

Photograph by B.R. Erickson

Branching *Ophiomorpha in situ* Pleistocene deposits along Colleton River at Victoria Bluff, Beaufort County, South Carolina.



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BIOTURBATION STRUCTURES IN
PLEISTOCENE COASTAL PLAIN SEDIMENTS OF
SOUTH CAROLINA, NORTH AMERICA

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INTRODUCTION

The recent cutting of a large forested area along the present south shore of the Colleton River in Beaufort County, South Carolina, has exposed an extensive tract of well-preserved burrows in unconsolidated Pleistocene marine sediments. These biogenic structures belong to the shallow water ichnogenus *Ophiomorpha* which closely resembles the burrows of the extant Carolina ghost shrimp *Callinassa* (Williams, 1984; Ruppert and Fox, 1988). The immense number of structures preserved here in the exact orientation they had in life is perhaps the most noteworthy aspect of this assemblage. They are dominantly vertical shafts, some having inclined branches and a few with basal chambers.

Burrows from sublittoral and intertidal deposits are among the most common ichnofossils ranging from the early Paleozoic to the Pleistocene. The present assemblage is worthy of documentation however because of its size (field of over 12,000 square meters with an estimated 500,000 burrows), the interesting paleoenvironmental implications which it provides, and the fact that commercial development will soon alter or destroy it.

KEY WORDS: *Ophiomorpha*, Pleistocene ichnofossils, intertidal burrows, trace fossils, Lebensspuren

MATERIALS AND METHODS

The authors visited the site on two separate occasions, once for mutual examination of the burrows and extensive photography by Erickson, and a second time for the collection of specimens and for sample measurements of burrow concentration densities by Sanders and Mr. Bruce Lampright. Sections of burrow structures were removed for preservation in the collections of The Charleston Museum (ChM) and The Science Museum of Minnesota (SMM). Prior to collection, specimens were stabilized by repeated applications of a liquid solution of the polyvinyl resin Butvar B-76. When dry, they were removed and wrapped securely in several layers of paper toweling for safe transportation. Sampling of concentration densities was made by counting the number of burrows in each of four randomly-selected one-meter squares spaced well apart from each other. Both the largest and the smallest burrow in each square were located, and the transverse diameter of their respective openings was recorded (Table 1).

TABLE 1. Population and size ranges of *Ophiomorpha in situ*, burrow field site, Beaufort County, South Carolina.

Meter square no.	Number of structures	Greatest internal diameter in mm	Least internal diameter in mm
1	38	13	7
2	67	12.5	5.5
3	54	13.5	5
4	51	15	3.5

Additional stabilization of the extremely friable burrow structures was applied to the collected specimens at The Charleston Museum. In some of them the sand filling was removed and replaced by cotton, which was then saturated with the Butvar solution (five grams Butvar powder/550 ml acetone), solidifying the cotton and bonding it securely to the previously-stabilized internal walls of the burrow shaft. Broken halves of burrows were rejoined by creating an internal core composed of a combination of cotton saturated with Butvar and a compound of plaster and gypsum (50%) and Butvar powder (50%) saturated in place with acetone. Composed entirely of sand, the burrow structures cannot be handled or maintained in a collection without comparable methods of preservation.

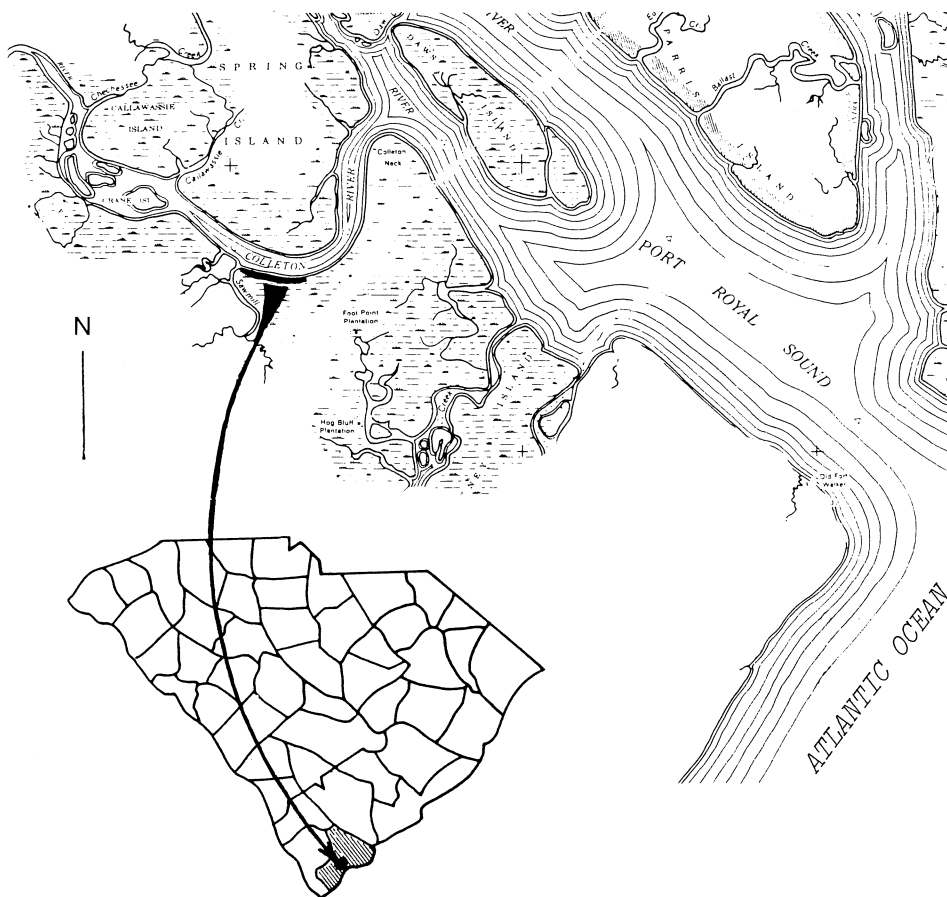


FIGURE 1. Maps show location of Pleistocene burrow field (solid black) in Beaufort County (cross-hatched) South Carolina.

DESCRIPTION

- Ichnogenus: *Ophiomorpha* Lundgren 1891
 Description based on field observations and of burrow sections in The Charleston (ChM PI9574-9580) and The Science Museum of Minnesota (SMM P91.3.1., lot of 15 specimens).
- Horizon: Wando (?) Formation, late Pleistocene.
- Locality: Victoria Bluff, south bank Colleton River east of Sawmill Creek, Beaufort County, South Carolina, USA (32o 16.3' N., 80o 48.8' W., USGS Spring Island 7.5' quad., Fig. 1).

Ophiomorpha has diverse morphology among its various ichnospecies ranging from simple to complex systems. Each shows distinctive linings of agglutinated pelletoidal sediments of: elliptical end-to-end pellets in rings around the burrow; irregularly distributed, ovoid to mastoid or conical pellets; or a mosaic of densely distributed discoid, ovoid or polygonal pellets (Frey and Howard, 1990). The present assemblage resembles the latter type (fig. 2). Raup and Stanley (1971) compare recent and fossil callianasid burrows.

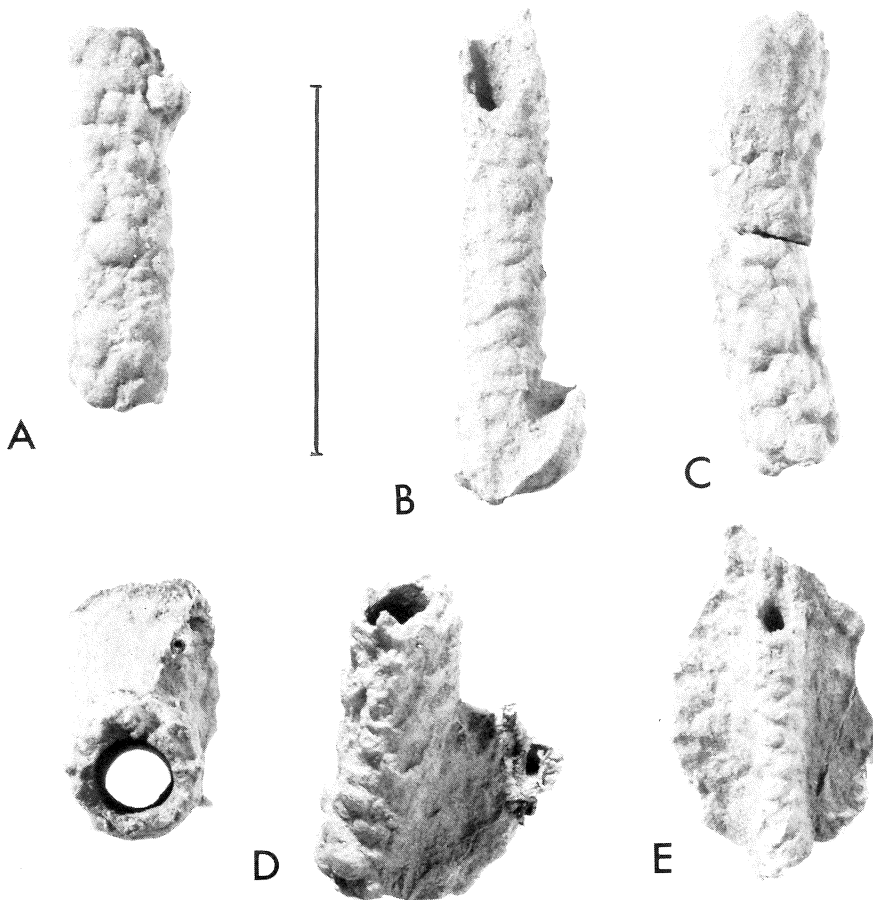


FIGURE 2. *Ophiomorpha* SMM P91.3.1 (lot) from Pleistocene burrow field site Beaufort County, South Carolina. A-C and E, show mammillated external surface and relative sizes; D, sectional view of burrow (left) and oblique view of burrow in situ (right). Scale bar equals 10 cm.

The burrow field discussed herein provides a glimpse of the principal infaunal element that inhabited this former intertidal sand flat. Wind scour and shifting of the present sandy surface of the host sediments, which is some two meters above present-day high tide level, has exposed thousands of permanent burrow "chimneys" (frontispiece and figs. 3-5).

The many visible structures are remnants of the thick-walled main burrows near an erosional bedding plain. These are cylindrical pipes with smooth linings and mammilated exterior surfaces. A few show inclined branches (frontispiece and fig. 5) which are interpreted as bypass structures or galleries. Others appear to have globe-shaped basal chambers that are located at about current high tide levels in the Colleton River. Burrow lengths up to two meters are present. Allowing for erosion of the upper end (entrance), this is similar to the length of burrows made by the extant form *Callianassa* (Ruppert and Fox, 1988). The supposed basal chamber ("enlarged pocket" of Williams, 1984, and "brood structure" of Curran and Frey, 1976) has the form of an asymmetrical, dorsoventrally compressed globe (fig. 6) of some 150 to 180 mm in diameter. Details of the chamber are not visible in the present material due to congealed mud and sand which covers its surface and increases its overall size. Curran and Frey (1976) describe the chamber (brood-structure bulb) walls and the small tubules that radiate from it.

Density counts by one of us (AES) range from 38 to 67 burrows per square meter (Table 1), an average of 52.5 structures among the four squares that were surveyed. Applied to the burrow field (an exposed surface of some 600 meters length and 20 or more meters breadth which disappears under a present-day stand of trees), that average indicates a burrow concentration in excess of 600,000 structures. Although the latter figure is at best a statistical implication and may exceed the actual number of structures present, the density of the population at this site is still impressive even if only half that number were present.

Measurements of external and internal diameters of individual burrows were taken from the six specimens in The Charleston Museum (Table 2). Both ends of the specimen were measured to provide a wider range of figures and a better appreciation of variations in the dimensions of individual burrows. Outside diameters of these structures range from 32 to 20.5 mm, with a mean diameter of 27.4 mm. Internal diameters range from 21 to 06.5 mm, with a mean of 14.7 mm. Among these specimens the most elaborate is a 189 mm section (ChM PI9575) consisting of a main burrow with smaller branches similar to the long burrow shown in the frontispiece. The main shaft is larger than either of its branches, one of which is broken off near the base of the preserved portion of the burrow and may represent an abandonment feature. The second branch (the "upper" branch in Table 2) departs the main burrow a short distance below its midsection and angles upward and outward, giving the entire structure its "Y"-shaped appearance. The long main burrow shown in the frontispiece shows a closure at its upper end which may also be an abandonment feature just above a bypass structure.



FIGURE 3. *Ophiomorpha*, Pleistocene burrow field along Colleton River at Victoria Bluff, Beaufort County, South Carolina with thousands of burrow “chimneys” exposed.

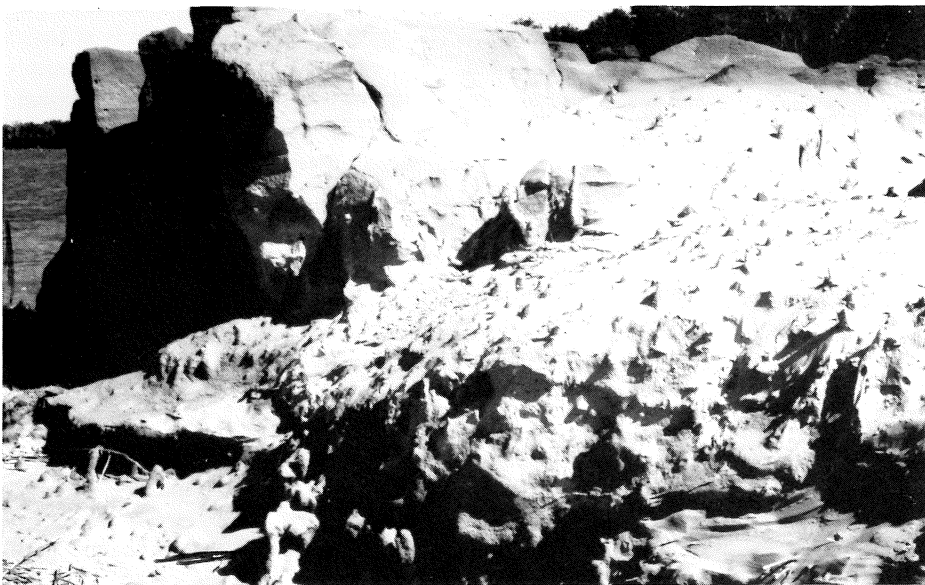


FIGURE 4. Eroding Pleistocene burrows at Victoria Bluff along Colleton River, Beaufort County, South Carolina.



FIGURE 5. *Ophiomorpha* *in situ* at burrow field site along Colleton River, Beaufort County, South Carolina. Arrow shows branch.

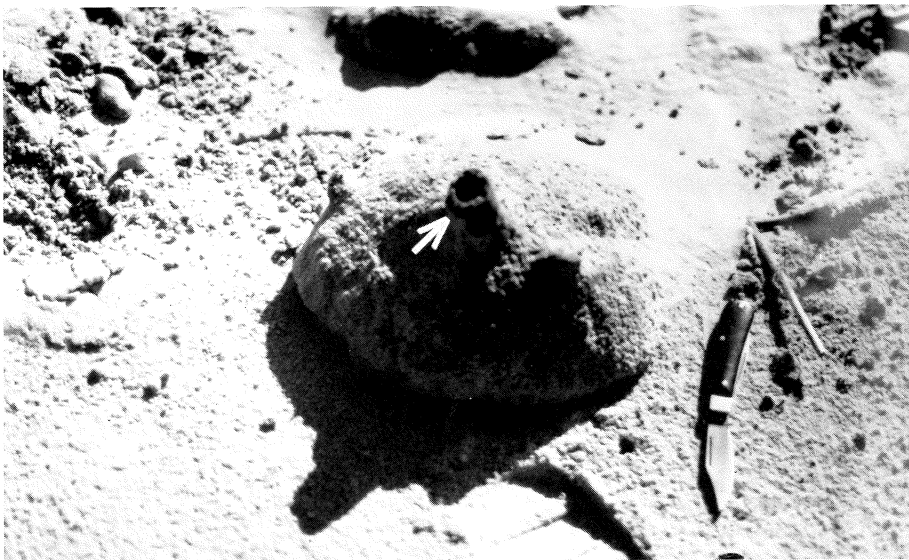


FIGURE 6. Supposed *Ophiomorpha* basal chamber, Pleistocene burrow field site at Victoria Bluff, Colleton River, Beaufort County, South Carolina. Arrow indicates main burrow.

No body fossils were found nor was there evidence of associated deposit-feeding forms such as bivalves or gastropods. It is suspected that aragonite-shelled invertebrates may have been dissolved away. Diagenesis often enhances trace fossils, whereas body fossils are often deformed or disintegrated (Seilacher, 1964; Frey, 1975). Biogenic structures are frequently the only fossils present in some sedimentary deposits (Rhoads, 1967).

TABLE 2. Measurements of *Ophiomorpha* from burrow field site, Beaufort County, South Carolina in mm.

ChM specimens	Length of section	External diameter	Internal diameter	Location
PI9575	189	26	16	main branch
PI9575		20.5	10	upper branch
PI9575		21	12	lower branch
PI9575		28	18	base
PI9576	140	30	20	upper
PI9576		31	20	lower
PI9577	75	31	21	upper
PI9577		30	20.5	lower
PI9578	75	23.5	16.5	upper
PI9578		25	16.5	lower
PI9579	52	32	15	upper
PI9580	55	30.5	10	upper
PI9580		28.5	6.5	upper
PI9580		32	10	lower
PI9580		23	10	lower

PALEOECOLOGICAL AND ETHOLOGICAL NOTES

The paleoenvironment of this assemblage of *Ophiomorpha* is interpreted as a muddy intertidal sand flat of low energy and low or fluctuating salinity. Cross-bedded facies within this deposit such as shown in the frontispiece indicate a tidal channel (Carter, 1975). The thickly lined burrows appear to have been both *Domichnia* (dwelling) and *Fodinichnia* (feeding) structures (Basan, 1978). Evidence of changes in water level is suggested by the bypass tunnels that were constructed to the substrate surface after erosion had reduced the permanent burrow to an open tube (Howard, 1978). Burrows, however, show few possible abandonment signs of main burrows at the bypass structure or any evidence of reactivation of the permanent burrow. This may be due to limited sampling.

At high tide a variety of bottom feeders, such as shelled invertebrates and flatfishes such as flounder, must have utilized the site. At low tide other deposit feeders, such as polychaetes and wading birds, most likely fed here as well.

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