocodilia
  - Family Crocodylidae
    - cf. *Gavialosuchus* sp.

Class Mammalia
- Order Insectivora
  - Family Soricidae
    - genus and species indet.
- Order Chiroptera
  - Family Vespertilionidae
    - genus and species undet.
- Order Rodentia
  - Family Sciuridae
    - genus and species indet.
  - Family Castoridae (?)
    - genus and species indet.
  - Family Eomyidae
    - undescribed genus and species
  - Family Heteromyidae
    - *Proheteromys* cf. *P. floridanus*
    - *Proheteromys* cf. *P. magnus*
    - *Proheteromys* sp. undet.[2]
  - Superfamily Geomyoidea
    - genus and species indet.
  - Family Cricetidae
    - cf. *Leidymys* sp.
- Order Lagomorpha
  - Family Leporidae
    - Subfamily Palaeolaginae
      - cf. *Palaeolagus* sp.
- Order Sirenia
  - Family Dugongidae
    - *Dioplotherium manigaulti*
    - *Halitherium olseni*
    - *Metaxytherium* sp.
- Order Carnivora
  - Family Canidae
    - genus and species indet.
- Order Perissodactyla
  - Family Equidae
    - *Parahippus* sp.
- Order Artiodactyla
  - Family Merycoidodontidae
    - genus and species undet.
  - Family Camelidae
    - genus and species indet.

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[1] indet. (indeterminate) indicates that the material of a particular taxon is insufficient for a more specific identification.

[2] undet. (undetermined) indicates that the material of a particular taxon has not been studied in enough detail for a more specific identification.

small dog, a browsing horse, an oreodont, and a camel. Cetaceans (whales and dolphins) and turtles (sea turtles, freshwater turtles, and tortoises) are notably absent from the fauna.

The White Springs vertebrate fauna is dominated by marine species. The most common taxa in the fauna are the rays Myliobatis and Dasyatis, the sharks Carcharhinus and Rhizoprionodon, the barracuda Sphyraena, and an unidentified genus of predaceous teleost fish. With the exception of the heteromyid rodents, the terrestrial species are mostly represented by just a few specimens, and many of the fossils are fragmentary or waterworn. The three species of heteromyid rodents are represented by about 50 complete isolated cheekteeth and about the same number of fragmentary teeth. Two partial articulated skeletons of land mammals, an oreodont and a camel, have been collected from White Springs 3B. The primary site of deposition was most likely in a shallow, quiet nearshore marine habitat such as a protected bay or lagoon. A slow flowing river probably carried the rodent teeth and other terrestrial vertebrate fossils into this marine environment.

Among the sharks identified from the White Springs fauna, Negaprion, Galeocerdo, Rhizoprionodon, and Ginglymostoma are all typical of shallow, nearshore habitats in subtropical to tropical seas. Lemon (Negaprion) and tiger (Galeocerdo) sharks commonly enter bays, lagoons, and estuaries, while species of sharpnose (Rhizoprionodon) and nurse (Ginglymostoma) sharks are confined to shallow, nearshore marine habitats. Eagle rays (Myliobatis) and stingrays (Dasyatis) are primarily shallow water bottom dwellers. The bony fish fauna is composed primarily of species commonly found in subtropical to tropical inshore marine waters, particularly barracuda (Sphyraena), parrotfish (Scaridae), triggerfish (Balistidae), and puffer fish (Sphoeroides). The extinct long-snouted crocodile Gavialosuchus also appears to have lived in estuarine and nearshore marine habitats (Morgan, 1986).

The presence of three co-occurring and probably sympatric species of sea cows in one fauna is most unusual (Domning, this volume). Furthermore, two of the sirenian specimens from the White Springs fauna were found as articulated skeletons, suggesting rather rapid deposition in quiet water. Deep parallel gashes in the fossilized rib of a sea cow from White Springs 1A (Fig. 2) were almost certainly caused by sharks, a common predator on sirenians. Sea cows are generally found in tropical waters in shallow coastal marine habitats, and sometimes in freshwater. However, modern dugongs, the family which includes all three of the Suwannee River sea cows, are a strictly tropical marine group. The abundance of dugongs in the White Springs fauna suggests that seagrass beds were probably common in this region, although no plant fossils are preserved. The presence of the puffer Sphoeroides, a fish rarely found in Florida Miocene faunas, is also indicative of seagrass beds. The presence of sirenians in the White Springs Local Fauna further supports the hypothesis that these strata were deposited in a quiet nearshore habitat in tropical waters.

Stratigraphy, Age, and Correlation

The stratigraphic interval that produces the White Springs Local Fauna is here tentatively referred to the Porters Landing Member of the Parachucla Formation following Huddlestun (1988). The bone-bearing bed consists of a light gray to buff to brown, slightly clayey, fine quartz sand with a minor percentage of fine phosphate grains. At the White Springs 1A locality, invertebrate fossils are rare except for poorly preserved silicified oysters, pectens, and fragments of echinoids. However, in some places this stratigraphic unit contains large numbers of well-preserved fossils of invertebrates having calcitic shells, including oysters, pectens, echinoid spines, shrimp claws, and barnacles, as well as poorly preserved aragonitic shells or casts and molds of many other species of mollusks (see Portell's paper in this volume). Hereafter, the beds that produce the vertebrate fauna are termed the "bone bed," while the sediments producing the rich invertebrate fauna are called the "shell bed."

The primary bone bed has been traced for about 10 km along the banks of the Suwannee River from the White Springs 1A Site to the White Springs 3A Site. As discussed in more detail by Portell, the shell bed is variably exposed along the Suwannee River in the vicinity of White Springs for a distance of at least 5 km, beginning between the U. S. 41 bridge and the Florida Route 136 bridge and extending downriver well beyond the Stephen Foster Memorial. The bone bed and shell bed grade into one another, and thus appear to be lateral or facies equivalents of the same unit. In at least one locality on the north side of the river at the Stephen Foster Memorial (Stop 3 of this field trip), we observed the interfingering of these two units, where a thin layer of the dark brown sandy bone bed is both overlain and underlain by lighter grayish-colored sediments containing the typical invertebrate fauna of the shell bed.

Except for the presence of calcitic shells of invertebrates, the lithology of the shell bed is very similar to that of the bone bed. The bone bed tends to be a medium to dark brown color in outcrop; however, unweathered and unoxidized sediments from this unit are often bluish-green in color. The shell bed is usually a lighter grayish color probably resulting from the abundance of carbonates present in this unit. The occurrence of poorly preserved traces of pectens and other mollusks in the darker bone unit suggests that invertebrate fossils may have originally been present, but were subsequently leached out. Both units are tentatively referred to the Parachucla Formation and have a composite thickness of about 4-5 m in the banks of the Suwannee River in the vicinity of White Springs. The shell bed has produced a small sample of marine vertebrates essentially identical to those from the bone bed, but appears to lack the terrestrial component of the fauna. The Parachucla Formation lies unconformably above the Oligocene Suwannee Limestone in this vicinity.

In his description of the Porters Landing Member of the Parachucla Formation at the type locality on the Savannah River in Effingham County, Georgia, Huddlestun (1988:47) noted that, "The southern limits of the member are not known at this time, but the member does occur in outcrop (a parastratotype of the Hawthorne Group) on the upper Suwannee River at White Springs in northeastern Florida. The Porters Landing Member is thin at this site, and is not recognized elsewhere in the Suwannee area..." It is unclear exactly which strata in the White Springs section were included in the Porters Landing Member of the Parachucla Formation by Huddlestun. Huddlestun (pers. comm., 1989) has since informed me that he was specifically referring to the fossiliferous shell bed exposed beneath the Florida Route 136 bridge in White Springs (Stop 5 of this field trip; Unit 1 in Fig. 1 of Portell's paper in this volume; and Units 1-3 in Fig. 27 of Brooks, 1966). I am here expanding Huddlestun's (1988) concept of the Parachucla Formation in the vicinity of White Springs to include all strata that overlie the Suwannee Limestone and underlie his (1988:62) "unnamed dolostone, clay, and sand of the Hawthorne Group." The latter unit is best recognized by the occurrence of large irregularly shaped boulders and lenses of highly lithified dolostone.

According to Huddlestun (1988), the planktonic foraminiferal suite suggests that the Porters Landing Member of the Parachucla Formation is either upper Zone N4 (upper <u>Globorotalia kugleri</u> Zone) or lower Zone N5 (lower <u>Catapsydrax dissimilis</u> Zone), indicating an early Miocene (Aquitanian) age of about 23 to 22 Ma. In terms of North American Land Mammal Ages, this would be equivalent to the middle of the Arikareean (Tedford et al., 1987). The planktonic forminifera described for the Porters Landing Member by Huddlestun are from cores taken in Georgia; none have been reported from the Suwannee River section.

Perhaps the most significant aspect of the White Springs Local Fauna is that it contains land mammals preserved in nearshore marine sediments. Therefore, the White Springs vertebrate fauna offers the rare opportunity for correlation between terrestrial and marine biochronologies. As discussed above, Huddlestun (1988) has determined the age of the

Parachucla Formation based on planktonic foraminifera and Portell (this volume) discusses the biochronology of the mollusks and other invertebrates collected from the fossiliferous shell beds in the Parachucla Formation at White Springs. Similar analyses involving both marine and terrestrial biochronologies have recently been conducted on other Miocene faunas in northern Florida (Fig. 1), including the Brooks Sink Local Fauna of late early Miocene (late Hemingfordian) age described by Morgan and Pratt (1988) and several Hemingfordian and early Barstovian vertebrate faunas from the eastern Florida panhandle (Bryant, 1988). Tedford and Hunter (1984) compiled most of the available published information on Miocene land mammal faunas from Florida found in close association with marine geologic units. All of these studies have correlated the Miocene terrestrial mammals found in the respective faunas with the North American Land Mammal biochronology (e.g. Savage and Russell, 1983; Tedford at al., 1987).

North American Land Mammal Ages (NALMA) are biochrons characterized by a composite assemblage of land mammals, usually genera, that coexisted in North America during a particular interval of time. The characteristic mammalian assemblage for each NALMA has been obtained by combining correlative faunas throughout North America, and contains genera that are either restricted to that age or have their first or last appearance during that time period. The most reliable method for determining the relative age of fossil vertebrate faunas from Florida is through biostratigraphic correlation with well-dated mammalian faunas from western North America using the land mammal biochronology. Comparisons are also made with other early and middle Miocene vertebrate faunas from Florida, particularly those faunas that can be dated using other methods such as invertebrate or microfossil biochronologies.

Marine vertebrate groups such as sharks, rays, and bony fish, tend to have long stratigraphic ranges and are thus usually of little help in determining the specific age of a fauna in which they occur. However, two of the sharks from the White Springs fauna are age diagnostic. In his discussion of the stratigraphic ranges of various fossil sharks in Florida, Tessman (1969) listed the extinct white shark, _Carcharodon auriculatus_, only from Eocene and Oligocene strata in Florida. Tessman (1969:22) examined a specimen of _C. auriculatus_ from the "...Springhouse locality, about 100 yds. N. W. (downstream right bank) of White Sulphur Springs, White Springs, Hamilton Co." Tessman thought this tooth was derived from the Suwannee Limestone, however, examination of the strata in this immediate vicinity reveals that there are no Suwannee outcrops present, and thus the tooth of _C. auriculatus_ was almost certainly collected from the Parachucla Formation.

Figure 2. Vertebrate fossils from the White Springs Local Fauna, Columbia and Hamilton counties, Florida, Parachucla Formation, earliest Miocene (Arikareean).

A. *Carcharodon angustidens*, tooth, UF 17994, X0.8.
B. *Carcharodon angustidens*, tooth, UF 119999, X0.8.
C. *Galeocerdo aduncus*, tooth, UF 50792, X1.3.
D. *Carcharhinus* new sp., tooth, UF 119941, X1.3.
E. *Ginglymostoma serra*, tooth, UF 50793, X2.0.
F. *Plinthicus* sp., tooth, UF 119913, X2.3.
G. *Lepisosteus* sp., scale, UF 119964, X2.3.
H. *Metaxytherium* sp., partial rib with shark tooth marks, UF 119998, X0.8.

Figure 3. Vertebrate fossils from the Occidental Local Fauna, Hamilton County, Florida, Statenville Formation, late middle Miocene (early Clarendonian).

A. *Gavialosuchus americanus*, tooth, UF 120093, X1.0.
B. *Pseudhipparion curtivallum*, RP3 or P4, UF 36445, X1.2.
C. *Pseudhipparion curtivallum*, Rm1 or m2, UF 121934, X1.2.
D. *Calippus martini*, LP2, UF 120154, X1.0.
E. *Cormohipparion ingenuum*, Rm1 or m2, UF 120155, X1.2.
F. *Cormohipparion* cf. *C. occidentale*, Lm1 or m2, UF 120156, X1.0.
G. *Pliohippus* cf. *P. pernix*, RM1, UF 121938, X1.0.
H. *Calippus* new sp., Rm3, UF 120152, X2.7.
I. *Calippus* new sp., Lm3, UF 120153, X2.7.

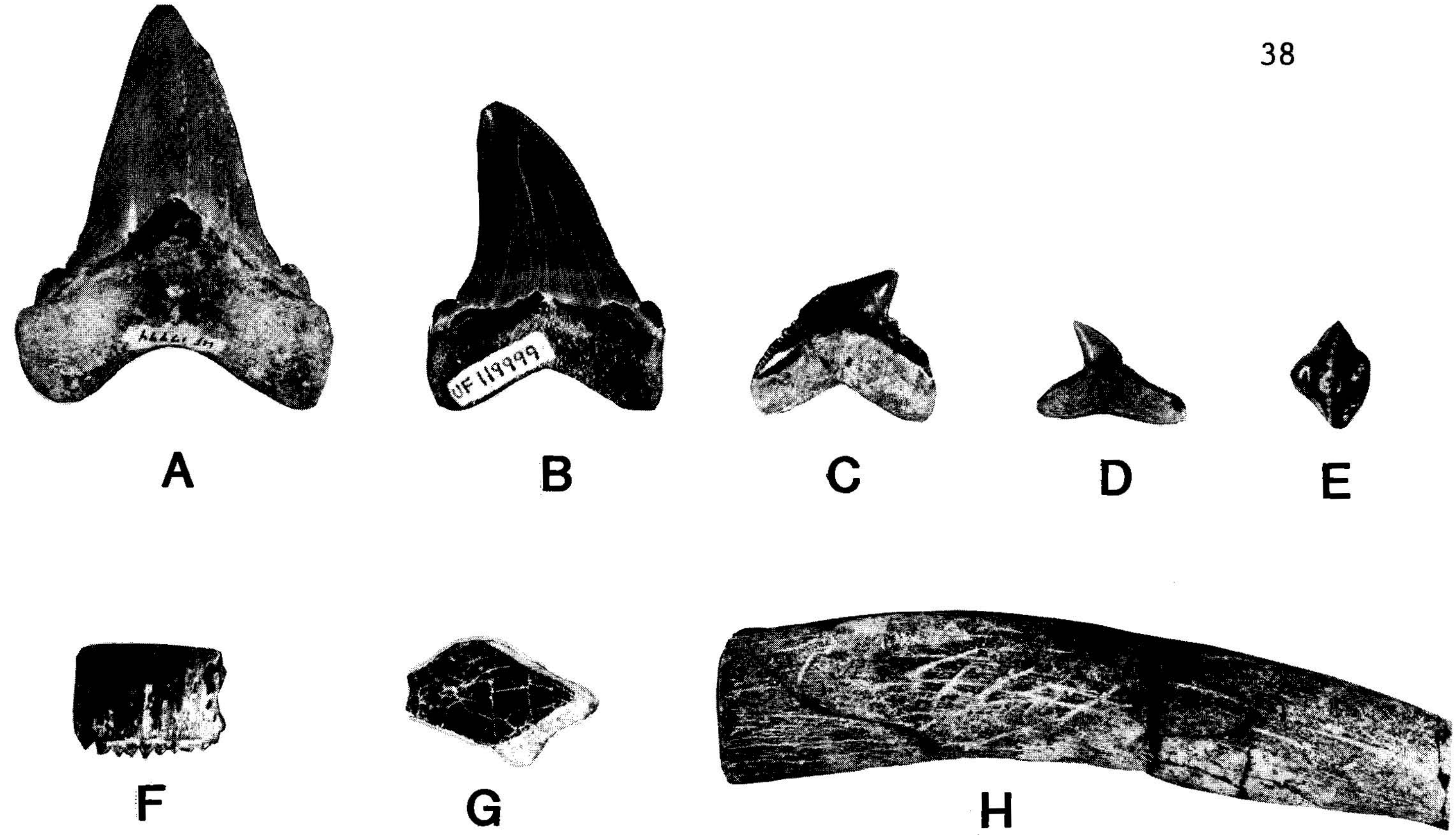

Figure 2

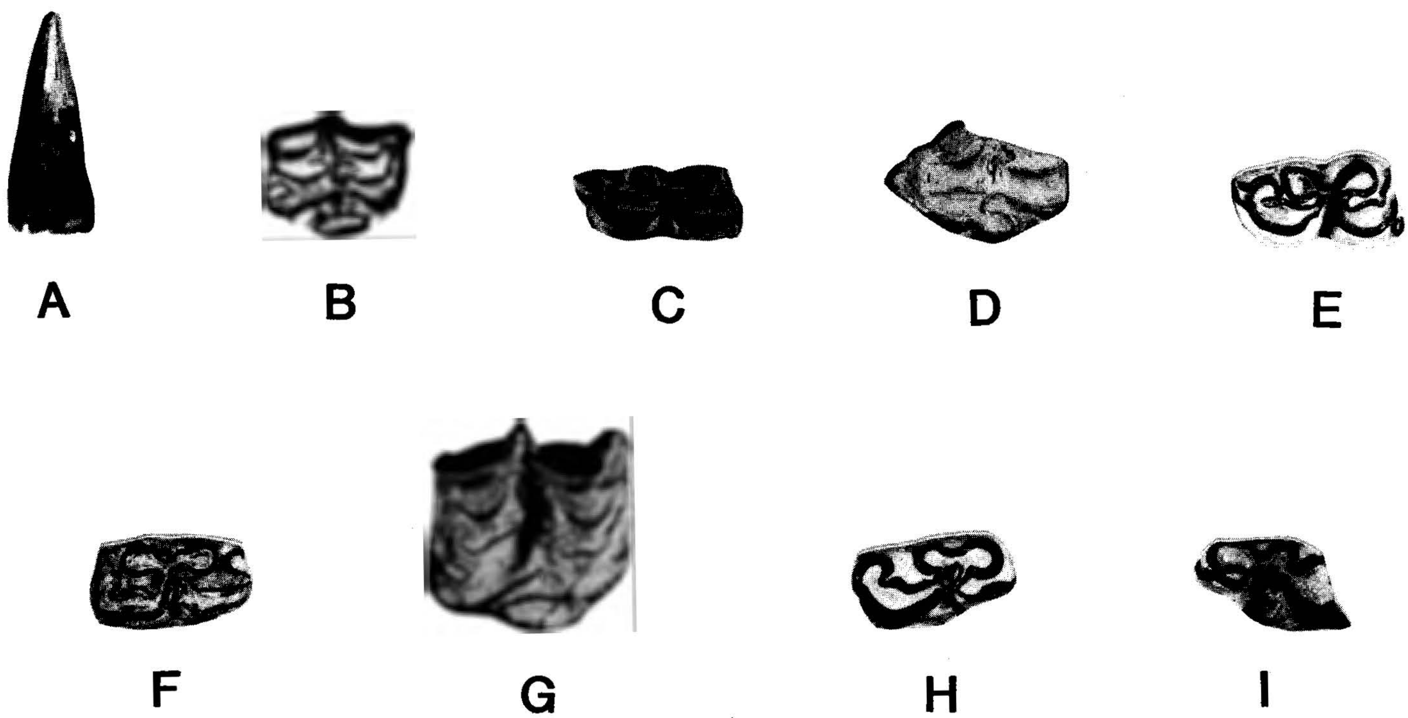

Figure 3

Some confusion exists in the literature regarding the names C. auriculatus and C. angustidens. Some authors regard these two species as synonyms, but Welton and Zinsmeister (1980) separated them. A high narrow crown, coarse serrations, and large lateral cusplets are characteristic of Paleogene and early Neogene species of Carcharodon (=C. auriculatus and C. angustidens). However, according to Welton and Zinsmeister (1980), C. angustidens can be distinguished by having lower and broader-crowned anterior teeth than C. auriculatus. C. auriculatus is characteristic of the Eocene and Oligocene and evolved into C. angustidens in the Oligocene. Based on the relatively low, broad crown, especially well exemplified in a beautifully preserved tooth (Fig. 2) collected in place near the Dioplotherium skull locality at White Springs 1A (UF 119999), and the presumed early Miocene age of this unit, the two Carcharodon teeth from the White Springs fauna are tentatively referred to C. angustidens. The record of C. angustidens from White Springs is one of the youngest known occurrences for this species, and indicates that the fauna is no younger than early Miocene.

The most common shark in the White Springs Local Fauna is a small species of Carcharhinus with coarse marginal serrations on the base and extremely fine serrations on the narrow crown (Fig. 2). Tessman (1969) referred a single tooth of this same shark from White Springs to a new undescribed species of small Carcharhinus, elsewhere known only from the late Oligocene I-75 Local Fauna, Alachua County, Florida. The absence of this species of shark in younger deposits (Tessman, 1969) lends support to the suggestion that the White Springs fauna is not younger than early Miocene.

Domning (this volume) discusses the stratigraphic occurrence of the Suwannee River sirenians. According to him, Halitherium olseni or a very closely related species, occurs elsewhere only in late Oligocene strata in South Carolina. The small Metaxytherium collected from the White Springs 1A locality compares closely with the type specimen of "Hesperosiren" (=Metaxytherium according to Domning) crataegensis, described by Simpson (1932) from the late early Miocene (late Hemingfordian) Dogtown Clay Member of the Torreya Formation near Quincy in Gadsden County in the Florida Panhandle. Other records of Dioplotherium manigaulti are of unknown stratigraphic provenience.

Several species of land mammals from the White Springs Local Fauna provide the most convincing evidence for the age of the Parachucla Formation. A single upper cheektooth of a small, primitive rabbit has been identified in matrix collected from White Springs 1A at the Dioplotherium skull locality. For some as yet unknown reason, lagomorphs are extremely uncommon in Florida faunas from the late Oligocene through the middle Miocene. The only previous Florida record of rabbits from this time interval is a sample of teeth tentatively referred to the genus Palaeolagus from the late Oligocene (early Arikareean) Cowhouse Slough fauna in Hillsborough County in central Florida. The White Springs tooth appears to most similar to small species of Palaeolagus from the western United States. The youngest recorded occurrence of Palaeolagus is in early Arikareean (latest Oligocene and earliest Miocene) faunas (Tedford et al., 1987).

Two teeth of a large rodent are referred to the extinct family Eomyidae. Eomyids have been reported previously from only a single fauna in Florida, the late Oligocene (Whitneyan) I-75 Site (Patton, 1969). However, teeth assignable to this family are now known from five additional sites in Florida, including White Springs. The eomyid teeth from four of the Florida sites are very similar and appear to belong to an undescribed genus. The early Arikareean Cowhouse Slough fauna, the earliest Miocene (late Arikareean) Buda Local Fauna, Alachua County, the late Arikareean Live Oak or SB-1A Local Fauna, Suwannee County, and the White Springs fauna, all contain this new undescribed genus. The late early Miocene (early Hemingfordian) Thomas Farm fauna contains a smaller and morphologically distinct genus of eomyid (Pratt, 1986). The new genus of large eomyid does not appear to be present elsewhere in North America, but is characteristic of all Arikareean small mammal faunas so far discovered in Florida. A lower molar of a large, brachydont cricetid from the White Springs 3B site is similar to primitive cricetids such as Leidymys. Leidymys and closely related genera such as Scottimus are characteristic of late Oligocene and earliest Miocene (Arikareean) faunas. *

There are three different species of heteromyid rodents in the White Springs fauna, all of which are tentatively referred to the extinct genus Proheteromys. The rarest species of heteromyid from White Springs, represented by several well preserved teeth, is a large form similar in size to P. magnus. P. magnus was originally described from the late early Miocene (late Hemingfordian) Midway Local Fauna (Wood, 1932), but is now much better known from the early Hemingfordian Thomas Farm fauna (Wood, 1947; Black, 1963). Teeth of the large Proheteromys from White Springs are also very similar in size and morphological characters to heteromyid teeth from the late Arikareean Live Oak and Buda faunas. The most common heteromyid from White Springs, represented by more than 20 complete cheekteeth, is a medium-sized species of Proheteromys that appears to be undescribed. A similar species is also present at both Buda and Live Oak. A tiny heteromyid tentatively referred to P. floridanus has been identified from White Springs on the basis of five complete and several partial teeth. Like P. magnus, P. floridanus was originally described from Midway, but is now much better represented at Thomas Farm. This small heteromyid is also known from Live Oak.

The heteromyid fauna from White Springs is most similar to that from the late Arikareean Live Oak site, both sites possessing a small, medium, and large species of *Proheteromys*. The same or very closely related species of the medium and large heteromyids also occur at Buda. The White Springs heteromyid fauna supports the Arikareean age suggested by *Palaeolagus*, the large eomyid, and the *Leidymys*-like cricetid.

Only four taxa of ungulates and carnivores are known from the White Springs fauna. A partial upper molar from White Springs 1A is referred to the three-toed horse, *Parahippus*. The genus *Parahippus* is known from the late Arikareean (earliest Miocene) through the early Barstovian (middle Miocene). The White Springs *Parahippus* tooth is from a large species representing a primitive grade of evolution in the genus, characterized by brachydont teeth and the lack of cement. This tooth compares favorably with late Arikareean to early Hemingfordian species of *Parahippus* such as *P. tyleri* and *P. texanus*. The early Hemingfordian Thomas Farm fauna contains a smaller, more advanced species of *Parahippus*, *P. leonensis*, having hypsodont teeth possessing cement. Although horses have been reported from both the Buda and Live Oak faunas, the equid fossils from these two sites do not include an upper molar (Frailey, 1978; 1979).

The most complete specimen of a land mammal from the White Springs Local Fauna is a partial articulated skeleton of a small oreodont (family Merycoidodontidae), including the skull, mandibles, and partial postcranial skeleton, collected very recently from the White Springs 3B site. As of this writing the specimen has not yet been prepared, and thus its taxonomic affinities are unknown. A small, primitive species of camel is represented in the White Springs fauna by an associated sacrum, femur, both tibiae, metatarsals, and phalanges. This specimen cannot be identifed to genus as it lacks diagnostic cranial and dental elements. Certain primitive features of the postcranial elements preserved do, however, suggest that this camel is early Miocene or older in age (Webb, pers. comm.).

The White Springs fauna is clearly older than the early Miocene (early Hemingfordian) Thomas Farm fauna, dated at between 19 and 18 Ma, based on the presence of *Palaeolagus*, cf. *Leidymys*, the large eomyid, and a primitive species of *Parahippus*. The White Springs fauna shares *Palaeolagus* and the large undescribed genus of eomyid with the early Arikareean Cowhouse Slough fauna, although the species in these genera differ between the two sites. The horses also differ between the two faunas. White Springs has a large, low-crowned species of *Parahippus*, while Cowhouse Slough has a much smaller species of the more primitive genus *Miohippus* (Webb, pers. comm.). Based on the co-occurrence of the same species of large eomyid and the similarity of their heteromyids, the White Springs rodent fauna appears to be most similar to rodents from the late Arikareean Buda and Live Oak faunas. The presence of the shark Carcharodon angustidens also indicates that the White Springs fauna is not younger than early Miocene and is probably earliest Miocene in age.

In summary, the White Springs Local Fauna is earliest Miocene in age and can be assigned to the Arikareean NALMA. The precise placement of this fauna within the Arikareean must await more detailed comparisons of the rodents and other small mammals with the rich microfaunas from other Arikareean sites in Florida, and with microvertebrate faunas from well-dated Arikareean sites in the western United States. However, the vertebrate fauna from White Springs as presently known can be placed with some confidence in either the late early Arikareean or the early late Arikareean, between about 25 and 21 Ma. This time frame agrees very closely with the age for the Porters Landing Member of the Parachucla Formation proposed by Huddlestun (1988) based on planktonic foraminifera.

OCCIDENTAL LOCAL FAUNA

The Occidental Chemical Corporation began mining phosphate deposits in 1966 in Hamilton County in northernmost peninsular Florida (Fig. 1; stop 1 of this field trip). Occidental operates two different mines in this region, the Suwannee River Mine and the Swift Creek Mine. These two mines cover a large area located 10 to 15 km north of White Springs in southeastern Hamilton County (T1N-T1S, R15-16E, Genoa and Benton 7.5 minute quadrangles). For purposes of this paper, I will use the name Occidental Mine for this entire region, owing to the close proximity of the Suwannee River and Swift Creek mines and the similarity of their vertebrate faunas.

Over the past 20 years the Florida Museum of Natural History has accumulated a small sample of vertebrate fossils from the Occidental Mine. In an effort to add to this fauna, Florida Museum field crews have visited the Occidental Mine several times in the last year. These recent collecting efforts, along with those of Eric Taylor of Lake City, Florida, have significantly increased the vertebrate fauna known from the Occidental Mine, particularly the biochronologically important land mammals.

Vertebrate Fauna

The Occidental Local Fauna includes the vertebrate fossils collected from the Statenville Formation in the Occidental Mine. The Occidental fauna is composed of 43 species: 14 species of sharks and rays, six species of bony fish, four turtles, a crocodile, a bird, two sea cows, two species of toothed whales, and 13 taxa of land mammals (Table 2). The number of species in the Occidental fauna will surely increase with future field work in this extensive phosphate mining region. The fauna includes 26 taxa of marine vertebrates, two freshwater forms, and 15 terrestrial species. The marine vertebrates dominate the fauna, both in numbers of taxa represented and abundance of specimens.

The most common fossils encountered in the Occidental Mine are shark teeth. Eleven different species are represented in the fauna, at least six of which are extinct: Carcharodon megalodon, Isurus desori, I. hastalis, Galeocerdo aduncus, Hemipristis serra, and Ginglymostoma serra. The most common sharks in the fauna are living species, including the lemon shark Negaprion brevirostris, the bull shark Carcharhinus leucas, and the small sharpnose shark, Rhizoprionodon terraenovae. Among the rays, both eagle rays, Myliobatis sp., and stingrays, Dasyatis sp., are common. Bony fish are not well represented, although this probably reflects a collecting bias and not a real rarity. The most common fish are the porcupinefish, Diodon, and the sheepshead, Archosargus probatocephalus. The shark and bony fish fauna suggests that the Occidental fauna inhabited tropical to subtropical waters in a shallow nearshore marine environment such as a bay or estuary.

Amphibians are absent in the Occidental fauna, as are small freshwater and terrestrial vertebrates in general. Four taxa of turtles have been identified, including a sea turtle, a pond turtle, and a small and large species of land tortoise. Teeth of a large crocodilian are rather common at Occidental. Based on their long, slender, curved shape, these teeth are identified as Gavialosuchus americanus (Fig. 3). Gavialosuchus appears to have favored nearshore marine habitats, as it occurs only in faunas containing at least some marine component (Morgan, 1986). Birds are represented in the fauna by a single partial bone tentatively identified as a booby (family Sulidae), a group of primarily tropical seabirds.

The most common mammals in the Occidental Local Fauna are marine mammals, specifically sirenians. Broken fragments of sea cow ribs are abundant throughout the Occidental Mine. Two types of dugongs have been identified from the fauna, Metaxytherium and the rarer Dioplotherium manigaulti (Domning, this volume). Cetaceans are represented by two different types of toothed whales or dolphins (Odontoceti). Several rostral fragments are very similar to those of the long-beaked dolphin Pomatodelphis that is common in the Bone Valley Formation of central Florida. A single tooth represents a second larger species of dolphin.

Among the 13 terrestrial mammals identified from the Occidental Local Fauna, most are known from only one or at most several specimens. The rhinoceros, gomphotheriid proboscidean, camel, and two small deer-like artiodactls are identified by fragmentary teeth. One of the deer-like artiodactyls is among the smallest known Miocene members of this group, barely larger than a rabbit. Like most other Florida Miocene faunas, horses are the most common members of the terrestrial vertebrate assemblage. The equid fauna includes eight species, the most common of which is the small horse, Pseudhipparion curtivallum.

Stratigraphy, Age, and Correlation

Scott (1988) referred the Miocene strata exposed in the Occidental mines to the Statenville Formation of Huddlestun (1988), a unit characterized by crossbedded phosphatic quartz sands interbedded with clays and dolostones. Scott (1988:50) states, "Phosphorite from the Statenville Formation is presently being mined by Occidental Chemical Company in Hamilton County, Florida. These phosphorite sands occur in the upper, less dolomitic portion of the unit." Scott (1988:52) also noted that, "A reworked zone with more parallel bedding is present above the crossbedded and thinbedded section." This upper reworked zone contains larger phosphate pebbles and clasts than does the lower crossbedded unit, and as such bears some resemblance to the classic phosphatic gravel of the upper Bone Valley Formation of central Florida. This coarser phosphatic matrix at the top of the Statenville section in the Occidental Mine appears to be the unit that is producing the majority of the vertebrate fauna, particularly the land mammals. The spoil piles that have produced the richest samples of vertebrate fossils also contain abundant phosphate pebbles.

Huddlestun (1988) considered the Statenville Formation to be middle Miocene (early Serravallian) in age. He correlated the Statenville Formation with the Berryville Clay Member of the Coosawhatchie Formation which contains a Zone N10 to N11 assemblage of planktonic foraminifera indicating an age of approximately 14 to 13 Ma (Berggren et al., 1985). A small land vertebrate fauna, the Statenville Local Fauna (Voorhies, 1974), is known from the type locality of the Statenville Formation along the Alapaha River in Echols County, Georgia about 40 km northwest of the Occidental Mine. Voorhies (1974) considered the Statenville fauna to be Barstovian in age based on the presence of the beaver Monosaulax, two advanced species of the three-toed horse Merychippus, and a small species of the rhinoceros Teleoceras. According to Tedford and Hunter (1984), the Statenville fauna and the Ashville Local Fauna (Fig. 1) found near Ashville in Jefferson County, Florida (Olsen, 1963),

Table 2. Vertebrates from the late middle Miocene (early Clarendonian) Occidental Local Fauna, Hamilton County, Florida.

Class Chondrichthyes
- Order Rajiformes
  - Family Myliobatidae
    - *Aetobatus* sp.
    - *Myliobatis* sp.
  - Family Dasyatidae
    - *Dasyatis* sp.
- Order Lamniformes
  - Family Lamnidae
    - *Carcharodon megalodon*
    - *Isurus desori*
    - *Isurus hastalis*
  - Family Carcharhinidae
    - *Carcharhinus leucas*
    - *Carcharhinus* sp.
    - *Galeocerdo aduncus*
    - *Galeocerdo cuvieri*
    - *Hemipristis serra*
    - *Negaprion brevirostris*
    - *Rhizoprionodon* sp.
  - Family Orectolobidae
    - *Ginglymostoma serra*

Class Osteichthyes
  - Family Lepisosteidae
    - *Lepisosteus* sp.
  - Family Elopidae
    - *Megalops atlanticus*
  - Family Sparidae
    - *Archosargus* cf. *A. probatocephalus*
  - Family Sciaenidae
    - *Pogonias cromis*
  - Family Sphyraenidae
    - *Sphyraena barracuda*
  - Family Diodontidae
    - *Diodon* sp.

Class Reptilia
- Order Testudines
  - Family Cheloniidae
    - genus and species indet.
  - Family Testudinidae
    - *Geochelone* small sp.
    - *Geochelone* large sp.
  - Family Emydidae
    - cf. *Pseudemys* sp.

Order Crocodilia
    Family Crocodylidae
        Gavialosuchus americanus

Class Aves
    Order Pelecaniformes
        Family Sulidae (?)

Class Mammalia
    Order Sirenia
        Family Dugongidae
            Dioplotherium manigaulti
            Metaxytherium sp.
    Order Cetacea
      Suborder Odontoceti
        Family Schizodelphidae
            cf. Pomatodelphis sp.
        family indet.
    Order Proboscidea
        Family Gomphotheriidae
            genus and species indet.
    Order Perissodactyla
        Family Rhinocerotidae
            genus and species indet.
        Family Equidae
            Calippus (Calippus) sp. A
            Calippus (Calippus) sp. B
            Calippus (Grammohippus) martini
            Cormohipparion ingenuum
            Cormohipparion occidentale
            Nannippus sp.
            Pseudhipparion curtivallum
            Pliohippus cf. P. pernix
    Order Artiodactyla
        Family Camelidae
            genus and species indet.
        Family Moschidae
            cf. Blastomeryx sp.
            cf. Pseudoceras sp.

occur in correlative strata and represent an early phase of the late Barstovian between 14 and 12 Ma in age.

Brooks (1966) mentioned a Neohipparion tooth and several gomphothere tooth fragments collected from the Occidental Mine soon after mining operations began. MacFadden and Webb (1982, figure 2) included the Occidental Mine fauna on their map of Miocene land mammal localities in Florida. They stated (p.194), "An undescribed faunule of land mammals housed at the Florida State Museum was collected from the Occidental Phosphate Mine north of White Springs in Hamilton County (Webb, 1967). Based on the stage of evolution of the land mammals, particularly the horses, the locality is Hemphillian." Tedford and Hunter (1984:144) noted, "Scattered Hemphillian mammalian remains are known from non-marine and near-shore deposits in northern Florida, such as the occurrence of Neohipparion and gomphotheres in the phosphorite at Purvis Still, Hamilton County, Florida..." No other vertebrate fossils have been reported from the Occidental Mine until now.

The age of the vertebrate fauna from the Occidental Mine has been considered to be Hemphillian by most previous authors (MacFadden and Webb, 1982; Tedford and Hunter, 1984). The Hemphillian Land Mammal Age spans the time period from the late Miocene to the early Pliocene from 9 to 4.5 Ma (Tedford et al., 1987). An analysis of the richer vertebrate fauna now available from the Occidental Mine suggests an older late middle Miocene age (early Clarendonian; late Serravallian or early Tortonian), between 11.5 and 10 Ma.

Several potential problems exist in determining the age of the Occidental Local Fauna. Almost all fossils so far recorded from the Occidental Mine have been collected from spoil piles, and thus lack a precise stratigraphic context. Due to the nature of the phosphate mining operations employed in Florida, large spoil piles are created from overburden that is not rich enough in phosphorite to warrant processing. It is from these spoil piles that the great majority of vertebrate fossils have been recovered, both from the Occidental Mine and the extensive mines in the Bone Valley (or Central Florida) phosphate mining district in Polk, Hardee, and Hillsborough counties.

It was previously thought that the Bone Valley phosphate mines produced a relatively uniform vertebrate fauna of late Hemphillian (earliest Pliocene) age, however, it has been shown in recent years that the situation is far more complex. In addition to the classic late Hemphillian fauna (called the Palmetto Fauna by Webb and Hulbert, 1986 and the Upper Bone Valley Fauna by Tedford et al., 1987), terrestrial vertebrates of early Barstovian, late Barstovian, early Clarendonian, and late Clarendonian/early Hemphillian age have also been shown to be present in the Bone Valley region

(Webb and Crissinger, 1983; Morgan, 1986; Webb and Hulbert, 1986; Hulbert, 1988a, 1988b). Therefore, vertebrate faunas spanning much of the time period from the middle Miocene to the early Pliocene between 16 and 5 Ma are present in the Bone Valley phosphate mines. This suggests it should not be assumed that all vertebrate fossils from the Occidental Mine are necessarily the same age.

As is often typical of Florida Miocene land vertebrate faunas, it is the horses (family Equidae) that are the most useful group for determining the age of the Occidental vertebrate fauna. Eight species of horses have been identified from Occidental, five of which can be placed in described species (Fig. 3). Of the remaining three species, two appear to be undescribed and one is too poorly known for specific identification. The most important species from a biochronologic standpoint, and also the most common species in the fauna, is the small horse, Pseudhipparion curtivallum. This species has been recorded elsewhere only from early Clarendonian faunas, including the Lapara Creek Local Fauna on the Gulf Coastal Plain of Texas and the Agricola Fauna in the Bone Valley District of central Florida (Webb and Hulbert, 1986). Calippus (Grammohippus) martini is known from early Clarendonian faunas in the Great Plains, the Texas Gulf Coastal Plain, and Florida (Hulbert, 1988a). Cormohipparion ingenuum occurs in early Clarendonian through early Hemphillian faunas throughout Florida, as well as in the early Clarendonian of Texas and the early Hemphillian of Honduras (Hulbert, 1988b). Cormohipparion occidentale is a long-lived species occurring in late Barstovian through early Hemphillian faunas of the Great Plains. However, the only other Florida records of C. occidentale are both early Clarendonian sites in the Bone Valley region (Hulbert, 1988b). The largest horse in the Occidental fauna, Pliohippus cf. P. pernix, is one of the rarest species of Miocene horses in Florida, as it has been recorded previously only from several early Clarendonian faunas in the Bone Valley region (Hulbert, pers comm.). In the western United States, Pliohippus pernix is a characteristic early Clarendonian horse. The two undescribed species of horses include a tiny Calippus smaller than any member of the genus (Hulbert, pers. comm.) and a species of Nannippus known from other Clarendonian faunas in Florida and Nebraska, and soon to be described (Hulbert, in prep.). With the exception of one tooth discussed below, the equid fauna from the Occidental Mine is indicative of an early Clarendonian age.

One equid upper cheektooth from the Occidental Mine appears to be older than the remainder of the horses identified from the fauna. This tooth is tentatively referred to the species Calippus cf. C. proplacidus, a horse typical of the late Barstovian (Hulbert, pers. comm.). This same species is also present in the late Barstovian Ashville Local Fauna (Fig. 1; Olsen, 1963). The presence of Calippus proplacidus suggests that at least a portion of the Statenville Formation in the Occidental Mine is late Barstovian in age.

In summary, the majority of the land mammals from the Occidental Mine, particularly the horses, indicate an early Clarendonian (late middle Miocene) age for this fauna or between 11.5 and 10 Ma. However, at least one horse tooth has been identified from the Occidental Mine that represents an older late Barstovian (middle Miocene) age. Presumably, this tooth was derived from the lower unit of the Statenville Formation, rather than the upper coarser unit that seems to produce most of the terrestrial early Clarendonian fauna. Some of the marine vertebrates found in the Occidental Mine could also be derived from this older unit. Both the late Barstovian and early Clarendonian vertebrate faunas appear to have been deposited in nearshore marine environments, and thus it would difficult to separate the marine components of the two faunas, as most sharks, rays, and bony fish have long stratigraphic ranges. The solution to the problem of mixing of faunas caused by collecting from spoil piles must await the discovery of in place vertebrate fossils in the Occidental Mine that contain biochronologically significant land mammals.

The Occidental Local Fauna is the first early Clarendonian vertebrate fauna reported from northern Florida. Barstovian faunas from this region include the Statenville Local Fauna from the type locality of the Statenville Formation near Statenville, Echols County, southern Georgia (Voorhies, 1974), the Ashville Local Fauna near Asheville, Jefferson County, Florida (Olsen, 1963), and several sites in Gadsden County in the eastern Florida panhandle (Bryant, 1988).

Several other smaller faunas or isolated specimens of Miocene vertebrates have been discovered in northernmost Florida and southernmost Georgia that are deserving of brief mention here. In the late 1960s a partial upper molar of a horse (UF 17246) was recovered from a brown clayey sand containing 25% phosphate at a depth of 35 feet below the surface in a core drilled by the Kerr McGee Company 3 km north of Lulu in southeastern Columbia County, Florida. This tooth is referable to Calippus martini (Hulbert, pers. comm.), an early Clarendonian horse also found in the Occidental Local Fauna.

Two additional faunas are known from sediments referred to the Statenville Formation. A small sample of Miocene marine vertebrate fossils consisting primarily of rays, sharks, and sea cows has been recovered from phosphatic sandy sediments along the west bank of the Suwannee River in the vicinity of the Florida Route 6 bridge (Stop 2 of this field trip). Because terrestrial mammals are lacking, it is difficult to place an exact age on this fauna, although other vertebrate faunas from the Statenville Formation have been placed in either the late Barstovian or early Clarendonian.

A nearly complete skeleton of the dugong Metaxytherium was discovered by Dennis Price in 1986 on the west bank of the Suwannee River about 1 km north of the Florida line in Echols County Georgia 8 km southeast of Needmore (see photograph in Fig. 2 of Domning's paper). The sediments in which the sea cow was found consisted of greenish-gray clays and fine phosphatic sands that are tentatively referred to the Statenville Formation. This site contains a sparse fauna of marine vertebrates, along with a partial tooth of a rodent tentatively identified as cf. Copemys sp., a small cricetid characteristic of the Barstovian (Tedford et al., 1987).

ACKNOWLEDGEMENTS

Many people have assisted me in the field during my studies of the White Springs and Occidental faunas including, Daryl Domning, Richard Franz, Richard Hulbert, Kim Hyde, Winston Lancaster, Cliff Maxwell, Roger Portell, Arthur Poyer, Ann Pratt, Dennis Price, Catherine Puckett, and Eric Taylor. I gratefully acknowledge the cooperation and assistance of Larry Miller and the Occidental Chemical Corporation for allowing me access to their mine. Daryl Domning initially stirred my interest in the Miocene section along the Suwannee River near White Springs. Without his persistence this study would probably never have been conducted. Arthur Poyer has accompanied me on countless field trips to the Suwannee River to collect fossiliferous sediment for screenwashing and has been primarily responsible for washing, sorting, and processing this matrix for the contained microvertebrate fauna. Without his tireless efforts the study of the White Springs fauna could never have been completed. Ann Pratt and Arthur Poyer helped with the identifications of the small mammals from the White Springs fauna. Eric Taylor donated a number of critical fossil vertebrate specimens from the Occidental Mine. Richard Hulbert kindly provided the identifications of the horse teeth from both White Springs and the Occidental Mine.

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FOSSIL SIRENIANS FROM THE SUWANNEE RIVER, FLORIDA AND GEORGIA

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Fossil remains of sea cows (Mammalia, Sirenia, Dugongidae) have been collected at several sites of Early and Middle Miocene age along the Suwannee River, and are among the most significant fossils found to date along that river. These specimens are in general superbly preserved, and some of them consist of nearly complete and articulated skulls and skeletons. Of the four complete or partial skulls so far recovered, one represented a new genus and species, another was the first skull of its genus to be found, and a third is the best-preserved example of its species. Furthermore, two of the three genera so far found along the Suwannee represent a subfamily not previously known to have lived in the New World. Finally, all three genera appear to occur in a single unit, making the Suwannee the only place in the world to date where sympatry of so many sirenian genera has been documented. Therefore the beds exposed on the Suwannee River have already made unique contributions to our knowledge of sirenian evolution and diversity, and they have the potential to yield further important finds in the future. Not least in importance is the fact that these same beds also yield remains of rodents and other land mammals, making possible correlations of the sirenian fossil record with the established land-mammal chronology.

"Halitherium" olseni Reinhart, 1976

This species, which will be the type of a new genus (Domning, in prep.) was based on a skull and nearly complete skeleton collected in 1961 by S. J. Olsen, C. Hendry, and W. Yon. This was the first sirenian fossil (other than isolated bone fragments) to be found along the Suwannee. The type locality was originally described as being on the east bank of the river about 1.6 miles "below" White Springs. Apparently, this should not be interpreted as 1.6 miles along the river, but rather 1.6 miles in a straight line west of White Springs (i.e., in the northwest corner of Section 11, T2S, R15E, White Springs West 7.5′ Quadrangle, 1961). Only at this latter location is there an exposure that matches the original description. The horizon of the type specimen is in the Early Miocene (Arikareean, Aquitanian-equivalent) Porters Landing Member of the Parachucla Formation (Huddlestun, 1988:47).

"Halitherium" olseni is the most primitive known member of the dugongid subfamily Rytiodontinae. Previously known only from a single European genus, this subfamily now appears to have both originated and significantly diversified in the New World. Its members include Dioplotherium (see below) and at least two new genera recently discovered in Yucatan and Florida (Domning, in press b). The rytiodontines in general were characterized by a pair of very large, flattened and bladelike upper tusks. These usually bore enamel only on the medial side, resulting in a self-sharpening edge somewhat like that of a rodent's incisor. Since these sea cows also had strongly downturned snouts indicating that they were bottom-feeders, I believe that their tusks were adapted to cut and dig up the tough but nutritious rhizomes of sea-grasses like Thalassia. "H." olseni, however, represents a primitive stage of this trend; its tusks were still relatively small and had subconical enamel crowns rather than a bladelike cutting edge.

This species and/or its immediate ancestor is also known from Late Oligocene beds near Charleston, South Carolina, and in one or two other scattered occurrences on the East Coast. The type specimen from the Suwannee, however, remains the most complete one at this writing.

Dioplotherium manigaulti Cope, 1883

This peculiar sea cow was first discovered in the Charleston phosphate beds of South Carolina. However, for most of a century it was known only from its curiously shaped tusks, which are somewhat diamond- or lozenge-shaped in cross section. The first such tusk collected outside the Charleston area was found in the Occidental phosphate mine at White Springs, Florida by L. F. Miller about 1968. But the rest of the animal was virtually unknown until Gary S. Morgan found a nearly complete skull in the bed of the Suwannee in 1985 (Domning, in press a). This discovery provided the first convincing evidence that Dioplotherium was a rytiodontine, and allowed "Halitherium" olseni to also be identified as a member of this group.

The Dioplotherium skull locality is on the southeast bank of the river about 300 m northwest of the U. S. Highway 41 bridge. It is in beds assigned to the "unnamed dolostone, clay, and sand formation of the Hawthorne Group" described by Huddlestun (1988:62, 65; Hunter and Huddlestun, 1982) and thought by him to be correlative with the Torreya Formation and of Early Miocene (Burdigalian; late Arikareean to late Hemingfordian) age. Teeth of heteromyid rodents and other small mammals from the Dioplotherium site studied by Gary Morgan and Ann Pratt (see Morgan's paper in this volume) indicate an Arikareean age, and the tooth of a horse (a primitive Parahippus, identified by Richard Hulbert) is consistent with this date. However, the Dioplotherium horizon is lithologically almost indistinguishable from, and appears to be laterally traceable to, the horizon of "Halitherium" olseni, and both of these either underlie or grade into the shell bed at White Springs that was taken by Huddlestun (1988) to represent the Parachucla Formation (Morgan and Domning, personal observation). The Arikareean age of the land mammals is consistent with assignment to the Parachucla Formation or the unnamed unit. In view of its superpositional relationships, therefore, the Dioplotherium horizon seems best assigned to the Parachucla Formation, and Huddlestun's unnamed unit should be sought farther upstream and up-section than the Dioplotherium site. The Dioplotherium specimen from the Occidental mine may also have come from the Parachucla Formation, but this is unclear.

Dioplotherium is advanced beyond "H." olseni in the great enlargement and flattening of its tusk, whose enamel was also starting to be confined to the medial surface. I believe it was already specialized to feed on seagrass rhizomes; but by the Late Miocene it apparently evolved into a much more specialized rhizovore recently discovered in Yucatan (Domning, in press b). Dioplotherium, therefore, despite its rarity in collections made to date, was part of a lineage that enjoyed several million years of success in the Caribbean basin.

Metaxytherium ssp.

Fossils of rytiodontines in general are still rare in both Europe and the Americas. Far more "typical" of the fossil sirenians encountered in field and museum are the halitheriine dugongids, best represented in the Miocene by the cosmopolitan genus Metaxytherium. Indeed, the most abundantly fossilized seacow in the world may be the Middle to Late Miocene species Metaxytherium floridanum from the Bone Valley district of Florida (Domning, 1988). Less abundant, but more widely distributed, are Early and Middle Miocene members of this genus that may have been ancestral to M. floridanum. Two of these have been named from North America: "Hesperosiren" crataegensis Simpson, 1932 from the Early Miocene (Hemingfordian) fuller's earth deposits (Torreya Formation) near Quincy, Florida, and M. calvertense Kellogg, 1966 from the Middle Miocene (Barstovian) Calvert Formation in Maryland. Although "Hesperosiren" is certainly a junior synonym of Metaxytherium, it is not yet clear whether these two species are identical. Although they are indistinguishable by means of qualitative characters, the holotype of the earlier nominal species is slightly smaller than specimens of the later one.

This inverse correlation of size with age is repeated in two new specimens from the Suwannee River. First, an

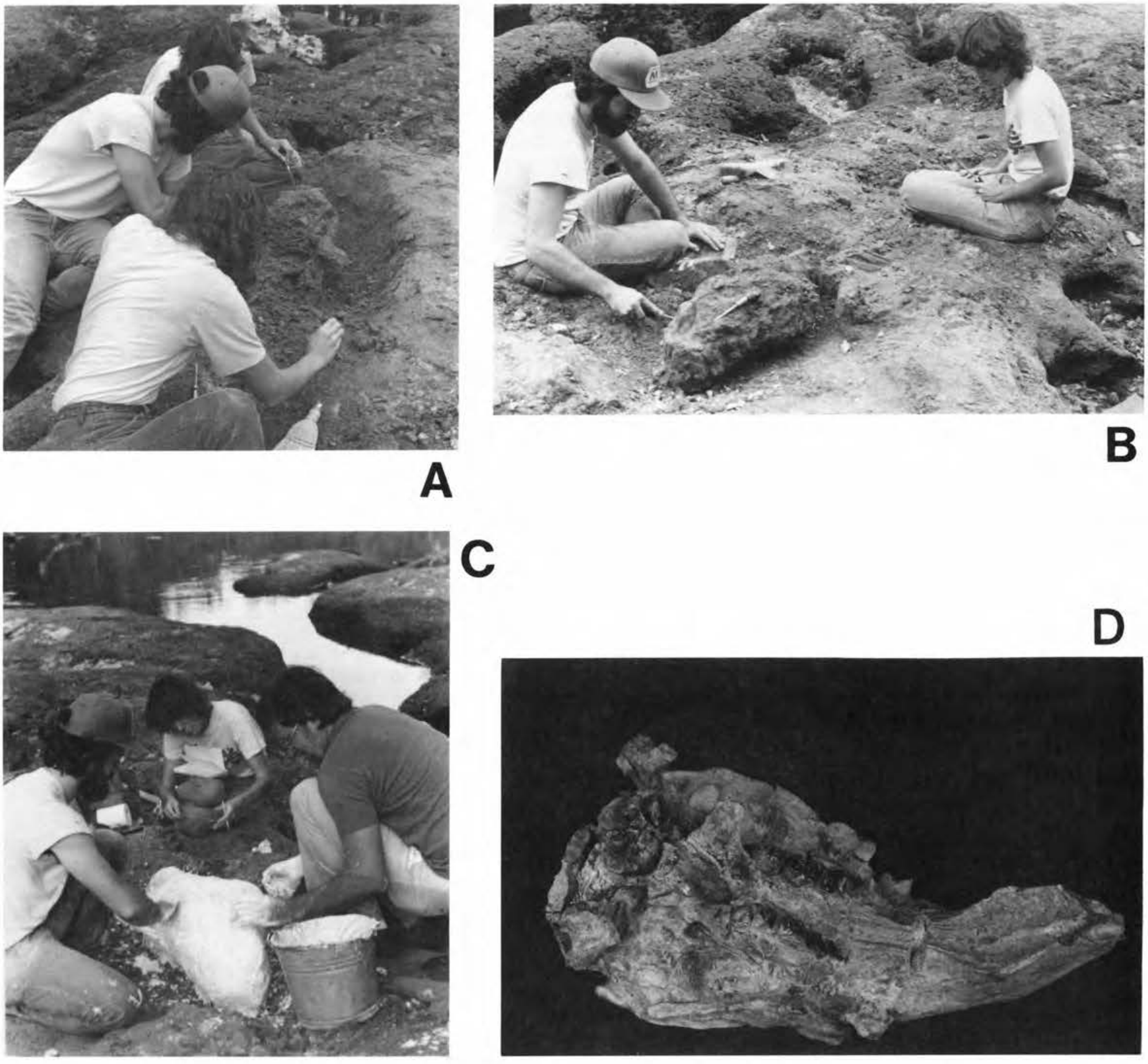

Figure 1. Early Miocene <u>Metaxytherium</u> from Parachucla Formation along Suwannee River near White Springs, Florida. A-C. Excavation of skull and partial skeleton by Florida Museum of Natural History field crew in November 1982; D. Partially prepared skull.

Figure 2. Articulated skeleton of Metaxytherium from Statenville Formation along Suwannee River in Echols County, Georgia. Skull toward bottom (photo courtesy of Dennis Price).

excellent skull and partial skeleton of the same size as "Hesperosiren" was discovered in 1982 in the bed of the Suwannee very close to the Dioplotherium site and in the same unit (Morgan and Pratt, 1983; Figure 1). As discussed above, this unit is apparently correlative with the "Halitherium" olseni horizon, which seems to represent the Arikareean, Aquitanian-equivalent Parachucla Formation. Second, in 1986, Harlan and Dennis Price discovered and G. S. Morgan, R. W. Portell, and W. C. Lancaster collected another partial skull and skeleton on the Suwannee in Georgia about 1 km north of the Florida state line (Figure 2). This one more closely matches M. calvertense in both size and age, having come from the Statenville Formation which is of Middle Miocene (late Barstovian, Serravallian-equivalent) age (Huddlestun, 1988).

In contrast to rytiodontines, Miocene species of Metaxytherium had very small tusks with simple conical enamel crowns. Although they doubtless fed on seagrasses like other dugongids, they do not seem to have been equipped to excavate thick rhizomes and may have specialized on small seagrasses growing on relatively soft bottoms. In any case, both halitheriine and rytiodontine dugongids disappeared from the Caribbean about the end of the Miocene, and were replaced by manatees (trichechids) that spread north from their center of origin in South America (Domning, 1982).

In addition to the major finds described above, isolated bone fragments of sirenians are commonly found along the Suwannee in the vicinity of White Springs. The abundance of fossil seacows along this beautiful river makes it an attractive place to prospect in more ways than one, and holds out the promise of future discoveries matching in quality those made to date. Thanks in part to those discoveries, the known diversity of West Atlantic and Caribbean seacows has greatly increased in the past three decades. The Suwannee may well hold more surprises for us, and deserves continued and steady attention from vertebrate paleontologists, including those interested in the Miocene terrestrial fauna of Florida.

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