PALEONTOLOGICAL NOTES ON THE WANNAGAN CREEK QUARRY SITE (PALEOCENE — NORTH DAKOTA)

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The specimens described here are the first contribution from the ichnological materials which have been recovered from the Paleocene deposits of the Wannagan Creek quarry site. The present specimens, representing at least two distinct forms, are preserved *in situ* in sandstones, shales and siltstones of a fluvial-lacustrine environment. They are preserved as horizontal and vertical infillings and bear no portion of the animals which made them.

Our purpose here is to consider these structures and provide an interpretation of the circumstances of their preservation as well as the environmental conditions under which their makers lived.

GEOLOGY

The Fort Union Group, of which the Bullion Creek (Tongue River) Formation is a member, comprises part of a continuous depositional sequence extending from the Upper Cretaceous Hell Creek Formation to the basal sands of the Eocene Golden Valley Formation. Deposits of this sequence, with the exception of the marine Cannonball Formation, consist of fluvial and lacustrine sands, silts, clays, limestones and lignites that are part of a clastic wedge derived from the rising Rocky Mountains to the west (Royse, 1970). The Bullion Creek Formation lies midway in this sequence, with the marine Cannonball beds beneath, and the Sentinel Butte Formation above. Bullion Creek sedimentation began with the influx of basal

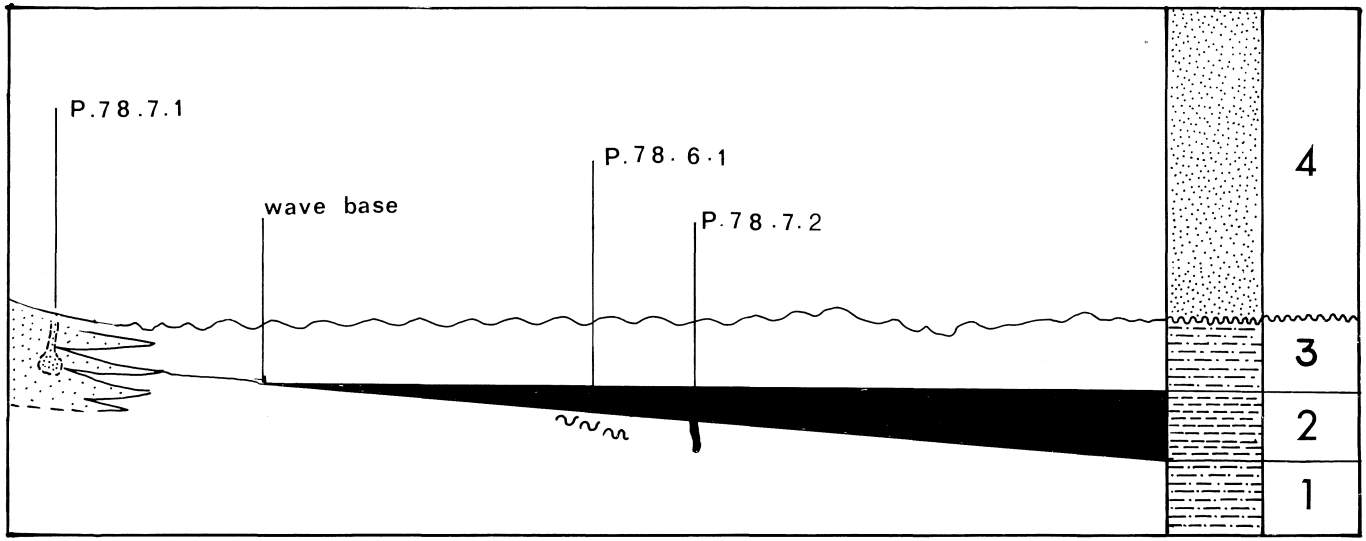

Figure 1. Diagrammatic cross-section, Wannagan Creek Quarry. Bed 1, gray laminated silty shale with plant fragments and abundant pelecypods; bed 2, black finely fissile, lignitic shale; bed 3, gray silty shale with plant fragments, abundant crocodile bones, and pelecypods; bed 4, buff, very fine grained silty sand. SMM P 78.7.1 and SMM P 78.7.2 are the relative positions of the two presumed decapod burrows, and SMM P 78.6.1 the relative position of the presumed oligocheate burrows. Wave base is located at the pinchout of bed 2 and is approximately one meter below the beach sands (vertically).

sands derived from a low-lying source area of sedimentary rocks to the west, over the Cannonball beds. Stability of the Bullion Creek fluvial system was established early in the sequence, and was characterized throughout by stable stream channels with low gradients and extensive flood plains developed at or near base level. Bullion Creek time ended with the development of an extensive swamp in which a major lignite bed (the HT lignite) accumulated (Royse, 1972).

The Wannagan Creek quarry site (Fig. 1) is located at a position 19.8 meters below the HT lignite bed. The quarry is in a lignitic gray silt and clay sequence corresponding to what Jacob (1972) describes as representative of sedimentation in local floodbasins on a floodplain. The sequence consists of three definable beds: a lower gray plant-bearing silt with abundant pelecypods and a few gastropods (bed 1), a central lignitic black shale (lignitic layer, bed 2), and an upper gray plant, pelecypod and crocodile-bone-bearing siltstone (bed 3). The three layers are gradational into one another and appear to represent a continuous sedimentation sequence, the dip of which corresponds to the basin morphology. Bed 3 is terminated by an erosional unconformity with an overlaying silty sand (bed 4) which is interpreted as a crevasse splay from an adjacent channel that filled the basin.

The lower portion of the sequence, consisting of the lower siltstone, and the black lignitic shale (beds 1 and 2, Fig. 1) is interpreted as representing sedimentation in a channel segment which perhaps became isolated from the main drainage and its associated clastic input,so that it accumulated locally produced organic material in progressively greater ratios to form a relatively anoxic black organic muck. The lower gray silt intertongues at its northern end with a well-sorted beach sand showing well-developed beach cusps. The lignitic layer begins as a feather edge at a point about one meter (vertically) below the inferred shoreline, and thickens rapidly in the deeper portions of the basin to an average thickness of 15.0 cm. The pinch-out point of the lignitic layer is inferred as wave base for that portion of the basin, which suggests a maximum wavelength of around two meters. Wavelengths of this magnitude imply considerable fetch, and therefore a relatively large body of water. Bed 3 (Fig. 1) represents a reintroduction of clastic materials into the basin which, taken together with the inferred wave base, suggests a lacustrine setting that was receiving fluvial input.

ECOLOGY

The ichnofossils described in this report are divisible into three categories based on their positions with respect to inferred water levels and to form. One vertical specimen was recovered from a probable subaerial position at the beach level. A second specimen, also a vertical type, occupied a submerged position. A third, horizontal type, was found in the gray silt (bed 1) at an inferred water depth of about two meters (two meters below beach level) (Fig. 1). Organic accumulation in the gray silt, at the level at which the submerged ichnofossils were recovered, consists predominantly of scattered leaves of the shoreline community, and of various remains of the aquatic community. The predominantly clastic nature, and only minor organic matter constituent of the sediments at this level, suggests at least some current flow, and probably relatively well-oxygenated water. That current velocities were low or intermittent, is suggested by the presence of unfragmented plant material from the surrounding communities. Overall, it is suggested that these fossils were formed in a body of water with a relatively high, although possibly intermittent, sediment load, relatively well oxygenated water, and a sluggish, possibly periodic, current.

The nature and position of the vertical beach burrow (Fig. 1) within the uppermost intertonguing layers of sand and silt would suggest a rather late origin with regard to the formation of the beach deposits. The existence of a well-developed shoreline during the early stages of a ''swamp'' is borne out by the distribution of crocodilian bones. These remains consist of stranded partial skeletons and numerous isolated bones throughout these sands and siltstones. Elements showing ''beachwear'' are common, and one large skull, which aided in the formation of a sand cusp by acting as a barrier, are evidence of a well-established shoreline environment existing up into the lacustrine depositional stage.

It is not clear whether the origin of this burrow was contemporaneous with the submerged ichnofossils or not. If not, its origin was during the time of accumulation of the lignitic layer (bed 2) prior to the time of lake sedimentation represented by the upper gray to buff siltstone (bed 3).

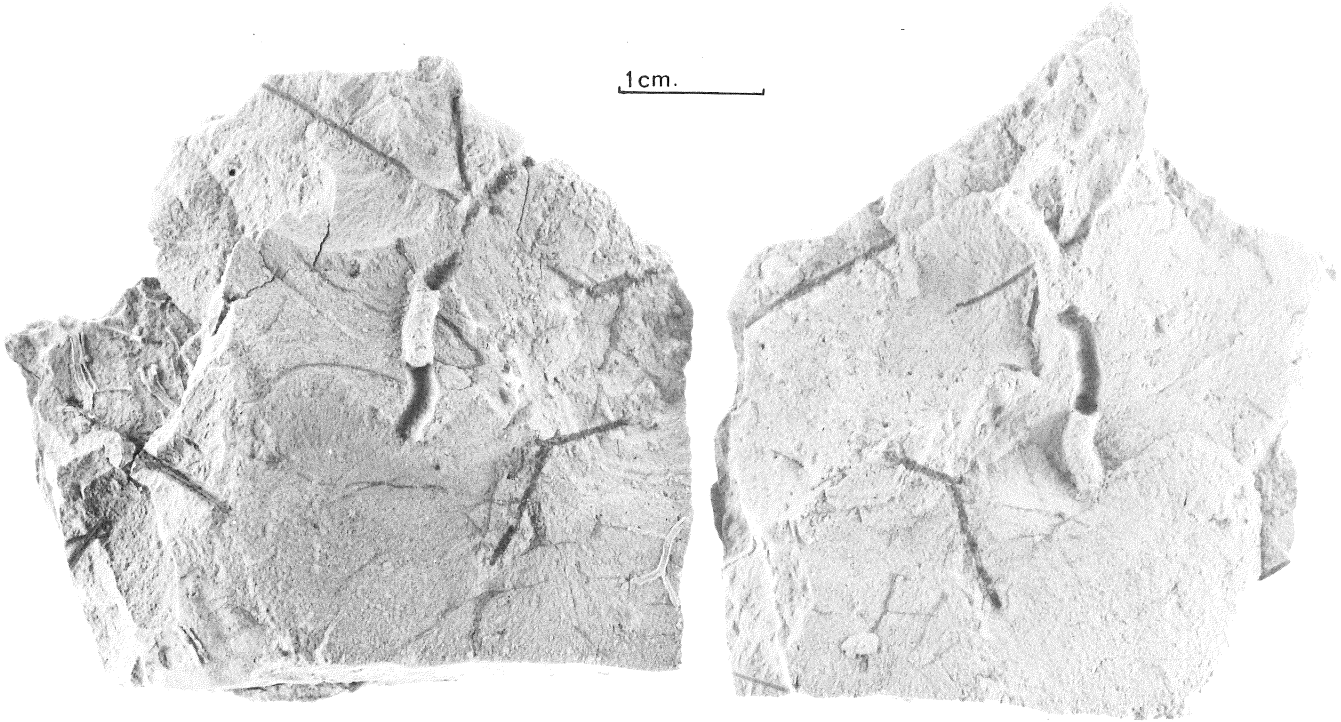

Figure 2. *Oligichnos limnos,* holotype SMM P 78.6.1, showing sinuous course parallel and sub parallel to bedding planes.

DESCRIPTIONS

Oligichnos limnos Ichnogen, et sp. nov.

Holotype. – SMM P 78.6.1 (Fig. 2)

Paratypes. – SMM P 78.6.2; SMM P 78.6.4; SMM P 78.6.5 (Figs. 3-5); SMM P 78.6.6; SMM P 78.6.7

Horizon and Locality. – Wannagan Creek Quarry, Bullion Creek (Tongue River) Formation. NW¼, Sec. 18, T.141N, R.102W, Billings County, North Dakota.

Etymology. – The generic name *Oligichnos* is proposed with regard to the suggestions of Häntzschel (1975). The term *Olig-* refers to the diminutive size of the structure, and the term *-ichnos* to its status as an ichnofossil. The specific epithet *limnos* refers to the aquatic habitat of the fossils.

Seilacher (1953) proposed an ethological classification of bioturbation structures (see also Frey, 1973, and Häntzschel, 1975) included in which is the category fodinichnia. Fodinichnia are defined as feeding structures that are more or less temporary burrows constructed by deposit feeding animals, and typically also used as shelter for the animals. Morphologically, fodinichnia are typically single, branched or unbranched, cylindrical and sinuous shafts oriented at various angles. A toponomic classification of ichnofossils has also been proposed by Seilacher (1953, 1964 a,b) and summarized by Frey and Häntzschel. In this classification scheme, modes of occurence, alteration, and preservation are stressed. Included in this system is the designation *full relief,* in which the fossil occurs wholly within the host sediment.

O. limnos is a fodinichnia, full relief, tubular ichnofossil that follows a straight to sub-sinuous course that is parallel or sub-parallel to the bedding planes of the sediment (Fig. 2). The sinuosity of the burrows is in both a horizontal and vertical plane with respect to the stratification. Occasional vertical elements (escape structures?) normal to the bedding are encountered (SMM P 78.6.5, Fig. 3), and the tubes may be unbranched or branched (as in the case of SMM P 78.6.1, Fig. 4). The burrows are apparently the feeding structures of an endobenthic deposit feeder and display what ap-

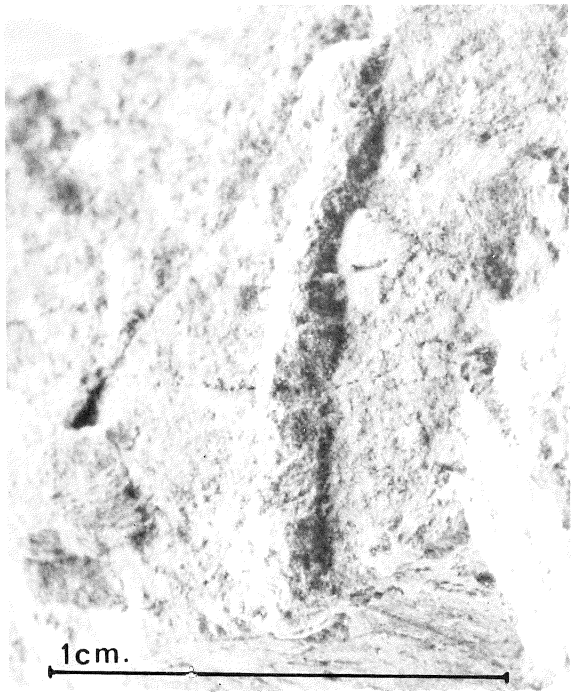

Figure 3. *O. limnos,* paratype SMM P 78.6.5, a vertical burrow segment that may represent an escape structure after a sedimentation pulse.

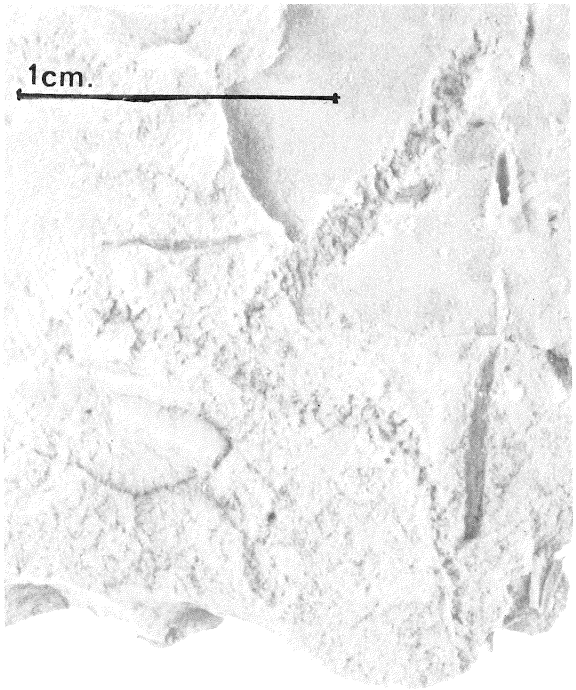

Figure 4. *O. limnos,* paratype SMM P 78.6.2, a portion of a branching segment. The pelletized nature of the active fill is well expressed on this specimen.

pears to be active fill (Frey and Howard, 1972) with undisturbed sediment adjoining the walls (Fig. 5). In all cases, the surfaces of the burrow casts are minutely verrucate due to spherical to ovoid pellets (Fig. 4) that range in size from 0.16 mm to 0.26 mm in largest dimension (average 0.22 mm). The diameters of the burrows range from 1.5 mm to 2.4 mm (average 1.8 mm) and exhibit only minor changes (0.3 mm) in dimension along their lengths. There appears to be no noticeable trend in the periodicity of the nodes (thicker portions) along the burrows, most being between 1.0 and 4.0 mm apart.

Oligichnos is distinguished from similar forms such as *Helminthoida* and *Gordia* by the lack of regular meanders, the absence of churned areas along the sides of the tunnels such as those described by Seilacher (1967), the pelleted surface expression of the active fill, and its branching habit.

Discussion. – It is tempting to speculate concerning the organism that is presumably responsible for *O. limnos*. The group that immediately comes to mind is the oligocheata, the majority of which are aquatic sediment feeders. Their lack of parapodia or other appendages

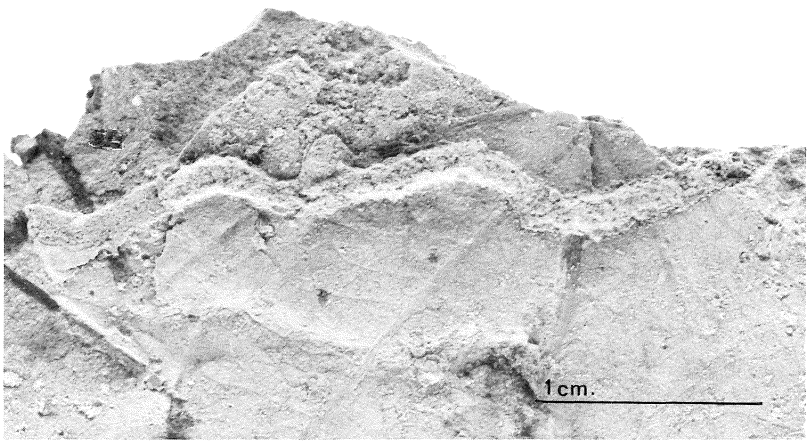

Figure 5. *O. limnos,* paratype SMM P 78.6.4, showing a typical meandering course through a portion of a leaf of *Cercidiphyllum arcticum*. There appears to be no modification of burrowing behavior in response to the presence of the leaf. Note that the margins of the burrow in contact with the leaf tissue present an undisturbed appearance.

(other than setae) would be consistent with the relatively undisturbed walls of the burrows, and their sediment feeding habit could account for the pelletized active fill, the pellets being the result of passage of the sediment through the digestive tract of the animals. In addition, variation in burrow diameter along the length is suggestive of a peristaltic mode of locomotion, as opposed to the constant diameters associated with the snakelike or crawling locomotive habit of the arthropods. The orders Plesiopora and Prosopora contain genera that have the required sediment feeding habit, and the proper size to be associated with the burrows.

The two largest burrows are preserved as infillings and possess little to characterize them. The broad range of burrowing forms that could have made these structures prevents a definite allocation of them. They appear, however, to be most like burrows of decapod origin (e.g., *Ophiomorpha*). The lack of freshwater forms from Paleocene deposits, however, appears to warrant the proposed new taxon.

Ichnofossil SMM P78.7.2 is less diagnostic than specimen SMM P78.7.1 which was constructed on a beach, as its occurrence is in sediments that were apparently beneath the water at the time of its construction. It may also, therefore, belong to a distinct form. The beach burrow alone will then be the basis for the following description.

Liticuniculatus erectus Ichnogen. et sp. nov.

Holotype. – SMM P 78.7.1 (Fig. 6)

Horizon and Locality. – Wannagan Creek Quarry, Bullion Creek (Tongue River) Formation. NW¼, Sec. 18, T.141N, R.102W, Billings County, North Dakota.

Etymology. – The generic name is based upon *litus*, L, beach + *cuniculatus*, L, burrow; the specific name on *erectus*, L. erect.

This specimen is constructed as a vertical shaft and is preserved as a 29.0 cm long infilling. Its position within beach sediments that were proximal to the water and therefore the water table, suggests that it is probably not much shorter than when initially made. It is markedly curved near mid-length, having a cylindrical shape in

Figure 6. *Liticuniculatus erectus*, holotype SMM P78.7.1. Stereophotograph of specimen *in situ*.

cross-section. The shaft enlarges slightly from top to bottom. This diameter variance does not appear to be of a diagenetic nature. The average diameter of the upper part is 2.6 cm, increasing to an average of 3.5 cm at its lower end.

Internally the burrow wall is rough and irregularly constricted. This would seemingly have given its owner a good purchase on its sides. Incorporated sand grains suggest that this could be residue of some colloidal cementing material used in lining the walls. Color differences between the infill and the host sediment might also be explained by this in that the animal's secretions may have biochemically altered the sediments used in the construction process (Frey, 1971).

Certain features associated with this specimen, viz., the fact that the upper end is truncated, and the lower end is terminated in a rather distinct, albeit subtle, disturbance of the sediments, suggest environmental conditions and characteristic behavior of its owner.

Discussion. – The beach ichnofossil existed in life on a sandy-silt shore, where success of its inhabitant surely depended upon its ability to survive the vicissitudes of currents, waves, drying, and in this instance, bioturbation from large crocodiles. This burrow therefore, was probably an escape structure as well as a dwelling, and can be classed ethologically as a domichnia (Seilacher, 1964 a, b). Truncation of the neck of the burrow, either by crocodile trampling or scour by wind and water, suggests a subaerial entrance position. The concentration of disrupted sediments at its base represents the infilling of a spheroidal-shaped cavity that has an estimated diameter of 15.0 cm. This is interpreted as further burrowing activity which resulted in the development of a chamber of the type frequently associated with extant decapod burrows. Collapse of the chamber's walls and filling from above by sandy silt of much the same composition as the host sediment, accounts for the rather vague expression of this feature. Unfortunately, the only record of this particular feature is contained in the field notes of one of us (Erickson, 1975); hence, no further direct observations can be made.

The slight constriction toward the top of the shaft is not well defined and speculation about its possible function as a feeding adaption will not be attempted.

The submerged burrow, SMM P78.7.2, noted above, is shorter than the beach burrow, of about the same diameter, so far as can be determined, and its overall form is the same; however, as this form is indeterminate, it is mentioned here only to indicate its occurrence, and its association with the oligocheate traces.

From the stratigraphic position in which the submerged ichnofossil (SMM P 78.7.2) is located (beneath the carbonaceous layer along with the oligocheate traces), it is apparent that this burrow was constructed before the accumulation of the organic rich lignitic materials. The burrow was apparently terminated prior to lignitic deposition because of the carbonized materials which have been incorporated into it as infilling. The burrows described in this report are regarded as characteristic lebensspuren of what is yet an undetermined assemblage of freshwater invertebrates. This includes a decapod and an aquatic oligocheate.

The backswamp environment was terminated by a period of beach erosion as evidenced by the truncated burrow and the associated beach features noted. This was succeeded by a freshwater lake with its own peculiar fauna and flora.

REFERENCES

Frey, R. W. 1971. Ichnology — The Study of Fossil and Recent Lebensspuren, in *Trace Fossils, A Field Guide,* Ed. by B.F. Perkins, Louisiana State University, School of Geoscience, Miscellaneous Publications.

———. 1973. Concepts in the study of biogenic sedimentary structures. *Journal of Sedimentary Petrology,* Vol. 43, No. 1, pp. 6-19.

Frey, R. W. and J.D. Howard. 1972. Georgia coastal region, Sapelo Island, U.S.A.: Sedimentology and biology. VI. Radiographic study of sedimentary structures made by beach and offshore animals in aquaria. *Senckenbergiana Maritima,* Vol. 4, pp. 169-182.

Häntzschel, W. 1975. Trace Fossils and Problematica. *Treatise on Invertebrate Paleontology,* Part W, Supplement 1. Geological Society of America, Boulder, Colorado.

Jacob, A.F. 1972. Depositional environments in parts of the Tongue River Formation, Western North Dakota. *North Dakota Geological Survey, Miscellaneous Series 50.* F.T.C. Ting, Editor.

Royce, C.F. Jr. 1970. A sedimentologic analysis of the Tongue River-Sentinel Butte interval (Paleocene) of the Williston Basin, Western North Dakota. *Sedimentary Geology,* Vol. 4, pp. 19-80.

———. 1972. The Tongue River and Sentinel Butte Formations (Paleocene) of Western North Dakota: A review. *North Dakota Geological Survey, Miscellaneous Series 50.* F.T.C. Ting, Editor.

Seilacher, A. 1953. Studien zur palichnologie. I. Uber die Methoden der Palichnologie. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen;* Beilage — Bände; Monatshefte. Stuttgart. Vol. 96, pp. 421-452.

Seilacher, A. 1964a. Biogenic Sedimentary Structures, in *Approaches to Paleoecology,* Ed. by J. Imbrie and N.P. Newell. John Wiley and Sons, New York, New York, pp. 296-316.

———. 1964b. Sedimentological classification and nomenclature of trace fossils. *Sedimentology,* Vol. 3, pp. 253-256.

———. 1967. Fossil Behavior. *Scientific American,* Vol. 217, No. 2, pp. 72-80.