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**THE TUCKER BORROW PIT: PALEONTOLOGY AND STRATIGRAPHY
OF A PLIO-PLEISTOCENE FOSSIL SITE IN BREVARD COUNTY, FLORIDA**

GARY S. MORGAN AND ROGER W. PORTELL

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THE TUCKER BORROW PIT: PALEONTOLOGY AND STRATIGRAPHY OF A PLIO- PLEISTOCENE FOSSIL SITE IN BREVARD COUNTY, FLORIDA

GARY S. MORGAN¹ AND ROGER W. PORTELL²

¹New Mexico Museum of Natural History, 1801 Mountain Road NW, Albuquerque, NM 87104

²Florida Museum of Natural History, University of Florida, Gainesville, FL 32611

ABSTRACT

During late April and early May of 1993, a crew composed of employees of the Florida Museum of Natural History and the St. Johns River Water Management District and volunteers from the Florida Fossil Hunters Club, Florida Paleontological Society, and Indian River Historical Society, collected a large sample of vertebrate and invertebrate fossils from the Tucker Borrow Pit in southwestern Brevard County, Florida. Over 1,000 vertebrate fossils representing at least 50 species were collected from this site, designated the Tucker Borrow Pit Local Fauna. The vertebrate fauna is composed of 4 species of sharks, a ray, a sawfish, 10 species of bony fish, a frog, a siren, 9 species of turtles, an alligator, at least 3 species of snakes, 4 species of birds, and 15 species of mammals. Fourteen extinct vertebrate species are present, including two land tortoises and twelve large mammals. The age of the vertebrate fauna is early to middle Pleistocene (late early to middle Irvingtonian) based on the association of the pampathere *Holmesina floridanus*, the giant tapir *Tapirus haysii*, and the mammoth *Mammuthus* cf. *M. hayi*. The presence of *Mammuthus* suggests this fauna is younger than 1.4 Ma, whereas the occurrence of *H. floridanus* indicates an age greater than 0.6 Ma. The paleoecology of the vertebrate faunal assemblage is complex, and includes species representing terrestrial, freshwater, and marine habitats. The bones probably were deposited in a nearshore marine depositional environment. The fauna was derived from a thin (5-10 centimeter thick) layer of grayish-green clayey sand underlain by a marine shell bed referable to the Nashua Formation and overlain by a second shell bed referable to the Fort Thompson Formation.

The invertebrate assemblage from the underlying Nashua Formation is dominated by marine mollusks and consists of 22 species of gastropods and 26 species of bivalves. Other invertebrates present include: 1 poriferan, 1 cnidarian, 6 bryozoans, 1 annelid, and 2 arthropods. Collectively, the extinct invertebrate taxa present: the coral *Septastrea crassa* (Holmes, 1858), the gastropods *Venturia rucksorum* Petuch, 1994 and *Volutifusus obtusus* (Emmons, 1858), and the bivalves *Anadara aequicostata* (Conrad, 1845), *Conradostrea sculpturata* (Conrad, 1840), *Mulinia congesta* (Conrad, 1833), and *Noetia limula* (Conrad, 1832), suggest a late Pliocene age. The paleoecology of Unit 1 indicates deposition in a high energy, nearshore, marine environment.

The poorly preserved marine invertebrate fauna from the overlying Fort Thompson Formation is dominated by the bivalve, *Chione cancellata* (Linnaeus, 1767). Additional taxa present include 1 gastropod, 6 bivalves, and 1 arthropod. The absence of extinct species of mollusks and the high shell content of this uppermost shell bed is indicative of the late Pleistocene Fort Thompson Formation. The species present in this unit suggest an intertidal to subtidal environment of deposition.

The Sebastian Canal sites 1 and 2 are located along the border between Brevard County on the north and Indian River County on the south, about 20 kilometers (12 miles) east of the Tucker Borrow Pit. These two sites constitute the Sebastian Canal Local Fauna, which consists of 25 species of vertebrates, including two species of fish, seven species of turtles, an alligator, several snakes, and 13 species of mammals. Ten of the mammals are extinct. An Irvingtonian age for this fauna is established by the presence of the wolf *Canis armbrusteri* and the short-faced bear *Arctodus pristinus*. The age of the Sebastian Canal Local Fauna is further restricted to the late Irvingtonian (middle Pleistocene, probably between 0.5 and 0.3 Ma) by the occurrence of the opossum *Didelphis virginiana* and the tapir *Tapirus veroensis*, both of which make their earliest Florida appearance in the late Irvingtonian Coleman 2A Local Fauna in Sumter County. Tucker Borrow Pit and Sebastian Canal are the only Irvingtonian vertebrate faunas currently known from the Atlantic coastal region of Florida.

INTRODUCTION

In March 1993, Jennifer McMurtray, a land manager for the St. Johns River Water Management District (SJRWMD), contacted paleontologists at the Florida Museum of Natural History (FLMNH), regarding fossil bones found by workers during the excavation of the Tucker Borrow Pit in southwestern Brevard County, Florida (see Figure 1) on land under the jurisdiction of the SJRWMD. The excavation of the pit was undertaken by Coastal Construction, a private company subcontracted by the Army Corps of Engineers (ACOE) under the auspices of the SJRWMD. Gary Morgan visited the Tucker Borrow Pit on 23 April 1993 to assess the paleontological importance of the site. He spent the day with Jennifer McMurtray looking for evidence of fossils and surveying the geology in the three separate pits comprising the Tucker Borrow Pit Site. They discovered a layer of fossil bones in place (*in situ*) along the north wall of the northeastern pit (Pit 2 on Figure 1B) in a sandy layer between two marine shell beds. Morgan also briefly examined several samples of fossil bones from the site found by construction workers. This preliminary investigation strongly indicated that the site was worthy of more thorough paleontological exploration.

FLMNH paleontologists, Jennifer McMurtray, and a large volunteer crew from the Florida Fossil Hunters Club in Orlando, the Florida Paleontological Society, and the Indian River Historical Society began excavations at the Tucker Borrow Pit on 5 May 1993. Several people explored the three pits to collect vertebrate fossils from spoil piles. The remainder of the crew began excavating the productive bone-bearing layer located along an approximately 100 m interval on the north wall of Pit 2 (Figure 1B). On the third and final trip to the Tucker Borrow Pit on 12 and 13 May 1993, FLMNH paleontologists and the volunteer crew continued excavations of the bone-bearing layer. In addition, Roger W. Portell and Gary S. Morgan made collections of invertebrate fossils, measured and drew a stratigraphic cross-section, and recorded field notes on the geology of the site.

Because of prior scheduling and contract deadlines, the ACOE and Coastal Construction were under a tight schedule to complete the excavation of the Tucker Borrow Pit. Their final work at the site involved grading the sides of the pit with heavy machinery and then turning off the pumps allowing the pit to fill with water, thereby obscuring the fossil-bearing deposits. Thus, FLMNH paleontologists were operating under a deadline to remove as many fossils as possible before the pit was flooded. Although this meant excavations were carried out quickly and in somewhat of a salvage mode, the cooperation between the FLMNH, SJRWMD, and the large volunteer crew allowed us to obtain a significant amount of paleontological and geological data on the Tucker Borrow Pit in a short period of time.

Following the discussion of the paleontology and geology of the Tucker Borrow Pit, a brief description of the Sebastian Canal sites 1 and 2 is presented. These two sites are here combined into the Sebastian Canal Local Fauna (LF) because of their proximity and similar vertebrate faunas. They are located along the north and south banks of the canal forming the border between Brevard County and Indian River County, about 20 km (12 miles) due east of the Tucker Borrow Pit (Figure 1A). Except for the list of mammals provided by Webb (1974) and the description of a tooth of the bear *Arctodus pristinus* by Emslie (1995), there has been almost no discussion of the Sebastian Canal vertebrate fauna in the literature. The Sebastian Canal sites do not have a particularly abundant or diverse vertebrate fauna compared to other Florida Pleistocene sites, but they are important for several reasons. The Sebastian Canal LF is one of only two late Irvingtonian (middle Pleistocene) vertebrate faunas known from Florida (Morgan and Hulbert, 1995), the other being the well known Coleman 2A LF from Sumter County in the north-central region of the peninsula. Sebastian Canal and Tucker Borrow Pit are the only Irvingtonian vertebrate faunas known from the Atlantic coastal region of Florida.

MATERIALS AND ABBREVIATIONS

All fossils from the Tucker Borrow Pit and Sebastian Canal are deposited in the Florida Museum of Natural History, University of Florida, Gainesville, Florida (Collection Acronym UF). Abbreviations used in the text are as follows: millimeter (mm), centimeter (cm), meter (m), kilometer (km), kilogram (kg), Township (T), Range (R), upper premolar (P), lower premolar (p), upper molar (M), lower molar (m), million years ago (Ma), Local Fauna (LF), Army Corps of Engineers (ACOE), United States Geological Survey (USGS), Florida Museum of Natural History (FLMNH), and St. Johns River Water Management District (SJRWMD).

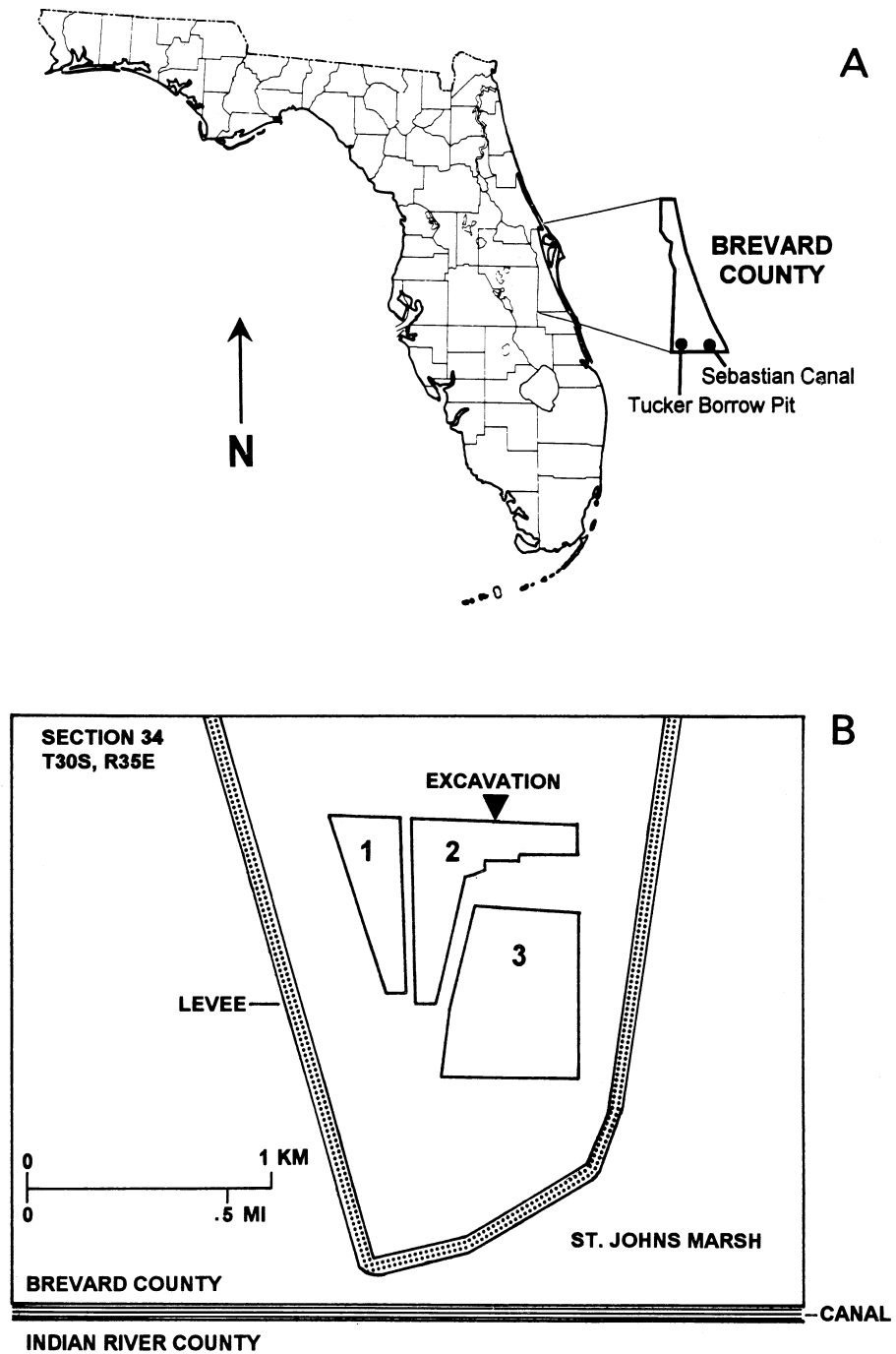


Figure 1. A. Map of Florida showing location of Tucker Borrow Pit and Sebastian Canal sites. B. Site map of Tucker Borrow Pit (includes southern two-thirds of section 34, T30S, R35E, Kenansville SE USGS 7.5 minute topographic map). The Tucker Borrow Pit was divided into three separate pits during mining operations, designated 1, 2, and 3 on map. The majority of vertebrate fossils comprising the Tucker Borrow Pit Local Fauna and all of the invertebrate fossils discussed in this paper were removed from excavations located along a 100 m section on the north wall of Pit 2 (see arrow on map). North arrow applies to both maps.

SITE DESCRIPTION AND GEOLOGY

The Tucker Borrow Pit (designated FLMNH vertebrate fossil site number BR011 and invertebrate fossil site numbers BR004, BR005, and BR006) is located on the western edge of St. Johns Marsh in the southwestern corner of Brevard County, Florida. The site is slightly less than 1 km (0.5) miles north of the Indian River County line, 6.5 km (4 miles) east of the Osceola County line, and about 40 km (25 miles) inland (west) from the Atlantic Ocean (see maps in Figure 1). The original surface elevation in the vicinity of the pit prior to excavation was between 6 and 7 m (21-23 feet) above sea level. The three pits comprising the Tucker Borrow Pit site are situated in the center of Section 34, T30S, R35E, Kenansville SE, USGS 7.5 Minute Quadrangle (1972). Although the majority of vertebrate and invertebrate fossils were excavated *in situ* along a 100 m section of the north wall of Pit 2 (Figures 1B, 2), some fossil specimens collected from spoil piles or the floor of Pit 2 lacked stratigraphic provenience. The exact location of the *in situ* deposits is in the SW $\frac{1}{4}$, NE $\frac{1}{4}$ of Section 34, T30S, R35E.

The fossil deposits were excavated using standard paleontological field techniques. Overburden was removed with picks and shovels, while careful excavation was carried out with trowels, screwdrivers, and dental picks. Two 3 HP water pumps equipped with small hoses were used to slowly wash the sandy matrix to recover vertebrate and invertebrate fossils (Figures 3A-B). Several hundred kilograms of matrix were washed through window screens on site to recover the remains of micro-vertebrates. Unwashed bulk samples of matrix were collected from each of the shell-bearing units and later washed and picked for micro-invertebrates.

The authors measured and described a stratigraphic section along the north wall of Pit 2 in the area where the productive vertebrate-bearing layer was excavated (Figure 4). The section is approximately 4 m in thickness from the lowest exposed shell layer (Nashua Formation) in the bottom of the pit to the modern soil horizon at the top. We divided the section into five informal stratigraphic units (Units 1-5) based on differences in sediment composition and fossil content. Unit 1, totaling 1.3 m in thickness, consists of an unconsolidated, massive, undulating, sandy shell bed containing abundant marine mollusks. The lowest exposed part of the section, Unit 1A, is 0.3 m in thickness and consists of a gray sand with tan and gray colored shells. Unit 1B is about 1.0 m in thickness and consists of a tan, shelly sand.

The lithology of Unit 1 and the taxonomic composition of its molluscan fauna is consistent with other faunas ascribed to the Nashua Formation. Huddleston (1988) reintroduced the Nashua Marl of Matson and Clapp (1909) as the Nashua Formation, a variably calcareous, shelly sand to fine sand coquina. Huddleston recognized the Nashua as a multi-deposit formation (deposition during more than one episode of sedimentation) that occurs as far north as in the vicinity of the St. Marys River to as far south as in the vicinity of Deland in Volusia County. However, Portell (unpublished data) has recognized the Nashua Formation from two localities substantially farther south than Volusia County. Portell et al. made collections from May, 1987 to October, 1992 at the F & W Mine (UF locality OR002) in Orange County and in March, 1992 from the Rucks Pit (UF locality OB006) in Okeechobee County. Recently, Petuch (1994) described several new species and subspecies of mollusks collected from the Nashua Formation at the Rucks Pit, one of which is recognized from Unit 1 at the Tucker Borrow Pit. It therefore appears that the Nashua extends at least as far south as in the vicinity of Fort Drum in northeastern Okeechobee County. The Nashua Formation is considered to be contemporaneous with the Caloosahatchee Formation of southern Florida and the Waccamaw and James City formations of the Carolinas based on associated molluscan taxa. Lyons (1991) and L. Campbell (written comm., 1996) believe these units should probably be restricted to the late Pliocene (see Lyons, 1991 for discussion). However, based on planktonic foraminifera, Huddleston (1988) suggests the Nashua Formation in northeastern Florida is late Pliocene to early Pleistocene. Pending further study, we have decided to place the Nashua Formation at the Tucker Borrow Pit in the late Pliocene.

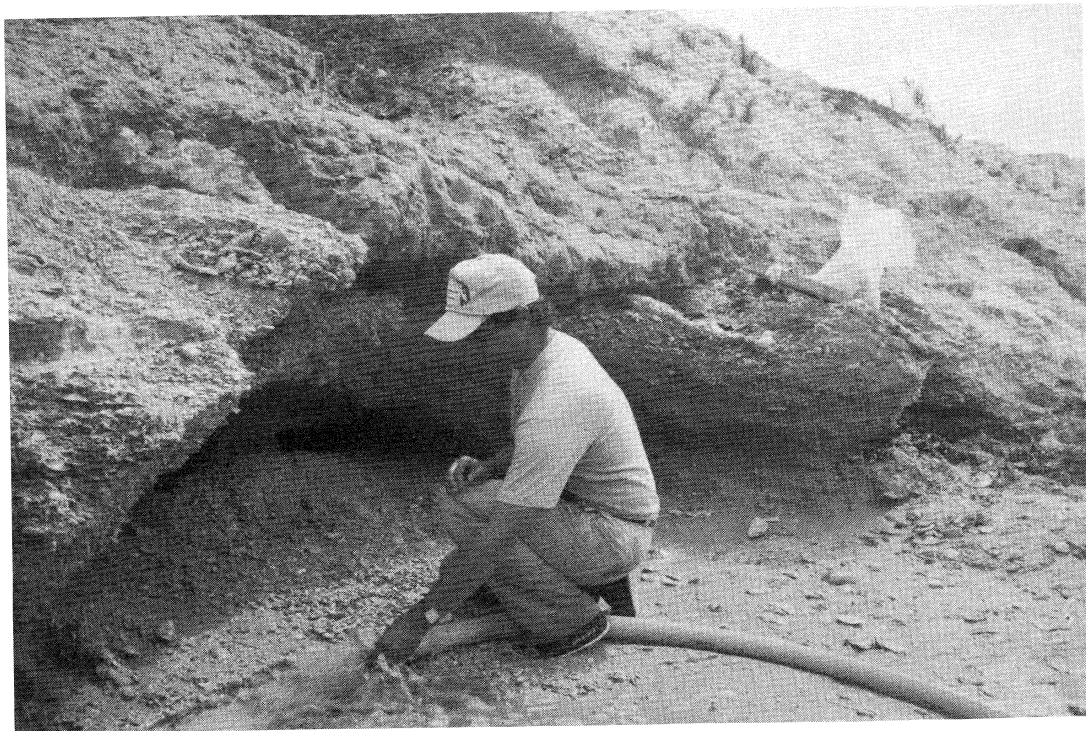
Unit 2 is separated from the underlying Unit 1 by an erosional unconformity. Unit 2, including sub-units 2A and 2B, is a grayish-green clayey sand about 1.0 m in thickness. Unit 2A, the primary bone-producing level in the stratigraphic section, is a 5-10 cm thick layer at the base of Unit 2. The fossils from this unit consist of isolated bones and teeth that occur randomly throughout the layer. The bones and teeth are black in color and well mineralized. The majority of fossils are small and/or fragmentary, (e.g. shark teeth, gar scales, fish vertebrae, and turtle shell pieces), although some larger more complete material was recovered, including a mammoth tooth, camel mandible and complete metacarpal, and sea turtle costal bone. Unit 2B consists of a 1 m thick layer of grayish-green clayey sand that is devoid of both bones and shells.



Figure 2. Field crew collecting vertebrate fossils along north bank of Tucker Borrow Pit 2.



A



B

Figure 3. A. Field crew collecting vertebrate fossils from north bank of Tucker Borrow Pit 2. B. Roger W. Portell preparing to sample invertebrate fossils from recently exposed stratigraphic section. Note: screwdriver is stuck into unfossiliferous Unit 2B.

**STRATIGRAPHIC SECTION
TUCKER BORROW PIT
BREVARD CO., FLORIDA**

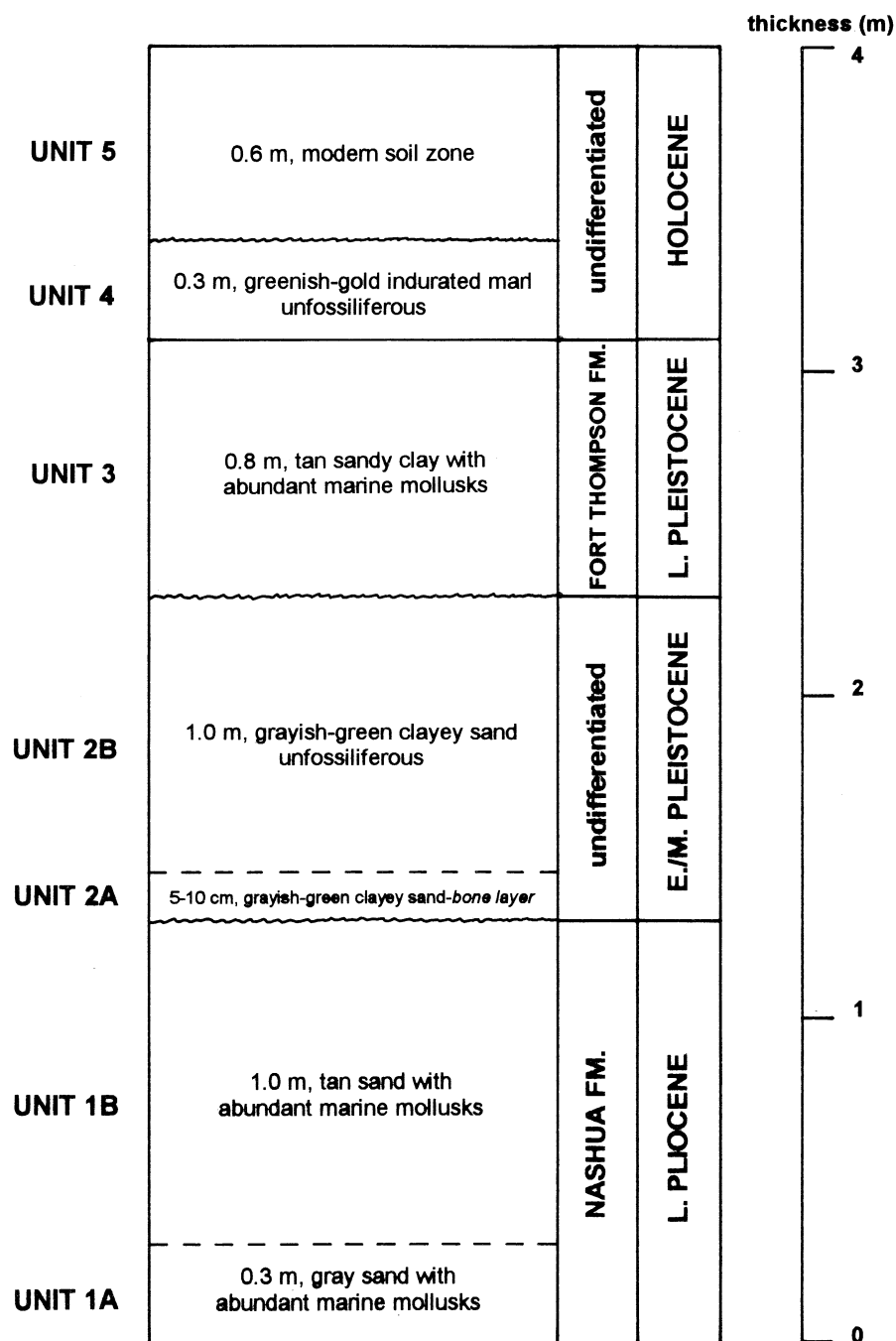


Figure 4. Stratigraphic section of the Tucker Borrow Pit, Brevard County, Florida. The section was measured by R. W. Portell and G. S. Morgan on 13 May 1993 along the north wall of Pit 2 (location marked by arrow on Figure 1B). The primary bone-producing layer was Unit 2A. Invertebrate fossils were abundant in Units 1 and 3. Abbreviations used are: Formation (Fm.), Early (E.), Middle (M.), Late (L.), meter (m), and centimeter (cm).

Unit 3 overlies an erosional unconformity at the top of Unit 2B. Unit 3 is a 0.8 m thick layer of tan, sandy clay containing abundant marine mollusks. The white-colored shells are highly leached and many consist of paired valves. The molluscan fauna is composed entirely of living species, particularly abundant is the bivalve *Chione cancellata* (Linnaeus, 1767). This unit is referable to the Fort Thompson Formation of late Pleistocene age because of its high shell content, rather than the more northeastern occurring Satilla Formation which primarily consists of sand with some shell, and the absence of any extinct molluscan taxa.

Unit 4 consists of 0.3 m of a greenish-gold indurated marl that is devoid of fossils. The top of the local stratigraphic section is a modern soil zone about 0.6 m in thickness.

VERTEBRATE PALEONTOLOGY

The Tucker Borrow Pit Local Fauna (LF) is composed of six classes and about 50 species of vertebrates (Table 1). Most of the fauna was excavated *in situ* from Unit 2A in Pit 2, although fossils representing several taxa, particularly large mammals, were collected from spoil piles. Following is a brief description of the vertebrate fauna highlighting some of most significant species, especially those that provide some information on the age of the site. Names of the vertebrate species used in the text and Table 1 follow Hulbert (1992).

CHONDRICHTHYES and OSTEICHTHYES.--Sharks are represented by four species in the Tucker Borrow Pit LF. Shark teeth are not especially abundant in the fauna. The two most common species are the sand shark *Odontaspis taurus* and a small *Carcharhinus*, probably the bull shark *C. leucas*. The living great white shark *Carcharodon carcharias* is identified from fewer than five teeth. In Florida vertebrate faunas this species replaced the giant shark *Carcharodon megalodon* during the Pliocene. All late Pliocene (late Blancan) and younger faunas from Florida, including the early Irvingtonian Leisey Shell Pit, contain *C. carcharias* (see Scudder et al., 1995). Teeth of one species of ray, the eagle ray *Myliobatis* sp., are fairly common and the sawfish *Pristis* sp. was identified from several of the diagnostic vertebrae. All six species of sharks and rays from the Tucker Site inhabit shallow, nearshore marine environments.

Ten species of bony fish (Osteichthyes) have been identified from the Tucker Borrow Pit LF (Table 1). A few more species of fish certainly are present among the large sample of unidentified vertebrae and cranial elements. Several hundred scales of the alligator gar *Atractosteus spatula* were identified from their large size, thickness, and characteristic surface texture. This large gar probably is over represented in the Tucker Fauna, as virtually all of the identified material consists of these heavily armored ganoid scales. The occurrence of *A. spatula* in a site midway along the Atlantic Coast of Florida is significant, since the alligator gar is now limited in Florida to shallow marine habitats in the western half of the Panhandle (Scudder et al., 1995). However, there are numerous records of this large gar from Pliocene and Pleistocene sites along the Gulf Coast in the southern half of the peninsula. The Tucker record of *A. spatula* is one of the first from the Atlantic coastal region. The youngest reported peninsular occurrence of the alligator gar is from the Oldsmar LF, a middle Pleistocene (early Rancholabrean) site in Pinellas County along the central Gulf Coast (Karrow et al., in press). Other nearshore marine fish from the Tucker fauna include the black drum *Pogonias cromis*, the sheephead *Archosargus probatocephalus*, the searobin *Prionotus*, and a porcupinefish (Family Diodontidae). Freshwater fish are uncommon in the fauna, consisting of a few bones of the bowfin *Amia calva* and the redear sunfish *Lepomis microlophus*.

AMPHIBIA, REPTILIA, and AVES.--Amphibians are rare in the Tucker fauna, represented by a few postcranial elements of a frog or toad and a vertebra of a siren (*Siren*). Turtles are the most abundant vertebrates in the Tucker Borrow Pit LF, with hundreds of isolated shell elements from at least nine species. No complete or partial shells of turtles were collected. Several shell elements of sea turtles (Family Cheloniidae) were recovered from the fauna, including a complete costal (UF 143397) of the loggerhead sea turtle, *Caretta caretta*. This genus recently was reported from the Bone Valley Formation of early Pliocene age in central Florida (Dodd and Morgan, 1992). Two species of extinct land tortoises (Family Testudinidae) are represented in the fauna, the large species *Hesperotestudo crassiscutata* and the small species *H. mlynarskii*. Meylan (1995) discussed the reasons for using the genus *Hesperotestudo* for all New World land tortoises formerly placed in the Old World genus *Geochelone*. *H. crassiscutata* occurs from at least the early Irvingtonian to the end of the Pleistocene in Florida, whereas *H. mlynarskii* apparently is restricted to the Irvingtonian. Large samples of this small tortoise are known from the Leisey Shell Pit (Meylan, 1995) and the late Irvingtonian Coleman 2A LF in Sumter County (Auffenberg, 1988).

A third terrestrial turtle, the giant extinct box turtle *Terrapene carolina putnami*, is also fairly common in the fauna. UF 121698 and 143405 are especially large partial plastra of *T. carolina putnami* from the Tucker Site. Auffenberg (1958) developed a rather elaborate paleoecological scenario to explain the RanchoLabrean distribution in Florida of large extinct box turtles. He did not at that time have samples of *T. c. putnami* from older pre-RanchoLabrean sites, and thus it is unknown if the presence of this form has any biochronological significance. The most common turtles in the Tucker fauna are freshwater taxa, including the emydids *Trachemys scripta* and *Pseudemys* sp. and the trionychid *Apalone ferox*.

Alligator (*Alligator mississippiensis*) fossils are common in the fauna, particularly isolated teeth. All sizes of alligators are represented, from small juveniles to large adults. Several dozen snake vertebrae were recovered, most of which are fairly large and appear to be from poisonous snakes (Family Viperidae), probably either the eastern diamondback rattlesnake *Crotalus adamanteus* or the water moccasin *Agkistrodon piscivorous*. Vertebrae of several additional species of snakes await further identification.

Four species of birds have been identified from the fauna, none of which are extinct. The most complete bird fossils are from the double-crested cormorant, *Phalacrocorax auritus*, including a complete femur (UF 121693) and a quadrate (UF 121692). A duck, *Anas* sp., a heron, cf. *Ardea* sp. and a hawk (Family Accipitridae) constitute the remainder of the Tucker avifauna.

MAMMALIA.--The mammalian fauna from the Tucker Borrow Pit LF consists of 15 species, all but three of which are extinct. We screen washed several hundred kilograms of fossiliferous matrix from Unit 2, but no small mammals were recovered despite the fact that we found numerous bones of other small vertebrates, including fish, amphibians, snakes, and birds.

The xenarthran fauna from the Tucker Site is composed of four species, two shelled forms and two ground sloths. The beautiful armadillo *Dasybus bellus* and the pampathere *Holmesina floridanus* are both represented solely by small samples of osteoderms. The *Holmesina* osteoderms (Figures 5A, 5B) are small and thin, suggesting referral to the late Pliocene and early Pleistocene species *H. floridanus* (see Hulbert and Morgan, 1993). The larger species, *H. septentrionalis*, has considerably larger and thicker osteoderms than the Tucker specimens. *Holmesina floridanus* first occurs in Florida late Blancan faunas and disappears in the late early or middle Irvingtonian. *Holmesina septentrionalis* appears in the late middle Irvingtonian McLeod LF in Levy County, Florida and persists throughout the remainder of the Irvingtonian and RanchoLabrean (Hulbert and Morgan, 1993). The giant ground sloth *Eremotherium* is known from a single tooth fragment (UF 143394) and Harlan's ground sloth *Paramylodon harlani* is represented by a metatarsal 3 (UF 143347) and a claw (UF 143262, Figure 5C). McDonald (1995) discussed the use of the genus *Paramylodon* for the North American Irvingtonian and RanchoLabrean mylodont sloths, rather than the more commonly used name *Glossotherium*.

The only rodent from the Tucker Site is the giant beaver *Castoroides* sp. identified from a single proximal phalanx (UF 137999, Figure 5D). Morgan and White (1995) recently described a new species of giant beaver, *C. leiseyorum*, from the late early Irvingtonian Leisey Shell Pit LF in Hillsborough County along Florida's Gulf Coast. The critical morphological features used to distinguish *C. leiseyorum* occur in the braincase, and thus the Tucker specimen can only be identified to the genus level. Other Florida Irvingtonian records of *Castoroides* are from Apollo Beach LF in Hillsborough County and the Crystal River Power Plant in Citrus County (Morgan and White, 1995).

The most common perissodactyl in the fauna is an extinct species of the horse *Equus*. Florida Irvingtonian faunas may have as many as three species of *Equus*, but none of these have been identified to the species level (Hulbert, 1995b). Representative teeth of *Equus* from Tucker include two upper P3s or P4s (UF 143255, 143354), an associated unworn upper M1 and M2 (UF 143224), and a lower p2 (UF 143259). The giant tapir, *Tapirus haysii*, is identified from a single lower molar (UF 143359). The presence of *T. haysii* is significant because this species is restricted to late early Irvingtonian (e.g. Leisey) and middle Irvingtonian (e.g. McLeod) faunas in Florida (Hulbert, 1995a). The smaller *T. veroensis* first appears in the late Irvingtonian Coleman 2A LF in Sumter County and persists to the end of the RanchoLabrean.

Three artiodactyls occur in the Tucker Borrow Pit LF, the living white-tailed deer *Odocoileus virginianus*, the long-limbed llama *Hemiauchenia macrocephala*, and short-limbed llama *Palaeolama mirifica*. The most diagnostic fossil of *H. macrocephala* is a complete right metacarpal (UF 143341, Figure 5E). The specimen is considerably longer than the metacarpal of *Palaeolama* from other Florida Irvingtonian sites. The Tucker *Hemiauchenia* metacarpal is somewhat longer and more robust than comparable metacarpals of *Hemiauchenia* from the Leisey Shell Pit (Webb and Stehli, 1995), suggesting that the Tucker Site may be somewhat younger than

Table. 1. Vertebrate fauna from the Irvingtonian Tucker Borrow Pit, Brevard County, Florida.

- Class Chondrichthyes
- Order Lamniformes
 - Carcharodon carcharias* (great white shark)
 - Odontaspis taurus* (sand shark)
 - Order Carcharhiniformes
 - Carcharhinus leucas* (bull shark)
 - Negaprion brevirostris* (lemon shark)
 - Order Pristiformes
 - Pristis* sp. (sawfish)
 - Order Myliobatiformes
 - Myliobatis* sp. (eagle ray)
- Class Osteichthyes
- Order Lepisosteiformes
 - Atractosteus spatula* (alligator gar)
 - Lepisosteus* sp. (gar)
 - Order Amiiformes
 - Amia calva* (bowfin)
 - Order Siluriformes
 - genus and species indeterminate (catfish)
 - Order Scorpaeniformes
 - Prionotus* sp. (searobin)
 - Order Perciformes
 - Archosargus probatocephalus* (sheephead)
 - Pogonias cromis* (black drum)
 - Lepomis microlophus* (redeer sunfish)
 - Mugil* sp. (mullet)
 - Order Tetraodontiformes
 - Diodontidae (porcupinefish)
- Class Amphibia
- Order Anura
 - one species of frog or toad
 - Order Urodela
 - Siren* sp. (siren)
- Class Reptilia
- Order Testudines
 - Caretta caretta* (loggerhead sea turtle)
 - Hesperotestudo crassiscutata* (giant land tortoise)†
 - Hesperotestudo mlynarskii* (dwarf land tortoise)†
 - Chelydridae (snapping turtle)
 - Apalone ferox* (soft-shell turtle)
 - Kinosternidae (mud turtle)
 - Trachemys scripta* (pond slider)
 - Pseudemys* sp. (cooter)
 - Terrapene carolina putnami* (giant box turtle)†
 - Order Crocodylia
 - Alligator mississippiensis* (alligator)
 - Order Squamata, Suborder Serpentes
 - Viperidae (rattlesnake/water moccasin)
 - several additional species of snakes
- Class Aves
- Order Pelecaniformes
 - Phalacrocorax auritus* (cormorant)

Order Gruiformes

cf. *Ardea* sp. (heron)

Order Falconiformes

one species of hawk

Order Anseriformes

Anas sp. (duck)

Class Mammalia

Order Xenarthra

Dasybus bellus (beautiful armadillo)†*Holmesina floridanus* (giant armadillo)†*Eremotherium* sp. (giant ground sloth)†*Paramylodon harlani* (Harlan's ground sloth)†

Order Rodentia

Castoroides sp. (giant beaver)†

Order Perissodactyla

Equus small sp. (extinct horse)†*Equus* large sp. (extinct horse)†*Tapirus haysii* (giant tapir)†

Order Artiodactyla

Hemiauchenia macrocephala (long-limbed llama)†*Palaeolama mirifica* (short-limbed llama)†*Odocoileus virginianus* (white-tailed deer)

Order Proboscidea

Cuvieronius tropicus (Cuvier's gomphothere)†*Mammuth americanum* (American mastodon)†*Mammuthus* cf. *M. hayi* (Hay's mammoth)†

Order Sirenia

genus and species indeterminate (manatee/dugong)¹

Order Cetacea

Balaenopteridae (baleen whale)¹

† extinct species

¹ probably derived from Nashua Formation and therefore somewhat older than remainder of fauna

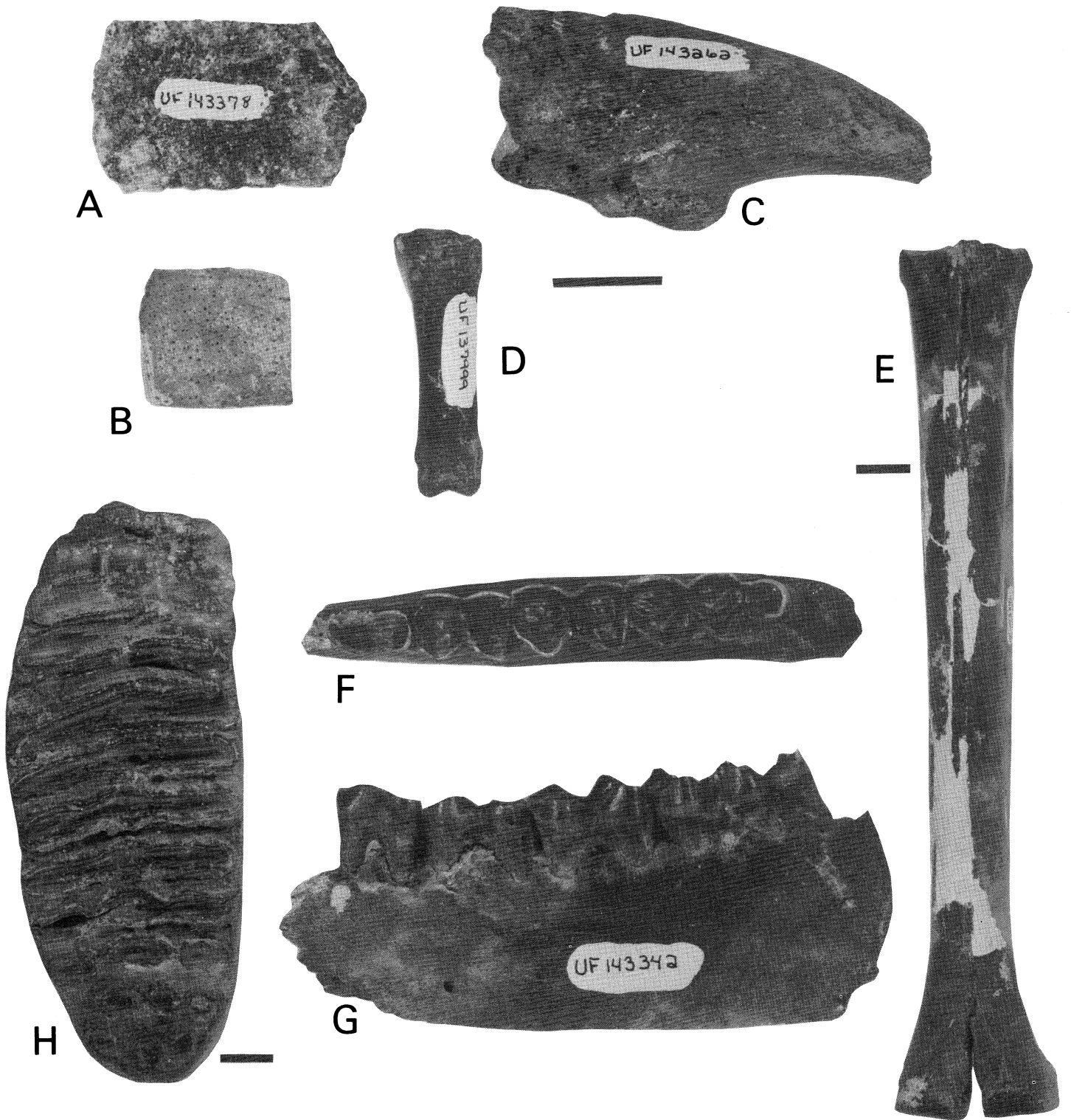


Figure 5 (opposite page). Vertebrate fossils from the Irvingtonian Tucker Borrow Pit Local Fauna, Brevard County, Florida. A. *Holmesina floridanus*, buckler osteoderm (UF 143378). B. *Holmesina floridanus*, buckler osteoderm (UF 143379). C. *Paramylodon harlani*, ungual phalanx (UF 143262). D. *Castoroides* sp., phalanx (UF 137999). E. *Hemiauchenia macrocephala*, right metacarpal (UF 143341). F. (occlusal view) and G. (lateral view), *Palaeolama mirifica*, partial left mandible with p4-m3 (UF 143342). H. *Mammuthus hayi*, right m3 (UF 121700). All three scale bars are 2.0 cm in length. The longer scale bar applies to A-D, F, and G (natural size), the shorter scale bars apply to E and H (1/2 natural size).

Leisey. Measurements of the Tucker *H. macrocephala* metacarpal are: total length 368 mm; breadth of proximal end 57 mm. Measurements of five Leisey *H. macrocephala* metacarpals are: total length, mean=345.6 mm, range=338-361 mm; breadth of proximal end, mean=50.8 mm, range=46-56 mm. *Palaeolama mirifica* is identified from the Tucker fauna on the basis of a partial left mandible with p4-m3 (UF 143342, Figure 5F, 5G). The teeth of this specimen are in a rather advanced state of wear; however, the morphology of the p4, lack of cement on the cheek teeth, and smaller size clearly identify the mandible as *Palaeolama* rather than *Hemiauchenia*. The Tucker mandible fits within the range of variation of the tremendous sample of *P. mirifica* mandibles from the Leisey Shell Pit (Webb and Stehli, 1995).

Three species of proboscideans occur in the Tucker Site. Cuvier's gomphothere *Cuvieronius tropicus* and the American mastodon *Mammot americanum* both are represented by fragmentary teeth. Several partial teeth and a complete lower m3 (UF 121700, Figure 5H) are referred to the primitive mammoth *Mammuthus hayi*. Webb and Dudley (1995) describe the largest known sample of *M. hayi* from the late early Irvingtonian Leisey Shell Pit. Three features are often used to characterize mammoth teeth (Maglio, 1973), number of enamel plates on the m3, number of enamel plates per 100 mm of tooth length (known as lamellar frequency), and enamel thickness. UF 121700 from the Tucker Site has 13 enamel plates that average 2.9 mm in thickness (mean of 10 measurements), and the lamellar frequency is 6 plates per 100 mm. In comparison with the large Leisey sample of *M. hayi*, the Tucker tooth has somewhat thinner and more complicated enamel plates that are more closely spaced, all of which are considered to be more progressive features. Although UF 121700 is intermediate in some characters between the Leisey *M. hayi* and late Irvingtonian and Rancholabrean *M. columbi*, it is closer to *M. hayi* and is here referred to that species.

The whale and sirenian specimens listed in Table 1 were collected from spoil piles and likely were derived from the late Pliocene Nashua Formation. Consequently, in the strict sense they should not be considered part of the Tucker Borrow Pit Local Fauna. More important from a biochronological standpoint is the presence of a single fragmented tooth (UF 143369) of *Bison* collected from Unit 3, about a meter above the primary bone-producing layer. This is the only vertebrate recovered from Unit 3 and confirms a Rancholabrean (late middle or late Pleistocene) age for the Fort Thompson Formation in the Tucker Borrow Pit.

INVERTEBRATE PALEONTOLOGY

The invertebrate fauna (Table 2) collected from Tucker Borrow Pit Unit 1 (UF locality BR005), Unit 3 (UF locality BR006), and spoil (UF locality BR004) is described below. Unit 1 was informally divided into two parts (1A and 1B) during field excavations based mainly on matrix color. As mentioned earlier, Unit 1A was a poorly sorted, shelly, gray sand with both aragonitic and calcitic mollusk shells being gray or gray and tan. Unit 1B was a shelly sand, much lighter in color with aragonitic shells being tan and calcitic shells being gray. As in Unit 1A the shells and sandy matrix were poorly sorted but in Unit 1B stringers of fine, pure, well sorted sand were occasionally present. No distinct faunal differences were evident once the materials were studied more closely. Many of the micro-invertebrates collected from Unit 1 and Unit 3 were not identified for this study. Throughout this paper the extinct *Linga waccamawensis* (Dall, 1903) is separated by a slash from the Recent *Linga amiantus* (Dall 1901) because it represents a taxonomically ambiguous taxon that is indistinguishable to the authors (see Portell et al. 1995 for further discussion).

Table 2. Preliminary list of fossil invertebrates collected from Tucker Borrow Pit. Occurrence of each species within Unit 1A and 1B (BR005), Unit 3 (BR006), and spoil (BR004) is noted by an "x" in the appropriate column. Species considered extinct are preceded by an asterisk (*).

	UNITS			
	1A	1B	3	SPOIL
Porifera				
cf. <i>Cliona</i> sp.	x	x		x
Cnidaria				
* <i>Septastrea crassa</i> (Holmes, 1858)	x	x		
<i>Solenastrea hyades</i> (Dana, 1846)				x
Bryozoa				
<i>Aimulosia</i> sp.	x	x		x
<i>Cleidochasma contractum</i> (Waters, 1899)	x	x		x
<i>Hippoporidra</i> sp.	x			
<i>Parasmittina</i> sp.		x		
<i>Parasmittina nitida</i> morphotype B Maturo and Schopf, 1968	x	x		x
<i>Schizoporella</i> sp.	x			
Mollusca (Gastropoda)				
<i>Bulla striata</i> Bruguiere, 1792				x
<i>Busycon carica</i> (Gmelin, 1791)	x	x		x
<i>Busycon contrarium</i> (Conrad, 1840)	x	x		x
* <i>Busycotypus incile</i> (Conrad, 1833)				x
<i>Busycotypus spiratus</i> (Lamarck, 1816)				x
<i>Cancellaria</i> sp.				x
* <i>Conus</i> sp. cf. <i>C. marylandicus</i> Green, 1830		x		
<i>Crassispira</i> sp.	x			
<i>Crepidula</i> sp.	x			x
<i>Crepidula aculeata</i> (Gmelin, 1791)	x			
<i>Crepidula fornicata</i> (Linnaeus, 1758)	x	x		x
<i>Crepidula plana</i> Say, 1822		x		
<i>Epitonium</i> sp.	x	x		
<i>Eupleura caudata</i> (Say, 1822)	x	x		x
<i>Fasciolaria</i> sp.	x			x
<i>Longchaeus suturalis</i> (H. C. Lea, 1843)				x
<i>Melongena corona</i> (Gmelin, 1791)			x	x
<i>Neverita duplicata</i> (Say, 1822)	x	x		x
<i>Oliva</i> sp.	x			x
<i>Oliva sayana</i> Ravenel, 1834		x		x
<i>Olivella</i> sp.	x	x		
<i>Planorbella duryi</i> (Wetherby, 1879)				x
<i>Planorbella scalare</i> (Jay, 1839)				x
<i>Prunum roscidum</i> (Redfield, 1860)	x	x		
<i>Strombus</i> sp.				x
<i>Terebra</i> sp.	x	x		x
<i>Triplofusus gigantea</i> (Kiener, 1840)				x

<i>Turbonilla</i> sp.	x	x		x
<i>Turritella</i> sp.		x		
<i>Urosalpinx</i> sp. cf. <i>U. perrugata</i> (Conrad, 1846)				x
* <i>Ventrilia rucksorum</i> Petuch, 1994	x			x
<i>Vermicularia</i> sp.	x			x
* <i>Volutifusus obtusus</i> (Emmons, 1858)	x			x
Mollusca (Bivalvia)				
<i>Abra aequalis</i> (Say, 1822)	x	x		
* <i>Anadara aequicostata</i> (Conrad, 1845)	x	x		x
<i>Anomalocardia auberiana</i> (d'Orbigny, 1842)	x			
<i>Anomia simplex</i> d'Orbigny, 1842	x	x	x	x
<i>Argopecten</i> sp.	x	x		x
<i>Brachidontes exustus</i> (Linnaeus, 1758)				x
* <i>Carditamera arata</i> (Conrad, 1832)				x
<i>Chama</i> sp.		x		
<i>Chione cancellata</i> (Linnaeus, 1767)	x	x	x	x
<i>Chione latilirata</i> (Conrad, 1841)		x		
* <i>Conradostrea sculpturata</i> (Conrad, 1840)	x	x		x
<i>Corbula</i> sp.	x	x		
<i>Crassostrea virginica</i> (Gmelin, 1791)		x		x
<i>Dinocardium robustum</i> (Lightfoot, 1786)	x	x		x
<i>Diplodonta</i> sp.				x
<i>Donax variabilis</i> Say, 1822	x	x		x
<i>Dosinia discus</i> (Reeve, 1850)				x
<i>Dosinia elegans</i> Conrad, 1843				x
<i>Ensis</i> sp.		x		
<i>Ensis minor</i> Dall, 1900		x		x
<i>Glycymeris pectinata</i> (Gmelin, 1791)		x		
<i>Laevicardium</i> sp.			x	x
* <i>Linga waccamawensis</i> (Dall, 1903)/ <i>amiantus</i> (Dall, 1901)	x			
<i>Macrocallista nimbosa</i> (Lightfoot, 1786)			x	x
<i>Mercenaria campechiensis</i> (Gmelin, 1791)	x	x		x
* <i>Mulinia congesta</i> (Conrad, 1833)	x	x		x
* <i>Noetia limula</i> (Conrad, 1832)	x	x		x
<i>Nucula proxima</i> Say, 1822	x	x		
<i>Parvilucina multilineata</i> (Tuomey & Holmes, 1856)	x			x
<i>Pitar</i> sp.	x			
<i>Pleuromeris tridentata</i> (Say, 1826)	x	x		
<i>Pseudomiltha floridana</i> (Conrad, 1833)		x	x	x
<i>Spisula</i> sp.	x	x		
<i>Tagelus plebeius</i> Lightfoot, 1786				x
<i>Tellina</i> sp.			x	
* <i>Trachycardium emmonsi</i> (Conrad, 1867)				x
Annelida				
<i>Spirorbis</i> sp.	x			
Arthropoda (Cirripedia)				
<i>Balanus</i> sp. A	x	x		
<i>Balanus</i> sp. B			x	
Arthropoda (Malacostraca)				
<i>Persephona</i> sp.	x			x

Figure 6 (opposite page). Invertebrate fossils from the Tucker Borrow Pit, Brevard County, Florida. A,B. *Mulinia congesta* (Conrad, 1833), internal and external view of right valve; (UF 65151). C. *Chione cancellata* (Linnaeus, 1767), external view of left valve; (UF 69419). D. *Pseudomiltha floridana* (Conrad, 1833), external view of right valve; (UF 69418). E. *Melongena corona* (Gmelin, 1791), ventral view; (UF 65723) F. *Mercenaria campechiensis* (Gmelin, 1791), external view of left valve; (UF 69414). G. *Busycon carica* (Gmelin, 1791), ventral view; (UF 65198) H. *Conradostrea sculpturata* (Conrad, 1840), external view of left valve; (UF 65277). Specimens F and G were collected from Unit 1A, specimen H from Unit 1B, specimens C,D, and E from Unit 3, and specimen A,B was collected from spoil. All specimens shown at natural size (x1).

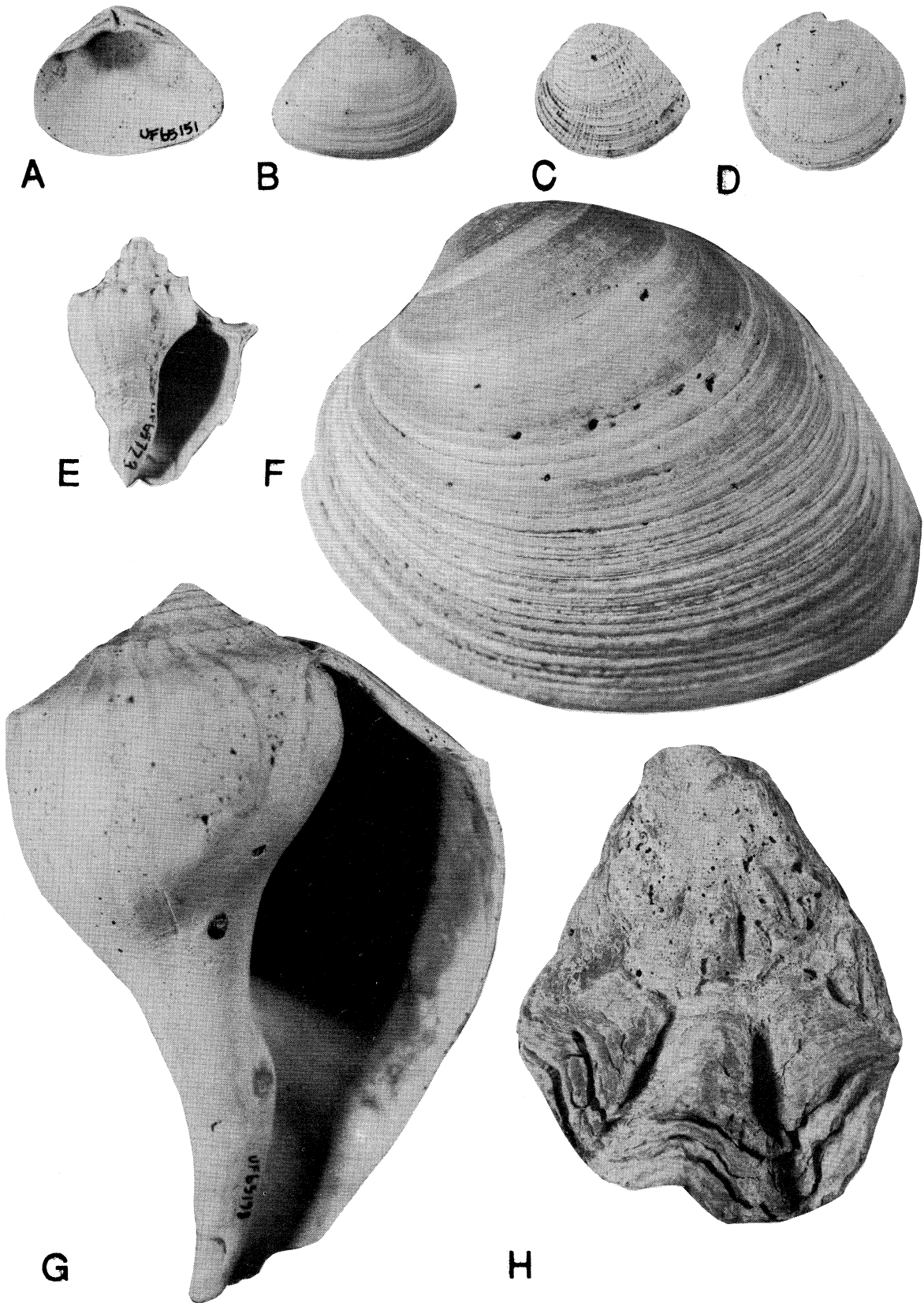
The marine invertebrate assemblage from Unit 1 consists primarily of mollusks; 22 gastropods and 26 bivalves. Other invertebrates present include: 1 poriferan, 1 cnidarian, 6 bryozoans, 1 annelid, and 2 arthropods. Dominating the fauna in abundance is the extinct bivalve *Mulinia congesta* (Conrad, 1833) (Figure 6A-B) followed by the gastropod *Crepidula fornicata* (Linnaeus, 1758). Other common constituents are the bivalves: *Mercenaria campechiensis* (Gmelin, 1791) (Figure 6F), *Conradostrea sculpturata* (Conrad, 1840) (Figure 6H), *Anadara aequicostata* (Conrad, 1845), and *Anomia simplex* d'Orbigny, 1842 and the gastropod *Busycon carica* (Gmelin, 1791) (Figure 6G). Bulk samples show that broken shells far outweigh unbroken shells and that all shells show signs of tumbling. Many shells are heavily eroded by both mollusk and sponge borings and are encrusted with bryozoans, annelids, or corals, which indicates exposure on the sea floor. No articulated clam valves were recovered. Because of the extreme wear on many of the shells, some of the more uncommon taxa were difficult to identify to specific level.

Unit 3 is also dominated by marine mollusks but the bivalves *Chione cancellata* (Linnaeus, 1767) (Figure 6C), and *Pseudomiltha floridana* (Conrad, 1833) (Figure 6D) are most abundant. The only gastropod present *Melongena corona* (Gmelin, 1791) (Figure 6E) was also quite common. Additional molluscan taxa present are the bivalves; *Anomia simplex*, *Laevicardium* sp., *Macrocallista nimbose* (Lightfoot, 1786), and *Tellina* sp. Many of the bivalves are paired and were collected in life position. A thin clay coating adhered to most of the shells and all are highly leached rather than highly abraded as was seen in specimens from Unit 1. One species of arthropod, a barnacle, was also found in this unit. Unfortunately, only isolated shells were collected. No opercular plates, necessary for identification, were recovered. Due to time constraints mentioned earlier in the paper (one day of invertebrate fossil sampling), our collecting efforts were concentrated on the more highly fossiliferous Unit 1 and therefore, a much smaller sample was collected from Unit 3.

Spoil materials were collected along the dirt road above the north wall of Pit 2 (Figure 1B). Eighteen taxa collected from spoil are not represented from the *in situ* collections of Units 1 and 3. These include the colonial coral *Solenastrea hyades* (Dana, 1846); the marine snails *Bulla striata* Bruguiere, 1792, *Busycotypus incile* (Conrad, 1833), *Busycotypus spiratus* (Lamarck, 1816), *Cancellaria* sp., *Longchaeus suturalis* (H. C. Lea, 1843), *Strombus* sp., *Triplofusus gigantea* (Kiener, 1840), and *Urosalpinx* sp. cf. *U. perrugata* (Conrad, 1846); the freshwater snails *Planorbella duryi* (Wetherby, 1879) and *P. scalare* (Jay, 1839); and the marine bivalves *Brachidontes exustus* (Linnaeus, 1758), *Carditamera arata* (Conrad, 1832), *Diplodonta* sp., *Dosinia discus* (Reeve, 1850), *D. elegans* Conrad, 1834, *Tagelus plebeius* Lightfoot, 1786, and *Trachycardium emmonsi* (Conrad, 1867). Nearly all of these invertebrates are represented by only a few specimens.

AGE AND PALEOECOLOGY

The age of the Tucker Borrow Pit Local Fauna can be determined by assessing the biochronology of selected species of land mammals. Further constraints on the age are provided by biochronological data from the underlying and overlying marine molluscan faunas. A late early or middle Irvingtonian age for the Tucker Borrow Pit LF is indicated by the presence of *Holmesina floridanus*, *Tapirus haysii*, and *Mammuthus* cf. *M. hayi*. None of these three mammals are known from Florida sites younger than middle Irvingtonian (Morgan and Hulbert, 1995), and *H. floridanus* is unknown after the early Irvingtonian (Hulbert and Morgan, 1993). The only well known



middle Irvingtonian site from Florida, the McLeod Limerock Mine in Levy County, has the large pampathere *Holmesina septentrionalis*, the typical Rancholabrean member of the genus. Other evidence indicates that McLeod is late in the middle Irvingtonian (Morgan and Hulbert, 1995). Mammoths do not appear in North America until the latter half of the early Irvingtonian, sometime after 1.4 Ma (Webb and Dudley, 1995), which provides a maximum age for the Tucker Borrow Pit. The slightly more advanced stage of evolution of the Tucker *Mammuthus* compared to the Leisey *M. hayi* sample, provides evidence that the Tucker Borrow Pit may be a bit younger than Leisey. Taking into consideration all of the evidence from mammalian biochronology, the Tucker Borrow Pit LF is definitely younger than 1.4 Ma and older than 0.6 Ma, and is most likely between 1.2 and 0.7 Ma.

The presence of sharks, rays, sawfish, alligator gar, and other marine fishes in the Tucker Borrow Pit provide strong evidence that the site formed in a shallow, nearshore marine environment. However, the relative abundance of freshwater species in the Tucker Site, particularly pond turtles, soft-shelled turtles, and alligators, complicates the situation. These freshwater species, as well as the less abundant terrestrial members of the fauna, suggest that a river flowed into the Atlantic Ocean near where the fossil site formed, carrying the bones of the freshwater and terrestrial species into the shallow marine environment where they were deposited. Relative sea level and the position of the Atlantic Coast at the time the Tucker Site formed are also important factors in this discussion. The location of the primary bone-bearing level (Unit 2A) about 3-4 m above present sea level and the occurrence of marine vertebrates 40 km inland from the modern Atlantic Coast both strongly suggest that sea level was somewhat higher when the Tucker Site was deposited. An even higher sea level is indicated by the presence of abundant marine mollusks in the overlying Fort Thompson Formation (Unit 3). Relative sea level, coupled with vertebrate and invertebrate biochronology, has been helpful in refining the age estimates for certain Florida Pliocene and Pleistocene sites (Morgan and Hulbert, 1995; Portell et al., 1995; Karrow et al., in press). Widespread application of relative sea level as a chronological tool will require a more refined sea level chronology for Florida during the late Pliocene and Pleistocene, as recent studies (see discussion in Morgan and Hulbert, 1995) now indicate that there were more than 20 glacial-interglacial cycles following the onset of continental glaciation in North America about 2.5 Ma.

The relative age of Unit 1 can be determined by looking to several of the extinct invertebrate taxa. These include: one cnidarian, *Septastrea crassa* (Holmes, 1858); two gastropods, *Ventrilia rucksorum* (Petuch, 1994) and *Volutifusus obtusus* (Emmons, 1858) (Figure 7); and four bivalves, *Anadara aequicostata* (Conrad, 1845), *Conradostrea sculpturata* (Conrad, 1840), *Mulinia congesta* (Conrad, 1833), and *Noetia limula* (Conrad, 1831). *Septastrea crassa* is a common Florida coral found in the Pliocene Jackson Bluff Formation, Pinecrest Beds, and Caloosahatchee Formation. *Ventrilia rucksorum* (Petuch, 1994), a newly described taxon, is currently known only from the late Pliocene Nashua and Caloosahatchee formations. Petuch (1994) also described *Volutifusus halscotti* from Nashua Formation deposits collected at Rucks Pit (UF locality OB006) but because of the variable morphology of *Volutifusus* species we chose to place both the Tucker Borrow Pit *Volutifusus* and the Rucks Pit *Volutifusus* into the species *obtusum* pending further study. *Volutifusus obtusus* occurs in the Pliocene Yorktown, Duplin, Raysor, Chowan River, Waccamaw, and James City formations of Virginia and the Carolinas. In Florida, *V. obtusus* has been collected only from the Pinecrest Beds and Nashua Formation. The bivalves *A. aequicostata* and *N. limula* are known from the Chowan River, Waccamaw, and James City formations of Virginia and the Carolinas and the Caloosahatchee and Nashua formations of Florida. The bivalve *M. congesta* typically occurs in Plio-Pleistocene deposits throughout Florida, North and South Carolina, and Virginia. *Conradostrea sculpturata*, a common oyster found in fossil deposits around Florida as far back as the early Pliocene Tamiami Formation, makes its last appearance in southern Florida in the early Pleistocene Bermont Formation. Elsewhere, *C. sculpturata* is found in Plio-Pleistocene deposits in Virginia, the Carolinas, and Georgia. Most of the aforementioned taxa indicate that the invertebrate fossils from Unit 1 are late Pliocene in age.

No taxa from Unit 3 are age diagnostic because all appear to be modern species. However, several taxa collected from spoil and not from *in situ* deposits are noteworthy. These are the extinct gastropod *Busycotypus incile* and the extinct bivalves *Carditamera arata* and *Trachycardium emmonsii*. In Florida, *B. incile* is occasionally collected from the more southern Pliocene Pinecrest Beds and the northern Jackson Bluff Formation but more typically is found along the east coast in deposits attributed to the Nashua Formation, such as the F & W Mine (UF locality OR002) and Rucks Pit (UF locality OB006). Elsewhere *B. incile* occurs in the late Pliocene Duplin and Raysor formations of the Carolinas and Yorktown Formation of Virginia. Recently, Petuch (1994) described *B. scotti* from the Nashua Formation at Rucks Pit. Examination of Petuch's poorly preserved holotype of *B. scotti* makes it difficult to distinguish his species from the previously named *B. incile*, therefore, we chose to use

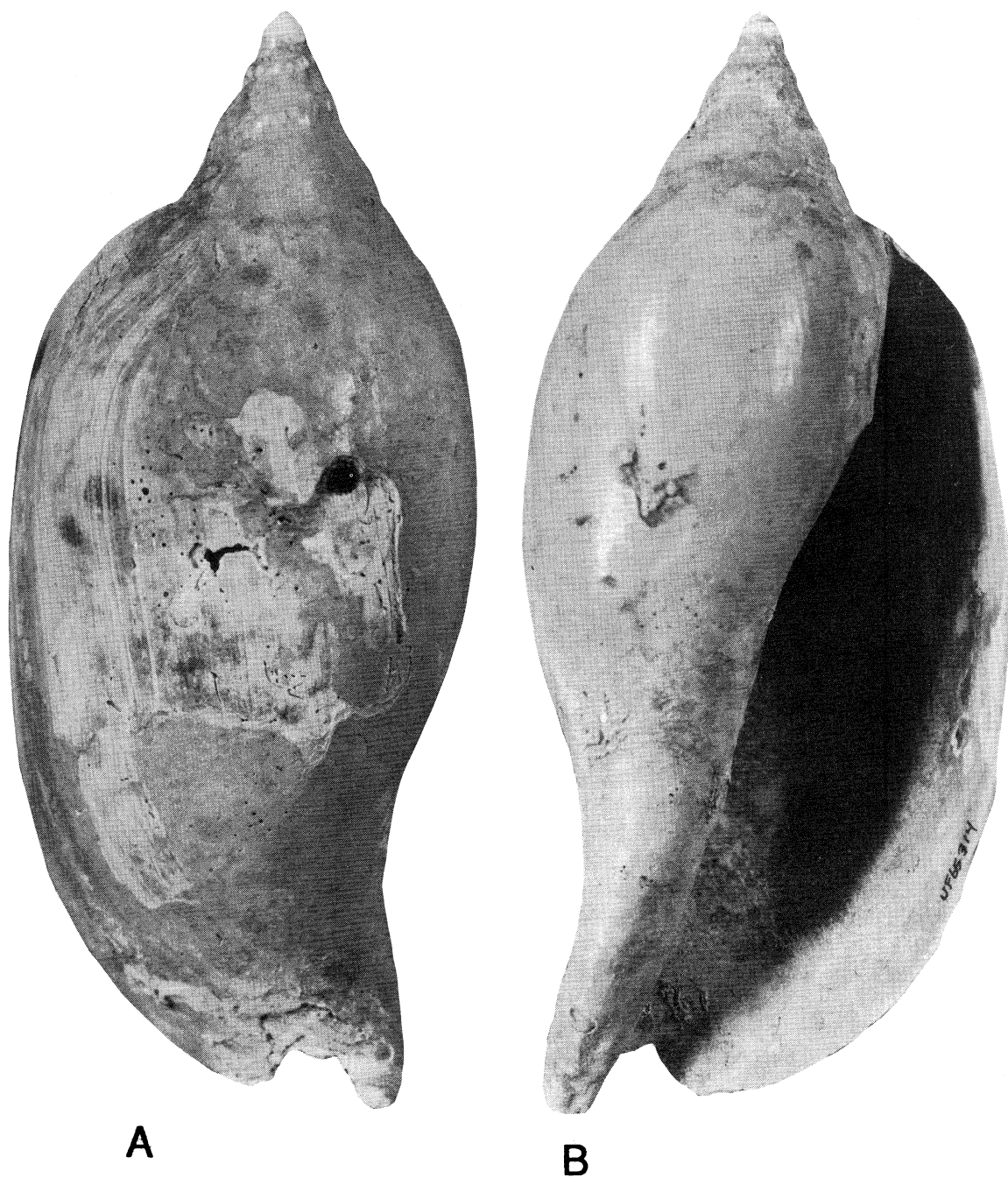


Figure 7. *Volutifusus obtusus* (Emmons, 1858) (UF 65314) collected from spoil at the Tucker Borrow Pit. A. Dorsal view. B. Ventral view. Specimen shown at natural size (x1).

the more established name pending further study. Along the west coast of Florida the bivalve *Carditamera arata* is known to occur in the Pliocene Pinecrest Beds, Jackson Bluff and Caloosahatchee formations, and the early Pleistocene Bermont Formation. *Trachycardium emmonsi* is found in the Pliocene Pinecrest Beds, Caloosahatchee Formation, and the early Pleistocene Bermont Formation. Taken together, all of the aforementioned taxa indicate a Pliocene age.

The paleoenvironment of Units 1 and 3 may be reconstructed by studying ecological preferences of modern molluscan taxa using data compiled by Stanley (1970) and Abbott (1974). As previously mentioned, the extinct bivalve *Mulinia congesta*, is by far the commonest species found in Unit 1 followed by the gastropod *Crepidula fornicata*. Other common taxa include *Mercenaria campechiensis*, *Anomia simplex*, and *Busycon carica*. The genus *Mulinia* is a shallow-burrowing surf clam which inhabits shallow water in sand and mud. *Mercenaria campechiensis* is a common, large, burrowing clam that inhabits nearshore marine environments preferably in soft, sandy sediments. *Anomia simplex* attaches to shell fragments and coarse sediment in shallow subtidal environments. *Crepidula fornicata* is a littoral species which attaches itself to shell debris, horseshoe crabs, and to one another. *Busycon carica* is also a shallow water species. Based upon the majority of modern species present in Unit 1 it becomes clear that these taxa were deposited in a shallow, marine, nearshore environment. Coupled with information previously presented on the poor condition of the majority of the shells with no preferred orientation, poor sorting, high percentage of broken shells many with signs of tumbling, and no articulation of bivalves, the environment of deposition for Unit 1 was also one of high energy. Additional evidence indicates burial did not take place immediately after the death of many of these organisms because bryozoans, barnacles, annelids, and corals had enough time to settle and flourish on this substrate.

Unit 3 is dominated by *Chione cancellata*, a shallow burrowing bivalve that generally can be found in intertidal to shallow subtidal environments in clean to slightly muddy sand. Other very common components collected from this unit include *Pseudomiltha floridana* (Conrad, 1833), common in shallow water up to a few fathoms, and *Melongena corona* (Gmelin, 1791) also shallow water. It appears that the environment of deposition was not nearly as high energy as in Unit 1.

SEBASTIAN CANAL LOCAL FAUNA

Webb (1974) reported a small vertebrate fauna from the Sebastian Canal, which forms the border between Brevard County on the north and Indian River County on the south (see map, Figure 1A). Two sites comprise the Sebastian Canal Local Fauna, designated Sebastian Canal 1 and Sebastian Canal 2 in the Florida Museum of Natural History vertebrate paleontology locality file. Sebastian Canal 1 is located on the southern side of the canal in northernmost Indian River County (NE $\frac{1}{4}$ of Section 3, T31S, R37E). Sebastian Canal 2 is located about 1 km east of Sebastian Canal 1, on both the northern side of the canal in southernmost Brevard County (SE $\frac{1}{4}$ of Section 35, T30S, R37E) and on the southern side of the canal in northernmost Indian River County (NE $\frac{1}{4}$ of Section 2, T31S, R37E). Both sites are on the Fellsmere 7.5 Minute Quadrangle and are located approximately 20 km (12 miles) west of Sebastian Inlet. The two Sebastian Canal sites were collected by S. D. Webb and Florida State Museum field crews between July 1967 and September 1968 under a grant from the U. S. Department of the Interior.

Both Sebastian Canal sites represent in-place accumulations, but they occupy slightly different stratigraphic positions and occur in different types of sediments. The Sebastian Canal 1 fossils were collected in the upper marly portion of a sequence of fine-grained limestone strata containing a diverse molluscan fauna. The vertebrate fossils at the Sebastian Canal 2 Site were derived from a layer of black organic silt and silty sand 30-70 cm thick. This organic layer lies stratigraphically above the vertebrate fossil-bearing unit at Sebastian Canal Site 1. Despite the differences in stratigraphic position and sediment composition, the vertebrate faunas from the two Sebastian Canal sites are indistinguishable and are combined into a single local fauna (Table 3).

The vertebrate fauna from Sebastian Canal consists of at least 25 species, including two species of fish, seven species of turtles, an alligator, several species of snakes, and 13 species of mammals (Table 3). Like the Tucker Borrow Pit Fauna, Sebastian Canal has a fairly diverse assemblage of freshwater taxa, particularly turtles and alligators. The abundance in both faunas of the giant box turtle, *Terrapene carolina putnami*, is notable. Although fish are rare and amphibians and birds are absent, this may be a collecting bias because the sediments in the

Sebastian Canal site were not extensively screen washed for micro-vertebrates. Another difference between these two faunas is the rarity of marine forms at Sebastian Canal. The only marine vertebrates in this site are the sawfish *Pristis* and a large baleen whale, each represented by a single vertebra.

At least half of the 12 species of terrestrial mammals in the Sebastian Canal LF are age diagnostic. The opossum *Didelphis virginiana* was thought to be restricted to the Rancholabrean Land Mammal Age until Martin (1974) identified this species in the late Irvingtonian Coleman 2A LF in Sumter County in central Florida. *D. virginiana* is represented at Sebastian Canal by an edentulous mandible (UF 12994). Coleman 2A is also the type locality of the extinct cotton rat *Sigmodon bakeri*, a species also known from several early Rancholabrean sites in Florida, as well as the middle Irvingtonian McLeod Limerock Mine in Levy County (Martin, 1974; Morgan and White, 1995). A small rodent mandible lacking cheek teeth (UF 12905) from Sebastian Canal can be referred to *S. bakeri* based on its size and presence of two accessory roots on the m1. Two large carnivores from Sebastian Canal help to constrain the age of this fauna. Emslie (1995) reported a right m2 (UF 19402) of the short-faced bear, *Arctodus pristinus*, from Sebastian Canal, one of the few fossils previously reported from this fauna. A recent examination of the Sebastian Canal collection uncovered a second fossil of this large bear, a distal femur (UF 150946). *A. pristinus* is restricted to late Blancan and Irvingtonian faunas in Florida, ranging from the late Blancan Kissimmee River LF and the earliest Irvingtonian Inglis 1A LF, both of which are late Pliocene, to its youngest record at Coleman 2A. The smaller Florida cave bear, *Tremarctos floridanus*, replaces *A. pristinus* in Florida Rancholabrean faunas. Armbruster's wolf, *Canis armbrusteri*, identified at Sebastian Canal by a distal radius (UF 150947), occurs only in Irvingtonian faunas. In Florida this small wolf is known from several late early Irvingtonian faunas, including Leisey Shell Pit, the middle Irvingtonian McLeod Limerock Mine, and the late Irvingtonian Coleman 2A (Berta, 1995). *C. armbrusteri* is replaced in Rancholabrean faunas by the much larger dire wolf, *Canis dirus*. Several upper premolars, a proximal metapodial, and a proximal radius (UF 12990) from Sebastian Canal are referred to the tapir, *Tapirus veroensis*. This small tapir first appears in Florida in the Coleman 2A LF and then persists throughout the Rancholabrean, going extinct about 11,000 years ago, along with the rest of the Pleistocene megafauna (Hulbert, 1995a). The only mammal present in Sebastian Canal 1, but absent from Sebastian Canal 2, is the Columbian mammoth, *Mammuthus columbi*. Mammoths are rare or absent in many Florida Irvingtonian faunas, thus their evolutionary history in the state is not well understood. Mammoths first appear in Florida during the late early Irvingtonian (after 1.4 Ma). The primitive species *M. hayi* is represented in several Florida sites of this age including, Leisey Shell Pit and Punta Gorda local faunas (Webb and Dudley (1995). *M. hayi* was tentatively identified from the Tucker Borrow Pit, although as noted above the best preserved tooth is intermediate in some features between *M. hayi* and *M. columbi*. According to Kurtén and Anderson (1980), *M. columbi* appears in the middle Irvingtonian and is the typical mammoth found in most Rancholabrean faunas.

Webb (1974) considered the Sebastian Canal vertebrate fauna to be Rancholabrean in age, but further study suggests that this fauna is late Irvingtonian instead. An Irvingtonian age for the Sebastian Canal LF is strongly indicated by the presence of *Arctodus pristinus* and *Canis armbrusteri*, both of which are unknown from younger Rancholabrean faunas. The age of this site is further restricted to the late Irvingtonian by the occurrence of *Didelphis virginiana* and *Tapirus veroensis*, two typical Rancholabrean species that make their earliest Florida appearance in the late Irvingtonian Coleman 2A LF. The overlapping range zones of *Arctodus pristinus* and *Canis armbrusteri* with *Didelphis virginiana* and *Tapirus veroensis* at both Coleman 2A and Sebastian Canal provides convincing evidence that these two sites are very close in age. The similarity between these two faunas is further emphasized by the presence of *Sigmodon bakeri*, as well as *Hesperotestudo mlynarskii*, a small land tortoise originally described from Coleman 2A (Auffenberg, 1988). Martin (1974) and Morgan and Hulbert (1995) considered Coleman 2A to be latest Irvingtonian in age, probably between 0.4 and 0.3 Ma.

The Sebastian Canal fauna appears to be somewhat younger than the Tucker Borrow Pit fauna. Despite the smaller number of taxa present in the Sebastian Canal, the age of this site can be more precisely determined owing to the occurrence of several biochronologically diagnostic species. The most convincing evidence of an older late early or middle Irvingtonian age for the Tucker Borrow Pit LF is the presence of the pampathere, *Holmesina floridanus*, the giant tapir, *Tapirus haysii*, and the mammoth *Mammuthus* cf. *M. hayi*. The Tucker Borrow Pit and Sebastian Canal are the only Irvingtonian faunas currently known from the Atlantic Coast of Florida.

Table 3. Vertebrate fauna from the late Irvingtonian Sebastian Canal, Brevard and Indian River counties, Florida.

Class Chondrichthyes
 Order Pristiformes
Pristis sp. (sawfish)

Class Osteichthyes
 Order Lepisosteiformes (gar)

Class Reptilia
 Order Testudines
Hesperotestudo crassiscutata (giant land tortoise)†
Hesperotestudo mlynarskii (dwarf land tortoise)†
 Chelydridae (snapping turtle)
Apalone ferox (soft-shell turtle)
 Kinosternidae (mud turtle)
Trachemys scripta (pond slider)
Terrapene carolina putnami (giant box turtle)†

Order Crocodylia
Alligator mississippiensis (alligator)

Order Squamata, Suborder Serpentes
 several species of snakes

Class Mammalia
 Order Marsupialia
Didelphis virginiana (opossum)

Order Xenarthra
Dasypus bellus (beautiful armadillo)†

Order Rodentia
Sigmodon bakeri (Baker's cotton rat)†

Order Carnivora
Arctodus pristinus (lesser short-faced bear)†
Canis armbrusteri (Armbruster's wolf)†

Order Perissodactyla
Equus sp. (extinct horse)†
Tapirus veroensis (Vero tapir)†

Order Artiodactyla
Platygonus sp. (peccary)†
Palaeolama mirifica (short-limbed llama)†
Odocoileus virginianus (white-tailed deer)

Order Proboscidea
Mammot americanum (American mastodon)†
Mammuthus columbi (Columbian mammoth)†

Order Cetacea
 Mysticeti (baleen whale)

† extinct species

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