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BALANOID BARNACLES FROM THE EARLY MIOCENE PARACHUCLA AND PENNEY FARMS FORMATIONS, NORTHERN FLORIDA

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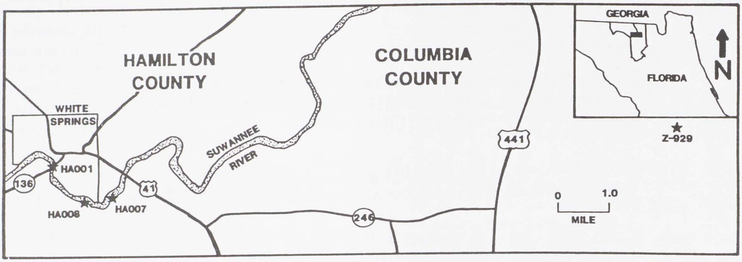
I. ABSTRACT

Balanus reflexus n. sp., geologically the earliest member of the *B. amphitrite* Darwin complex in the New World, *Concavus crassostricola* Zullo, a species originally described from the early Miocene (Aquitanian) of North Carolina, and "*Solidobalanus*" sp. indet., apparently related to the middle Eocene through early Oligocene "*Solidobalanus*" *antiquus* (Meyer) complex of the Gulf Coastal Plain, occur in the early Miocene (Aquitanian) Parachucla and laterally equivalent Penney Farms Formations in Columbia and Hamilton Counties, northern Florida. These species, together with *Actinobalanus floridanus* Zullo and Perreault from the late early Miocene (Burdigalian) Chipola Formation of the Florida Panhandle, and *Balanus humilus* Conrad, a *nomen dubium* purportedly from the Tampa Limestone and Hawthorne Formation, comprise the known Miocene cirriped fauna of Florida.

II. INTRODUCTION

The Porters Landing Member of the early Miocene (Aquitanian) Parachucla Formation exposed along the Suwannee River on the border between Hamilton and Columbia Counties near White Springs, northern Florida (text-fig. 1) contains a diverse invertebrate fauna which includes three balanoid barnacle species. A new species of the *Balanus amphitrite* Darwin complex is the most common barnacle in these beds, and the oldest recorded representative of this complex in North America. *Concavus crassostricola* Zullo, previously known from the early Miocene (Aquitanian) Pollocksville beds of North Carolina, is also represented in the Parachucla fauna. The Parachucla also contains a few scuta and shells of an indeterminate archaeobalanid. Although there is insufficient material for description of this archaeobalanid, the shell with its transparietal radii and solid basis, and the scutum, which lacks an adductor ridge, suggest relationship to the "*Solidobalanus*" *antiquus* (Meyer) complex of species that range from the late middle Eocene through the early Oligocene of the eastern Gulf Coastal Plain. A core (Osceola National Forest #1) penetrating the laterally equivalent Penney Farms Formation in Columbia County about 17.7 km (11 mi) east of White Springs (text-fig. 1) yielded disarticulated compartmental plates, small shells and opercular plates of the same three species.

Only two other barnacles have been described from Miocene deposits in Florida. The archaeobalanid *Actinobalanus floridanus* Zullo and Perreault occurs in the late early Miocene (Burdigalian) Chipola Formation of the Florida Panhandle (Zullo and Perreault, 1989). *Balanus humilus* Conrad, based on a steinkern of the internal cavity of a barnacle shell, was described by Conrad (1864) from the "Tampa Limestone" of south Florida, and was listed from an unspecified locality in the "Hawthorne Formation" by Ross and Newman (1967). *Balanus humilus* cannot be identified at either the generic or specific level (Ross, 1967) and, thus, must be regarded as a *nomen dubium*.



Text-Figure 1. Location of collecting sites along the Suwannee River and the Osceola National Forest #1 well (Z-929).

III. GEOLOGIC SETTING

The Parachucla Formation and laterally equivalent Penney Farms Formation are the oldest units in the early to middle Miocene (Aquitanian-Serravallian) Hawthorne Group (Huddlestun, 1988; Scott, 1988). In the study area at and near White Springs (University of Florida [UF] localities HA001, HA007, HA008), the Parachucla unconformably overlies the early Oligocene (Rupelian) Suwannee Limestone and is unconformably overlain by unnamed, undifferentiated Hawthorne sediments characterized by large boulders and lenses of highly lithified dolostone. Based on lithostratigraphic correlation with similar sediments found in Georgia, Huddlestun (1988 and personal communication, 1989) assigned the fossiliferous White Springs outcrops between his "unnamed dolostone, clay, and sand formation" and the Suwannee Limestone, to the Porters Landing Member of the Parachucla Formation. Here, the sediments range from well-sorted, fine quartz sand with minor amounts of clay and phosphate to a calcareous shelly sand. This locally continuous shell bed is approximately 9.8 ft (3.0 m) thick and contains a diverse invertebrate fauna (Portell, 1989). To the east, the Parachucla Formation grades into the laterally equivalent Penney Farms Formation (Scott, 1989). Eleven miles (17.7 km) to the east of UF locality HA001, barnacle-bearing sediments of the Penney Farms Formation were recovered from a depth of 142.5 ft (43.4 m) in the Osceola National Forest #1 core (University of North Carolina at Wilmington [UNCW] locality Z-929).

The primary difference between the Parachucla and Penney Farms Formations is that the latter contains a significantly higher proportion of carbonate beds interbedded with siliciclastics (Scott, personal communication, 1990). The Penney Farms mainly occurs as a subsurface unit and is found throughout northern and central Florida, whereas the Parachucla primarily underlies the eastern Coastal Plain of Georgia and extends northward into South Carolina (Scott, 1988, and Huddlestun, 1988, respectively). In addition to the White Springs area, the only other known occurrence of the Parachucla Formation in Florida is in northern Nassau County (Scott, 1989).

Huddlestun (1988) regarded the Porters Landing Member as being of early Miocene (Aquitanian) age based on planktonic foraminifera recovered from cores in Georgia. He suggested that the Porters Landing Member was either upper Zone N4 (upper *Globorotalia kugleri* Zone) or lower Zone N5 (lower *Catapsydrax dissimilis* Zone) of Blow (1969). Scott (1988) assigned a similar age to the Penney Farms Formation, also based on planktonic foraminifera.

IV. ACKNOWLEDGMENTS

We thank Paul F. Huddlestun, Georgia Geologic Survey, and Thomas M. Scott, Florida Geological Survey, for providing specimens from the Osceola National Forest #1 core in Columbia County, and for their insights regarding the stratigraphy of the Parachucla and Penney Farms Formations. This is University of Florida Contribution to Paleobiology number 381. We acknowledge the support of National Science Foundation Grant BSR-9002689.

V. SYSTEMATIC PALEONTOLOGY

Superfamily BALANOIDEA Leach
(Newman and Ross, 1976)
Family ARCHAEOBALANIDAE
Newman and Ross, 1976
Subfamily ARCHAEOBALANINAE
Newman and Ross, 1976
Genus SOLIDOBALANUS Hoek, 1913
(sensu lato)

SOLIDOBALANUS sp. indet.
Plate 1, figures 1-3

Discussion: Several disarticulated compartmental plates and two scuta from UF locality HA001 represent an archaeobalanid that is most similar in appearance to the Paleogene "*Solidobalanus*" *antiquus* complex of the eastern Gulf Coastal Plain. The compartmental plates have smooth parietes and narrow, transparietal radii (*i.e.*, radial sutural edges are fully denticulate and the radius spans the gap between adjacent paries). The scutum is relatively thin, flat, and higher than wide. The exterior of the scutum is ornamented only by growth increments. The interior is rather featureless, lacking both an adductor ridge and rugosities.

Material: Two scuta, disarticulated compartmental plates, UF locality HA001; one scutum, six compartmental plates, UNCW locality Z-929.

Occurrence: Early Miocene (Aquitanian), Parachucla and Penney Farms Formations, northern Florida.

Repository: Hypotypes UF 25163a-c, UF 25324a-b, UF 25347a-b are in the Invertebrate Paleontology Collection of the Florida Museum of Natural History, University of Florida, Gainesville.

Family BALANIDAE Leach
(Newman and Ross, 1976)
Subfamily BALANINAE Leach
(Newman, 1980)

BALANUS REFLEXUS, new species
Plate 1, figures 4-14

Diagnosis: Shell smooth, with toothed orifice; radii narrow with very oblique summits; scutum with sharply angulate tergal segment set off from remainder of plate by narrow ridge; adductor ridge long, parallel to occludent margin, and merging with very short articular ridge; narrow, vertical ridge present between adductor ridge and tergal margin; lateral depressor muscle pit absent or incipient; tergal spur furrow slightly overfolded; tergal spur basally rounded, short, less than one-quarter length of tergum, occupying about one-fourth length of basal margin, and placed less than its own width from basiscutal angle.

Description: Shell conic to cylindric, of small size, averaging 7 mm in height and 11 mm in greatest diameter for conic specimens, and 10 mm in height and 7 mm in greatest diameter for cylindric specimens; rostrum straight or slightly bowed toward carina; carina bowed outward; orifice toothed, large, diamond-shaped; exterior of parietes smooth or reflecting ornament of substratum; radii solid, very narrow, with very oblique (nearly 80°) summits; sutural edges of radii coarsely septate in lower part; alae broad, with welted, nondenticulate sutural edges and steeply oblique (60°) summits; sheath occupying upper half to two-thirds of interior of shell wall, with dependent lower edge and shallow cavity beneath; internal parietal ribs prominent near base of wall, and fading toward sheath; parietal tubes small, numerous, without transverse septa; parietal septa thin, basally denticulate; inner surface of outer lamina with several minute, incomplete septa between primary parietal septa; basis flat, or elongate in cylindric specimens, thickening toward margin, and bearing single row of tubes.

Scutum variable in width, but usually higher than broad, and flat or slightly twisted between apex and basal margin; tergal segment variable in width, but usually moderately broad, inflected about 45°, and delimited from remainder of external surface by exceedingly sharp angulation marked by low, narrow, longitudinal ridge; occludent and tergal margins straight; basal margin straight to slightly sinuous; exterior of scutum ornamented by narrow, closely spaced growth ridges; articular ridge prominent, but short, occupying no more than one-half of tergal margin, terminating in dependent point, and reflexed over deep, narrow, articular furrow; adductor ridge high, sharp, and long, extending parallel to occludent margin from near basal margin upward to merge with base of articular ridge; adductor ridge highest along margin of adductor muscle pit, and reflexed toward tergal margin; adductor muscle pit narrow, deep, elongate, with its midpoint at or below the midpoint of the scutum adjacent to the occludent margin; lateral depressor muscle pit absent or very small and incipient, located at basal margin within deep, triangular cavity formed by inflected tergal margin and short, thin, vertical ridge located halfway between adductor ridge and tergal margin; rostral depressor muscle pit long, slit-like, deep; basitergal angle broadly truncate; apical part of inner surface above adductor muscle pit and inner surface of articular ridge often rugose.

Tergum thin, flat, length excluding tergal spur slightly greater than width of basal margin; carinal margin convex; scutal margin slightly concave, forming moderately broad, flat shelf; basal margin slightly concave on carinal side of spur, straight on scutal side of spur; exterior ornamented by narrow, closely spaced growth ridges upturned in narrow strip along carinal margin; spur furrow broadly open, with both sides of plate slightly overfolding furrow; articular ridge prominent, long, erect, arcuate, narrowly rounded; articular furrow moderately broad, deep; inner surface of carinal side of basal margin with several, regularly spaced, longitudinal ridges between spur and basicarinal angle, including four short, but prominent depressor muscle crests situated in basicarinal angle; tergal spur short (less than 25% of total length of tergum), narrow (occupying about 25% of basal margin), parallel sided, broadly rounded basally, and placed a distance less than its own width from basiscutal angle; inner surface of tergum rugose and longitudinally ridged.

Holotype: Scutum, UF 25603a.

Type Locality: Porters Landing Member, Parachucla Formation, UF locality HA007.

Discussion: Balanus reflexus is distinguished from other species of the *B. amphitrite* complex by a combination of features including: (1) the marked angulation of the tergal segment of the scutum; (2) the presence of a secondary vertical ridge between the adductor ridge and tergal margin of the scutum; (3) the very short articular ridge of the scutum; (4) the short, narrow, broadly rounded tergal spur placed close to the basitergal angle; and (5) the narrow, steeply oblique radii. With the exception of the sharply angular tergal segment of the scutum, the opercular plates of *B. reflexus* share some features with species of *Fistulobalanus* Zullo, but the shell differs in lacking the multiple rows of parietal tubes and septate sheath characteristic of *Fistulobalanus*. The vertical ridge between the adductor ridge and the tergal margin of the scutum bears superficial resemblance to the lateral depressor ridge found in species of *Concavus* Newman, but the latter ridge is adjacent and functionally related to the structure of the depressor muscle pit, whereas that of *Balanus reflexus* is physically removed and unrelated to the area of lateral depressor muscle insertion.

Balanus reflexus is the oldest recognized species of the *B. amphitrite* complex in the Western Hemisphere. The next oldest records for the region are from the Pliocene of Florida and the Caribbean (*e.g.*, Weisbord, 1966, 1981), and the Neogene of the Gulf of California (Zullo and Buising, 1989). There are, however, a few Oligocene and numerous Miocene records in the literature from the Old World. Withers (1953) noted the presence of *B. amphitrite* at several Miocene localities in western Europe,

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PLATE 1

Figures

1-3. *Solidobalanus* s. l., sp. indet., UF locality HA001.
1, UF 25347a (hypotype), exterior of scutum, 10x; 2, UF 25347b (hypotype), interior of scutum, 10x; 3, UF 25347a (hypotype), interior of scutum, 10x.

4-14. *Balanus reflexus* n. sp.
4-5, UF 25470a (paratype), UF locality HA001, carinal and lateral views of conic shell, 3.5x; 6, UF 25470b (paratype), UF locality HA001, lateral view of subcylindric shell, 3.5x; 7, UF 25470c (paratype), UF locality HA001, lateral view of cylindric shell, 3.5x; 8, UF 25603b (paratype), UF locality HA007, interior of scutum, 10x; 9-10, UF 25621a (paratype), UF locality HA007, exterior and interior of tergum, 10x; 11-12, UF 25603a (holotype), UF locality HA007, exterior and interior of scutum, 10x; 13, UF 25603c (paratype), UF locality HA007, interior of scutum, 10x; 14, UF 25603d (paratype), UF locality HA007, interior of scutum, 10x.

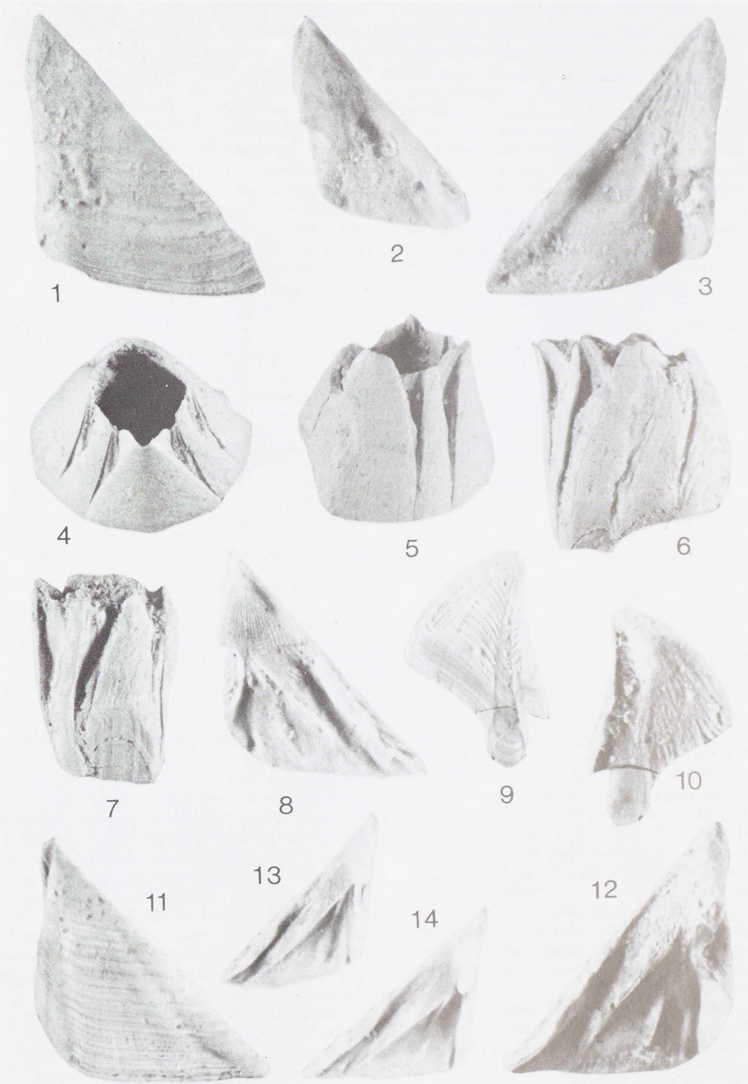

PLATE 1

but did not provide documentation. Davadie (1963) reported *B. amphitrite* (sensu lato) from the early Oligocene (Stampian) of Seine-et-Oise, France and the early Miocene (Aquitanian) of Carry, France, as well as from numerous localities ranging from the late early Miocene (Burdigalian) through the Pliocene of France and North Africa. The Neogene shells figured by Davadie (1963, pl. 19) are not diagnostic, and the figured opercular plates (*ibid.*, pls. 21-23), although assignable to the *B. amphitrite* complex, are from extant or Quaternary specimens. Alessandri (1906, pl. 17, figs. 10a, b, 11a, b) figured a scutum and tergum from the middle Miocene (Tortonian) of the Province of Messina, Sicily which he identified with *B. amphitrite*. These opercular plates do bear resemblance to those of *B. amphitrite* complex species, but in the absence of knowledge of the morphology of the shell, cannot be assigned to the complex with certainty. Kolosváry (1952) in a stratigraphic study of fossil Hungarian barnacles, recorded *B. amphitrite*, *B. amphitrite hungaricus* Kolosváry and *B. amphitrite litoralis* Kolosváry from the late Oligocene through Miocene, and *B. improvisus fossilis* Kolosváry from the early Miocene. In the absence of adequate descriptions or illustrations, it is extremely difficult to evaluate Kolosváry's taxa, or to utilize his data in determining geologic ranges and distribution of species groups.

Thus, although the literature on fossil cirripeds would suggest that the *B. amphitrite* complex has an extensive geologic history, there are very few well-documented records to support this contention. The importance of thorough description and illustration of fossil species in unravelling the geologic record of the balanoids is further underscored by the example of *Balanus amphitrite acutus* Withers, described from the Miocene of New Zealand. As shown by Buckeridge (1983), this barnacle has solid parietes and is, therefore, an archaeobalanid (now *Tasmanobalanus acutus*) and far removed from the *Balanus amphitrite* complex.

Etymology: The specific name is from the Latin *reflexus*, meaning bent or turned back, and refers to the marked angulation of the tergal segment of the scutum.

Material: Nineteen scuta, 36 shells, UF locality HA001; 16 scuta, one tergum, six shells, UF locality HA007; three scuta, UF locality HA008; four scuta, one tergum, two shells, UNCW locality Z-929.

Occurrence: Early Miocene (Aquitanian), Parachucla and Penney Farms Formations, northern Florida.

Repository: Holotype UF 25603a, and paratypes UF 25470a-c, UF 25603b-d, and UF 25621a are in the Invertebrate Paleontology Collection of the Florida Museum of Natural History, University of Florida, Gainesville.

CONCAVUS CRASSOSTRICOLA Zullo, 1984
Plate 2, figures 1-5

Concavus crassostricola ZULLO, 1984, Jour. Paleont., v. 58, p. 1328, figs. 6K-W'.

Diagnosis: "Medium-sized, conic shell with irregularly plicate, but most often prominently costate parietes; radii broad, with oblique summits; basis thick, porous. Scutum thick, slightly bowed between apex and basal margin, with narrowly reflexed tergal margin; exterior of scutum ornamented by deeply incised, broad, radial striae cutting growth ridges into prominent nodes. Tergum broad, with narrow tergal spur placed its own width from basiscutal angle; tergal spur furrow depressed, partially infolded, open to apex" (Zullo, 1984, p. 1329).

Holotype: Scutum, USNM 348774 (National Museum of Natural History, Smithsonian Institution).

Type Locality: Pollocksville beds (*Crassostrea* channel deposit), under railroad bridge on north bank of Trent River at Pollocksville, Jones County, North Carolina.

Discussion: Concavus crassostricola is distinguished from other North American species of *Concavus* by a combination of features including the simple sutural edge of the ala, the nodose external ornament of the scutum, and the paucity of transverse septa in the parietal tubes. *Concavus crassostricola* shares these features with *C. concavus* Bronn from the late Cenozoic of western Europe, from which it is most readily distinguished by the lack of a nonstriate strip on the exterior of the scutum adjacent to the occludent margin. This species appears to be restricted to deposits of Aquitanian age.

Material: 13 scuta, one tergum, three shells, UF locality HA001; two scuta, four compartmental plates, UNCW locality Z-929.

Occurrence: Early Miocene (Aquitanian), North Carolina and northern Florida.

Repository: Hypotypes UF 25128a, UF 25345a-b, and 25346a are in the Invertebrate Paleontology Collection of the Florida Museum of Natural History, University of Florida, Gainesville.

VI. LOCALITY DESCRIPTIONS

Florida Museum of Natural History, University of Florida (UF):

HA001 Early Miocene (Aquitanian), Porters Landing Member, Parachucla Formation, in river bank at or near State Route 136 bridge at White Springs on Columbia County side of Suwannee River (W1/2,

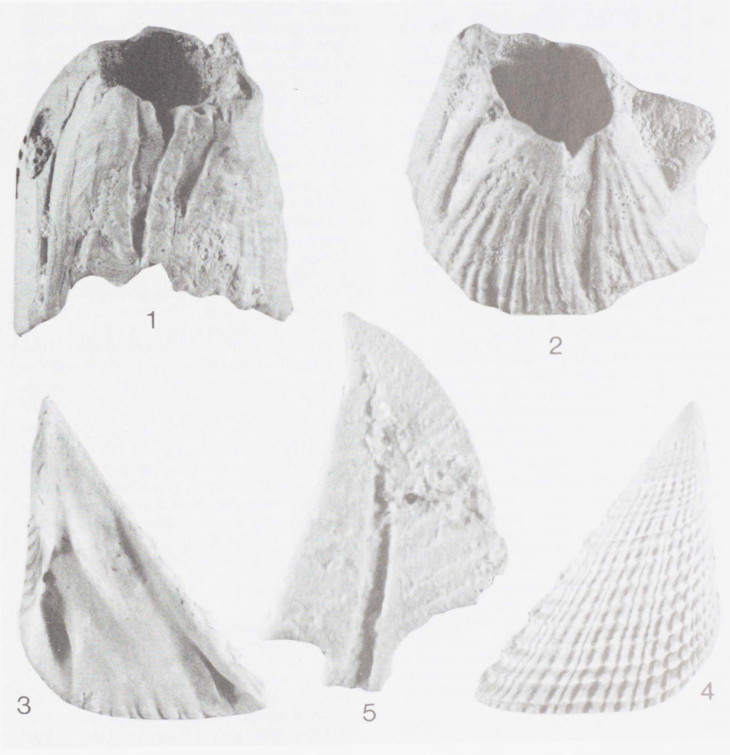

PLATE 2

Figures

1-5. *Concavus crassostricola* Zullo, UF locality HA001.
1, UF 25345a (hypotype), lateral view of plicate to obscurely ribbed shell, 3.5x; 2, UF 25345b (hypotype), lateral view of distinctly ribbed shell, 3.5x; 3-4, UF 25128a (hypotype), interior and exterior of scutum, 9x; 5, UF 25346a (hypotype), exterior of tergum, 9x.

NW1/4, SW1/4, sec. 7, R16E, T2S, White Springs West 7.5' quadrangle), Columbia County, Florida.

HA007 Early Miocene (Aquitanian), Porters Landing Member, Parachucla Formation, in river banks of Suwannee River, approximately 0.5 mi (0.8 km) southwest of U.S. Highway 41 bridge (W1/2, NW 1/4, sec. 17, R16E, T2S, White Springs East 7.5' quadrangle), Hamilton/Columbia Counties, Florida.

HA008 Early Miocene (Aquitanian), Porters Landing Member, Parachucla Formation, in river banks of Suwannee River, approximately 0.75 mi (1.21 km) southeast of State Route 136 bridge (NW1/4, NE1/4, sec. 18, R16E, T2S, White Springs West 7.5' quadrangle), Hamilton/Columbia Counties, Florida.

University of North Carolina at Wilmington (UNCW):

Z-929 Early Miocene (Aquitanian), Penney Farms Formation, 142.5 ft (43.4 m) depth, Osceola National Forest #1 core (NE1/4, NE1/4, NW1/4, sec. 11, R17E, T2S, Deep Creek 7.5' quadrangle), Columbia County, Florida.

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