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TRACE FOSSILS FROM THE ROCK BLUFF LIMESTONE (PENNSYLVANIAN, KANSAS)[1]

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ABSTRACT

The Rock Bluff Limestone Member of the Deer Creek Limestone of Virgilian age is marked by the presence of extensive bioturbation at its contact with the underlying Oskaloosa Shale Member. Three kinds of trace fossils are identified: elongate, sinuous trails, often containing the bivalve *Wilkingia;* nearly vertical cylindrical burrows packed with fusulinids and bioclastic debris; and the apparent resting burrows of ophiuroids, showing pentameral symmetry with quality dependent upon the coarseness of the bioclastic material filling them. The presumed ophiuroid burrows are here named *Pentichnus pratti, n. ichnogen., n. ichnosp.*

INTRODUCTION

In its position in the Deer Creek megacyclothem the Rock Bluff Limestone is equivalent to the Leavenworth Limestone Member of the Oread Formation, which has been studied so thoroughly by Toomey (1964, 1966, 1969a, 1969b, 1973, 1974). The fauna of the Rock Bluff Limestone is as diverse as that of the Leavenworth Limestone and contains many of the same species. In addition to these body fossils, the Rock Bluff also contains numerous trace fossils that are particularly evident on its lower surface.

The study of these trace fossils allows one to gain a broader understanding of the total community than is possible by study of the body fossils alone. Moreover, trace fossils are invariably *in situ,* whereas body fossils are likely to have been transported, especially in high-energy environments. In late Paleozoic sediments of the Midcontinent, trace fossils have mostly been studied from fine-grained detrital rocks (Bandel, 1967a, 1967b; Hakes, 1974), but Harbaugh and Davie (1964), Imbrie, Laporte, and Merriam (1964), and Ball (1971) have reported trace fossils from carbonate rocks.

Our purpose here is to draw attention to the occurrence of these trace fossils in carbonate rocks in hopes of stimulating more detailed research on them and on the environments of deposition of late Paleozoic limestones of the Midcontinent.

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ENVIRONMENTS OF THE ROCK BLUFF

The Rock Bluff Limestone is the middle limestone member of the Deer Creek Limestone (Shawnee Group, Virgilian). The Deer Creek ranges from six to a maximum of twenty-five meters in thickness (Zeller, 1968). The Rock Bluff is underlain by the Oskaloosa Shale Member and overlain by the Larsh-Burroak Shale Member.

The lower portion of the Oskaloosa Shale is bluish gray and unfossiliferous. Within 0.5 meters of the contact with the overlying Rock Bluff, this shale becomes yellowish gray and calcareous. Within 10 cm of the contact, it contains calcareous nodules. Fossils are abundant, with fragments of brachiopods, whole gastropods, and bivalves being especially prominent.

At the locality studied (NE NW NW Sec. 22, T. 12 S, R. 18 S.; 13 km west of Lawrence, Kansas, on Interstate 70) the Rock Bluff Limestone is approximately 0.5 meters thick. It is massive, light gray to light bluish gray, and contains numerous vertical joints. A solution groove occurs about 0.2 meters from the base.

Zandell (1963) has examined the microstratigraphy of the Rock Bluff along a portion of its outcrop belt from Shawnee to Greenwood counties in eastern Kansas. He described seven microfacies from within lower, middle, and upper parts of the unit. The lower part contained three microfacies which he called lower crystalline, reworked, and fusulinid microfacies and interpreted as having been deposited in a "uniform, quiet, deeper-water environment with mild current action," with the fusulinid microfacies representing the maximum transgression. The middle part consisted of gastropod and algal microfacies deposited in an environment sufficiently deep or protected to prevent reworking of bottom sediments. Brachiopod-pelecypod and upper crystalline microfacies occupied the upper part, with deposition judged to have been in "rather shallow water."

At the locality studied, the lower one-third of the unit consists of a fusulinid-mollusk biomicrosparite (fusulinid microfacies of Zandell, 1963). The most abundant allochems include fusulinids, gastropods, and bivalves with occasional brachiopod spines, bryozoan fragments, and crinoid columnals. Abrasion is negligible and sorting is poor. Fossil fragments show no preferred orientation.

The upper two-thirds of the unit corresponds to Zandell's algal microfacies and brachiopod-pelecypod microfacies. Allochems include brachiopod fragments, algae-coated grains, gastropods, and fusulinids. Most fossils are fragmented and slightly abraded. Both sorting of the allochems and content of clay increase toward the top of the unit (Plate 1, fig. 2). On the outcrop the contact with the overlying shale appears sharp, but on a microscale it is gradational through a vertical distance of 2 centimeters.

The final phases of deposition of the Oskaloosa Shale were characterized by a decrease of silt and clay while deposition of carbonates increased. Conditions became favorable for organic activity as the first increments of the Rock Bluff were deposited, and a diverse infauna and epifauna developed. As deposition continued, the terrigenous content of the sediment increased, and the preservable biotic constituents decreased. Energy conditions increased toward the top of the unit, as shown by the presence of the algae-coated grains and well-sorted allochems. Deposition of the Rock Bluff ended with the influx of abundant terrigenous material that accompanied the end of carbonate deposition (Fig. 1).

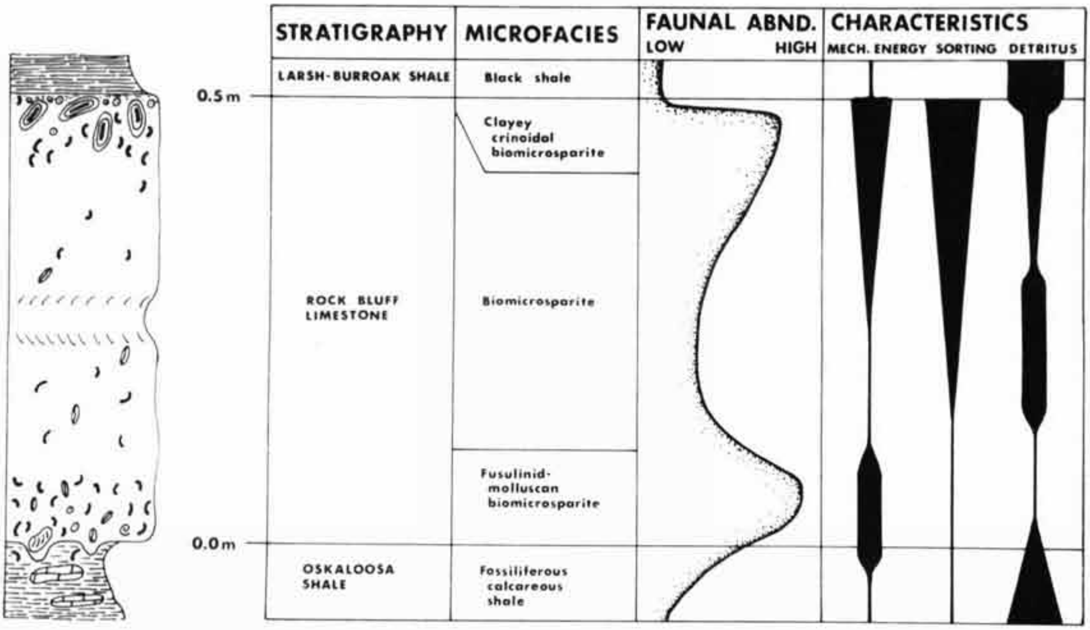

FIG. 1. Graphic section of the Rock Bluff Limestone Member of the Deer Creek Limestone showing lithology and inferred environments.

TRACE FOSSILS

Three different morphologic types of trace fossils were collected from the base of the Rock Bluff Limestone.

TYPE ONE

BIVALVE TRAIL

Plate 1, figures 3-5

Description.—This structure consists of a series of rounded ridges, 5 cm wide and from 10 to 30 cm long, preserved in convex hyporelief. The traces are straight to sinuous and can be seen to intersect each other occasionally. Many of the elongate structures contain fusulinids and other bioclastic debris, and in two specimens, the large bivalve *Wilkingia* was found oriented in life position within the structures.

Discussion.—Sedimentary structures similar to this trace fossil are common on the underside of many limestone units in the Upper Pennsylvanian of eastern Kansas. The presence of the bivalve *Wilkingia* within several of these structures strongly supports their biogenic origin. Abel (1937, fig. 217) has figured *Cardium edule* traversing a sediment surface and producing a furrow nearly deep enough to hold the animal. Other examples have been described by Lessertisseur (1955, fig. 11) and Pryor (1967, fig. 3). Seilacher (1953, fig. 7) illustrated the horizontal motion of a bivalve within the sediment at the sediment-water interface as an example of his Repichnia (locomotion trail). It seems likely that *Wilkingia* was the probable producer of most of these types of trails, and it is possible that bivalves with similar modes of life may have been responsible for many of the slightly sinuous ridges found on the underside of other Upper Pennsylvanian limestones of the Midcontinent.

TYPE TWO

BIOCLAST-PACKED BURROW

Plate 1, figure 1; Plate 2, figures 1,5

Description.—Vertical to subvertical cylindrical or conical burrows, approximately 4 cm in diameter and preserved endogenically. Length of burrows varies, may equal one to two diameters; structures commonly tightly packed with bioclastic debris. Obvious burrow walls lacking.

Discussion.—Burrows of this type are common at the base of the Rock Bluff Limestone. The bioclastic material that fills them has no preferred orientation and does not appear to have been arranged around the body of an organism. The burrow could have been packed by either organic or inorganic means.

TYPE THREE

PENTICHNUS Maerz, Kaesler, & Hakes, n. ichnogen.

"Five banded specimens" Branson, 1960, p. 203, pl. 3, fig. 3,4.

"Pentameral organisms" Branson, 1960, p. 203, pl. 4, fig. 6,10.

Asteriacites von Schlotheim, 1820; Chamberlain, 1971, p. 217, 219, table 2, pl. 30, fig. 11,12.

Type species.—*Pentichnus pratti* Maerz, Kaesler, & Hakes, n. ichnosp.

Description.—Subcylindrical to subconical structures often found projecting beneath the lower bedding plane of an indurated bed overlying a soft one. Pentameral symmetry moderately to very well developed, depending on size of grains in the rock.

PENTICHNUS PRATTI Maerz, Kaesler, & Hakes, n. ichnosp.

Plate 2, figures 2-4

Description.—Subcylindrical to subconical structures 3.0 to 5.0 cm in diameter projecting 3.0 to 5.0 cm from a lower bedding plane. Many possess moderately well-developed pentameral symmetry, while others display an irregular circular outline in transverse section. Shape of apical end ranges from subhemispherical to highly irregular, with fractured appearance. Smaller forms resemble pustules on underside of beds.

Discussion.—This trace fossil is interpreted as the probable dwelling or resting burrow of a sedentary organism, probably an ophiuroid. Many structures similar to these, but with a circular transverse section, have been attributed to sea anemones, which live partially concealed in the sediment (Shinn, 1968; Frey, 1970; Chamberlain, 1971; Schäfer, 1972). The animal feeds in this position and moves upward with increasing accumulations of sediment. The pentameral symmetry of the specimens described here suggests an echinoderm rather than a coelenterate origin.

Ophiuroids are known to bury themselves in the sediment so that only the tips of their arms are exposed (Thorson, 1957, fig. 14). Ager (1963, fig. 5, 11) interpreted the ophiuroid *Taeniaster spinosus* Billings (Billings, 1958, pl. 10, fig. 3c, d) to have been preserved in its burrow within the sediment. According to Ager, the reason many more ophiuroids than asteroids are found in the fossil record is because the former group maintained an infaunal existence. If ophiuroids were to burrow through a thin layer of lime mud into an underlying clay, biogenic sedimentary structures similar to those found at the base of the Rock Bluff Limestone could be preserved. Unfortunately, no ophiuroid remains have yet been found in either the Oskaloosa Shale or the Rock Bluff Limestone.

The burrows were found to contain a variety of biotic constituents, including fusulinids, brachiopod and gastropod fragments, and occasional crinoid columnals supported in a micrite matrix. The individual bioclasts are not preferentially oriented, except that near the rounded bottom of many of the burrows the material is arranged subparallel to the convexly curved base and appears to have been caused by the downward filling of the burrow with refuse.

The overall geometry of the burrows is apparently influenced by the degree of packing and the size of the allochems. Burrows with poorly developed pentameral symmetry are those most tightly packed with bioclasts. A trace fossil preserved in fine- to medium-grained sediments is more likely to conform to the morphology of its producer. In coarse-grained sediments, delicate patterns are generally not preserved. Thus the original, detailed morphology of a burrow filled with coarse bioclasts is unlikely to be preserved.

Several trace fossils similar to these have been described. Chamberlain (1971) described specimens of *Conostichus* Lesquereux (1880), which he judged to have been made by burrowing sea anemones such as *Cerianthus*. However, *Conostichus* has duodecimal symmetry. In addition, *Conostichus* contains a much more complex internal structure in which layers parallel the conical shape as cone-in-cone. The Rock Bluff specimens have a simpler internal structure and also lack the vertical external wrinkles characteristic of *Conostichus*. Myannil (1966) has described similar structures from the lower Paleozoic of eastern Europe. His specimens of *Conichnus* contain fairly abundant bioclastic debris but have a much smoother and more regular external surface than the Rock Bluff structures. They also lack pentameral symmetry. Specimens of *Kulindrichnus* have been described by Hallam (1960) and Doughty (1965) and are perhaps the most similar to those described here. *Kulindrichnus* has bioclastic filling of sorts and can possess a phosphatic sheath, which is lacking in the Rock Bluff material. *Kulindrichnus,* however, lacks pentameral symmetry.

Chamberlain (1971, p. 219) described three new forms of the trace fossil *Asteriacites lumbricalis* Schlotheim from the Pennsylvanian of Oklahoma. These three forms were named *A. lumbricalis* hiding forms A, B, and C. All the forms described by Chamberlain are somewhat similar to our material but are not identical. Differences in lithologies and preservation make good comparisons difficult, if not impossible. Häntzschel (1975, p. *W*42) did not consider that any of Chamberlain's material belonged to the ichnogenus *Asteriacites,* apparently because they were conical and not asterate.

The presence of pentameral symmetry in our material is considered taxonomically important. Therefore, the name *Pentichnus pratti* is proposed for the Rock Bluff material.

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EXPLANATION OF PLATES

PLATE 1

FIGURE

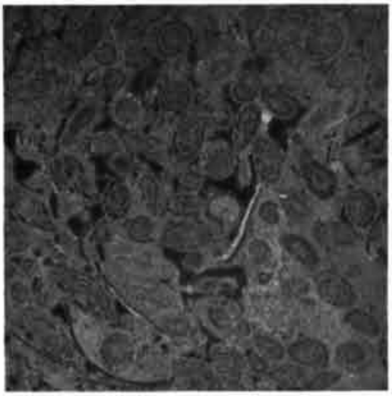
1. Peel print of fusulinid-packed burrow; KUMIP 110609, × 2.
2. Peel print of sample from upper two-thirds of the Rock Bluff Limestone, × 2.
3. Peel print of internal structure of bivalve trail with *Wilkingia* sp. in life position; KUMIP 110617, × 1.5.
4. *Wilkingia* sp. in life position in partially eroded bivalve trail; KUMIP 110606, × 1.
5. Bottom of slab of Rock Bluff Limestone showing sinuous bivalve trails; Lake Perry Locality (NW SW Sec. 8, T. 11 S, R. 18 E; Jefferson County, Kansas); hammer for scale.

PLATE 2

All figures × 1.

FIGURE

1. Bioclast-packed burrow, KUMIP 110607; lateral view of subcylindrical type. Adhering matrix gives impression of alignment, but bioclasts are randomly arranged.
2. *Pentichnus pratti* Maerz, Kaesler, & Hakes, n. ichnogen., nov. ichnosp., KUMIP 110604; bottom view of subconical type with poorly developed pentameral symmetry.
3. *Pentichnus pratti* Maerz, Kaesler, & Hakes, n. ichnogen., n. ichnosp.; KUMIP 110605; *3a*, lateral view; *3b*, bottom view with moderately developed pentameral symmetry.
4. *Pentichnus pratti* Maerz, Kaesler, & Hakes, n. ichnogen., n. ichnosp., holotype, KUMIP 110618; *4a*, lateral view; *4b*, bottom view with well-developed pentameral symmetry.
5. Bioclast-packed burrow, KUMIP 110602; *5a,b*, stereo pair of lateral view of subconical type.



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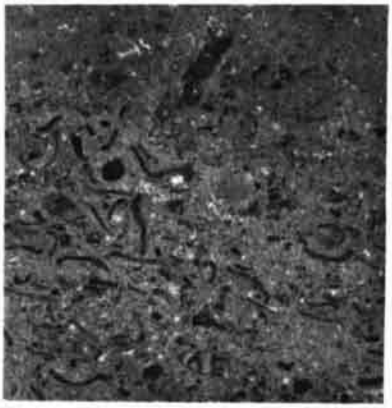

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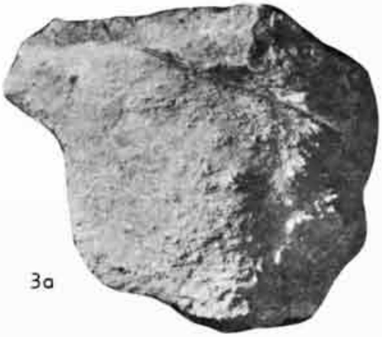

3a

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3b

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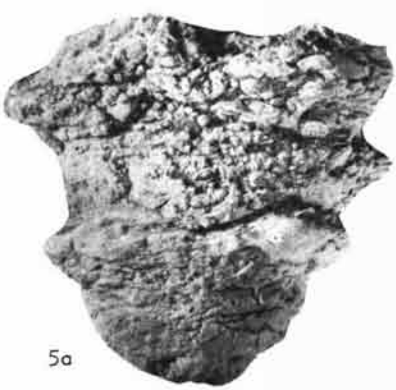

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5b