Gallery of Geology: The trace fossil Ophiomorpha from the Upper Cretaceous Trinidad Sandstone, northeastern New Mexico

Spencer G. Lucas

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New Mexico Bureau of Geology & Mineral Resources
New Mexico Institute of Mining & Technology
801 Leroy Place
Socorro, NM 87801-4796

https://geoinfo.nmt.edu

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Gallery of Geology

The trace fossil *Ophiomorpha* from the Upper Cretaceous Trinidad Sandstone, northeastern New Mexico

Spencer G. Lucas
New Mexico Museum of Natural History, Albuquerque, NM 87104

Trace fossils are structures in sedimentary rocks that record the interaction of organisms with sediment. Often thought of as "fossilized behavior," trace fossils are important archives of the activities of extinct plants and animals. Many trace fossils are also strong indicators of paleoenvironments, an observation that underlies the concept of ichnofacies. This is in part because specific organismal behaviors are often correlated with particular substrates. Many trace makers are also specific to a particular type of habitat, and this specificity provides an important tool in identifying and interpreting ancient environments.

One environmentally diagnostic trace fossil is the burrow *Ophiomorpha*, which indicates littoral to shallow-marine paleoenvironments (Buatois and Mángano, 2011). Thus, *Ophiomorpha* are found in virtually all of the shallow-marine or shoreline Upper Cretaceous

This outcrop just southwest of Raton, New Mexico, is characteristic of the Upper Cretaceous Trinidad Sandstone in the Raton Basin. The Trinidad forms a bold cliff of light-colored sandstone that accumulated in a nearshore environment above slope-forming shale of the offshore-marine, Upper Cretaceous Pierre Shale. Coal beds above the Trinidad Sandstone mark the base of the overlying, fluvio-deltaic deposits of the Upper Cretaceous Vermejo Formation.

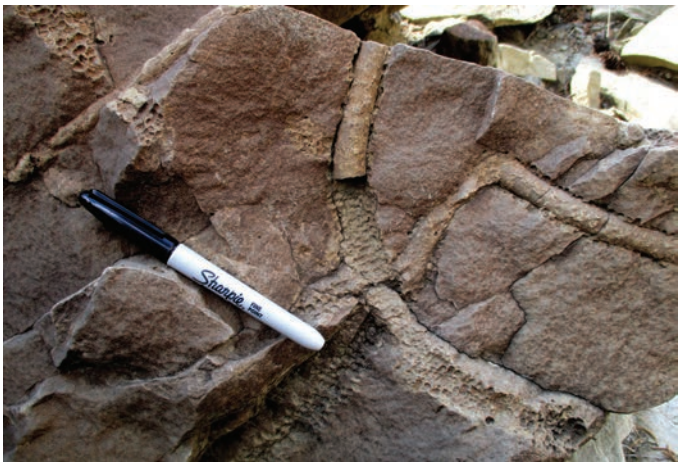
A characteristic *Ophiomorpha* burrow in the Trinidad Sandstone at Vermejo Park, northeastern New Mexico. Note the nodose, "corn-cob" wall of the burrow, which branches in the lower left part of the photograph. For scale, the pen is approximately 14 cm long.

sandstone-dominated stratigraphic units in the San Juan Basin of northwestern New Mexico. In the Raton Basin of northeastern New Mexico, *Ophiomorpha* is particularly abundant in the Upper Cretaceous Trinidad Sandstone, which records the final retreat of the Western Interior Seaway from the state.

Ophiomorpha consists of cylindrical tunnels with diameters of 0.5 to 3 cm and burrow lengths of up to one meter. These burrows often form three-dimensional burrow systems comprising both vertical and horizontal tunnels. The tunnels usually branch at acute angles, and the branch points are often "swollen"—larger than the adjacent tunnel segments. Perhaps most characteristic of *Ophiomorpha* is the structure of the burrow wall, which is packed with discoidal, ovate brick-like pellets several millimeters in diameter, giving the burrow wall its diagnostic nodose exterior—a "corn-cob" texture.

An extensive literature on *Ophiomorpha* has been published (see, for example, the bibliographies in Müller, 1969; Kennedy and Sellwood, 1970; Häntzschel, 1975). Particularly important to understanding the trace fossil is the recognition that modern decapod crustaceans, in particular callianassid shrimp, make *Ophiomorpha*-like burrows (Weimer and Hoyt, 1964). This correlation of trace and trace maker has also found fairly direct support in Cretaceous strata of Delaware, where Pickett et al. (1971) reported fossilized callianassid claws associated with *Ophiomorpha* burrows. Today, the callianassid shrimp build such burrows by digging and then packing the burrow walls with pellets that the shrimp cement together. Swollen parts of the burrows are places where the shrimp turned around.

The oldest fossils of *Ophiomorpha* are from Pennsylvanian–Permian rocks (Chamberlain and Baer, 1973; Driese and Dott, 1984; Buatois et al., 2002; Carmona et al., 2004; though note that L. Buatois, written commun., 2019, now doubts that any of these Paleozoic records should be assigned to *Ophiomorpha*). Reports of *Ophiomorpha* in



These *Ophiomorpha* burrows in the Trinidad Sandstone at Vermejo Park, New Mexico, show preservation of not only the exterior burrow walls, but of the fill of the burrow, which is finer grained than the host rock. For scale, the pen is about 14 cm long.

New Mexico are restricted to Cretaceous rocks. In addition to being indicators of shallow-marine, shoreline environments, the burrows also create what has been called an ichnofabric in the strata that were burrowed. Thereby, the *Ophiomorpha* burrows can enhance the permeability and the vertical transmissivity of impermeable sediment. This takes place when the burrows are filled with a contrasting sediment derived from overlying deposits. Thus, if the encasing bed is impermeable and the fill is permeable, the preserved burrow creates anisotropic porosity and permeability (Pemberton and Gingras, 2005). Furthermore, the burrow may also pass through an impermeable layer that separates two permeable layers.

Thalassinoides is another crustacean burrow preserved in the Trinidad Sandstone at Vermejo Park, New Mexico. *Thalassinoides* and *Ophiomorpha* are fairly similar in size and branching style, but *Thalassinoides* lacks the nodose exterior burrow wall that is diagnostic of *Ophiomorpha*. For scale, the pen is approximately 14 cm long.

In the Raton Basin of northeastern New Mexico and southeastern Colorado, the Trinidad Sandstone is a sandstone-dominated lithostratigraphic unit that is up to 100 m thick (Lee, 1917; Johnson and Wood, 1956). It consists of light-gray to yellowish-gray, fine- to medium-grained feldspathic sandstone that is tabular bedded or cross bedded, forming a bold, light-colored cliff at most of its outcrops. The contact with the underlying Upper Cretaceous Pierre Shale is a transition zone of interbedded shale and sandstone representing a lower shoreface environment of deposition. A coal bed marks the base of the Upper Cretaceous Vermejo Formation above the Trinidad Sandstone.

The Trinidad Sandstone was deposited in delta-front and other shoreline settings as the Western Interior Seaway retreated to the east and northeast (Pillmore and Maberry, 1976). *Ophiomorpha* is common and particularly abundant at almost all outcrops of the Trinidad Sandstone. The *Ophiomorpha* in the Trinidad Sandstone are primarily vertical and are indicative of relatively high-energy, delta-front and distal-delta paleoenvironments. They are commonly associated with other trace fossils indicative of shallow-marine or shoreline paleoenvironments, such as *Thalassinoides*, *Aulichnus,* or *Teichichnus*. Wherever it is found, *Ophiomorpha* is a good indicator of shallow-marine settings, usually of relatively high energy of deposition.

References

Buatois, L.A., and Mángano, M.G., 2011, Ichnology: organism-substrate interactions in space and time: Cambridge, Cambridge University Press, 358 p.

Buatois, L.A., Mángano, M.G., Alissa, A. and Carr, T.R., 2002, Sequence stratigraphy and sedimentologic significance of biogenic structures from a late Paleozoic marginal- to open-marine reservoir, Morrow Sandstone, subsurface of Kansas, USA: Sedimentary Geology, v. 152, p. 99–132.

Carmona, N.B., Buatois, L.A., and Mángano, G., 2004, The trace fossil record of burrowing decapod crustaceans: evaluating evolutionary radiations and behavioural convergence: Fossils and Strata, v. 51, p. 141–153.

Chamberlain, C.K., and Baer, J.L., 1973, *Ophiomorpha* and a new thalassinoid burrow from the Permian of Utah: Brigham Young University Geology Studies, v. 20, p. 79–94.

Driese, S.G., and Dott, R.H., 1984, Model for sandstone-carbonate "cyclothems" based on upper member of Morgan Formation (Middle Pennsylvanian) of northern Utah and Colorado: American Association of Petroleum Geologists Bulletin, v. 68, p. 574–597.

Häntzschel, W., 1975, Trace fossils and problematica, in Teichert, C., ed., Treatise on Invertebrate Paleontology, Part W, Miscellanea, Supplement 1: Geological Society of America, and Lawrence, University of Kansas Press, 2nd ed., p. W1–W269.

Johnson, R.B., and Wood, G.H., Jr., 1956, Stratigraphy of Upper Cretaceous and Tertiary rocks of Raton Basin, Colorado and New Mexico: American Association of Petroleum Geologists Bulletin, v. 40, p. 707–721.

Kennedy, W.J., and Sellwood, B.W., 1970, *Ophiomorpha nodosa* Lundgren, a marine indicator from the Sparnacian of southeast England: Proceedings of the Geologists' Association, v. 81, p. 99–110.

Lee, W.T., 1917, Geology of the Raton Mesa and other regions in Colorado and New Mexico: U.S. Geological Survey Professional Paper 101, 221 p.

Müller, A.H., 1969, Zur Kentniss von *Ophiomorpha* (Miscellanea): Geologie, v. 18, p. 1102–1109.

Pemberton, S.G., and Gingras, M.K., 2005, Classification and characterizations of biogenically enhanced permeability: American Association of Petroleum Geologists Bulletin, v. 89, p. 1493–1517.

Pickett, T.E., Kraft, J.C., and Smith, K., 1971, Cretaceous burrows: Chesapeake and Delaware Canal, Delaware: Journal of Paleontology, v. 45, p. 209–211.

Pillmore, C.L., and Maberry, J.O., 1976, Depositional environments and trace fossils of the Trinidad Sandstone, southern Raton Basin, New Mexico: New Mexico Geological Society, Guidebook 27, p. 191–195.

Weimer, R.J., and Hoyt, J.H., 1964, Burrows of *Calianassa major*, Say, geologic indicators of littoral and shallow neritic environments: Journal of Paleontology, v. 38, p. 761–767.