TRACE FOSSILS OF THE LIASSIC ROCKS OF NORTH WEST LINCOLNSHIRE

by

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Summary

The Liassic rocks of north west Lincolnshire have yielded seven trace fossils previously undescribed in the area. Five are described in detail and the stratigraphic range of all trace fossils known from the area is outlined.

Introduction

Since Dawson (1890) described Canadian examples from Palaeozoic rocks, sedimentary structures produced as a result of the activities or presence of animals in accumulating sediments have received little attention in this country. Early this century, German palaeontologists took the initiative in the study of trace fossils and much of our existing systematic knowledge is the result of work by Abel (1935), Richter, and more recently, Seilacher, who has established a binomial nomenclature based on Linnaean principles (Seilacher 1953). In this country, further interest has been shown in the last decade and British trace fossils have been described by Simpson (1957) and Hallam (1960), adding further to the types and knowledge of British material.

A preliminary examination of the Liassic succession of north west Lincolnshire has yielded seven kinds of trace fossils, not previously known in the area, one of which is entirely new.

The stratigraphic distribution of the trace fossils described is shown in Table 1. The specimens here described are lodged in the Borough Museum, Scunthorpe; specimen numbers are quoted, where appropriate, in the text.

TABLE 1

Horizon	Trace Fossil	Chondrites	Kulindrichnus	Teichichnus	Brancichnus	Pellets	Rhizocorallium	Diplocraterion	Zapfella	Cylindrites	Arenicolites
Upper Lias	Calcareous Shales					X					
	Paper Shales					X					
	Transition Bed	X		X							X
Middle Lias	Marlstone Ironstone										X
	Middle Lias Clays with Nodules										
Lower Lias	Upper Clays with Nodules	X								X	
	Pecten Ironstone	X								X	
	Clays above Frodingham Ironstone	X								X	
	Frodingham Ironstone						X	X	X		
	Clays below Frodingham Ironstone		X		X						

Systematic Section

FODINICHNIA Seilacher, 1953

Genus Chondrites. Sternberg, 1833

Description. The name is applied to sedimentary burrows of small diameter frequently commencing with a vertical tube which curves outward, usually to a horizontal position, at the same time branching at angles of less than 45° into smaller blind side channels. Commonly the branched portion of the burrow occupies a bedding plane (Simpson, 1957).

Stratigraphy. This genus has a very wide stratigraphic range, first appearing in the Ordovician and extending into Eocene and Flysch deposits. Its geographic range is known to embrace North America and Europe.

The important Liassic occurrences of this genus in Britain are tabulated below:

Lower Lias

Angulatum and Bucklandi Zones	- Church Cliffs, Lyme Regis	(Simpson, 1957)
Jamesoni and Ibex Zones	- Westhay Cliff, Charmouth, Dorset,	(Simpson, 1957)
Obtusum Zone	- Bishopsworth, Bristol	(Simpson, 1957)

Middle Lias

Staithes, Yorkshire (Tate and Blake, 1876, Nulliporites furcillatus)

Upper Lias

Alderley Waterworks, Glos.

To these can now be added the following Lincolnshire localities:

Lower Lias

	Raricostatum Zone	- Flixborough Mine, Scunthorpe (specimen P. 2040) Crosby Mine, Scunthorpe (specimen P. 2041)
	Jamesoni-Ibex Zone	- Cleatham, Kirton Lindsey (924014) (specimens P. 1933 a-d)
Middle Lias		
	Spinatum Zone	- Cleatham, Kirton Lindsey (935005) (specimens P. 2039 a/b)
Upper Lias		- Cleatham, Kirton Lindsey

Dimensions. The dimensions at all horizons differed, due probably to the different sedimentary environment at each level, although it is possible that the greater dimensions of the examples from the Spinatum Zone represent a different species:

Raricostatum Zone	-	diameter .5 mm.
Jamesoni-Ibex Zone	-	diameter from .3 to .5 mm.
Spinatum Zone	-	diameter 1 mm.

Mode of Occurrence. Lower part of the Raricostatum Zone. The burrows occur in the shales and clays six feet above the top of the Frodingham Ironstone and at this locality have a darker filling than the surrounding grey shales. This is not due to filling with darker material from above. The iron stains emanating from the burrows (specimen P. 2040) suggest the deeper colouring is due to the presence of iron compounds.

Upper part of the Raricostatum Zone. At this horizon, about 15 ft. above the Frodingham Ironstone, the burrows can just be seen on fresh specimens where they have been filled with clays of a slightly darker colour from above.

Jamesoni and Ibex Zones. The burrows are very distinct at this horizon where they are filled with a lighter grey clay than the surrounding porcellanous mudstone matrix (specimens P. 1933 a to d) (Doughty, 1965).

Spinatum Zone. The burrows have here been excavated into an iron-rich sandstone at the top of the Marlstone and they are filled with a grey mudstone similar to that of the overlying bed (specimen P. 2039 b). On exposed surfaces the mudstone soon weathers out, leaving a series of smooth branching grooves (specimen P. 2039 a).

Interpretation. Early descriptions of these structures suggested that they were the remains of non-calcareous algae, but Richter (1927) completely eliminated the botanical explanation. Following this, it was thought that the structures were the tunnels of some type of burrowing worm and the most recent interpretation (Simpson, 1957) has suggested the sipunculoid worms as the nearest in burrowing and feeding habits.

DOMICHNIA, Seilacher, 1953

Genus Kulindrichnus Hallam, 1960

Kulindrichnus langi. Hallam, 1960

Description. The shape of these trace fossils is either cylindrical or conical, with the apex directed downward, and they are usually oriented vertically or nearly so. The whole of the structure is normally of indurated small shells and shell fragments and a sheath of phosphatic rock is sometimes found around specimens. The size is up to 130 mm. long and 75 mm. in diameter (Hallam, 1960).

Stratigraphy. Kulindrichnus has so far only been described from lower Jurassic rocks and has been found in the Planorbis, Bucklandi, Semicostatum and Turneri Zones of north west Europe. The specimens described here, for which localities are known, originate in the limestone beds (Dudley, 1942) of the Bucklandi Zone extending along the Frodingham Ironstone escarpment from Messingham, 3 miles south of Scunthorpe, to Whitton, on the Humber, in the north west of the county.

Dimensions. Over seventy specimens were examined and only one-third were of the cylindrical variety. The rest were not straight-forward cones but had an inverted flasklike form with pronounced curving of the wall (Plate 6). Twenty three specimens were collected and the height, maximum diameter and minimum diameter of each were measured. Frequency distributions based on these data are shown in Text-fig. 1 . The maximum diameter histogram is likely to be the most accurate since many specimens showed signs of breakage at the lower end, thus affecting the height and minimum diameter of specimens. Generally speaking the dimensions conform well with those of the diagnosis (Hallam, 1960) but the range of height and maximum diameter should be extended to 260 mm. and 180 mm. respectively to embrace the largest specimen collected (P. 2043/k).

Mode of Occurrence. Kulindrichnus only occurs in the limestones of the Bucklandi Zone of the area and only one example seen penetrated an underlying shale horizon. The fine grained limestone or the phosphate of the specimens appears to make them more resistant to weathering than the surrounding limestones and many weather out completely.

Interpretation. It has been tentatively suggested (Hallam, 1960) that the Kulindrichnus structures represent depressions or burrows on the sea floor which were occupied by cerianthid sea anemones. The two problems which are difficult to reconcile with this interpretation are the phosphatic enrichment of the sheath and the uniformly small size of the shelly fillings.

Another possibility is suggested by the shape of Kulindrichnus, which resembles some of the "vase" and "ear" sponges of the sub-classes Calcarea and Demospongia. It is already known (Clarke and Wheeler, 1922) that calcareous sponges have a much higher phosphorous content than other marine invertebrates (excluding crustaceans and some brachiopods) and this could be the source of phosphorous in the sheath. The lack of spicules (if the sponge belonged to the Calcarea) may have its origin in the general ecology of the Lower Jurassic sea floor, where conditions appeared to be generally unfavourable to sponge preservation (Hinde, 1887 - 1912).

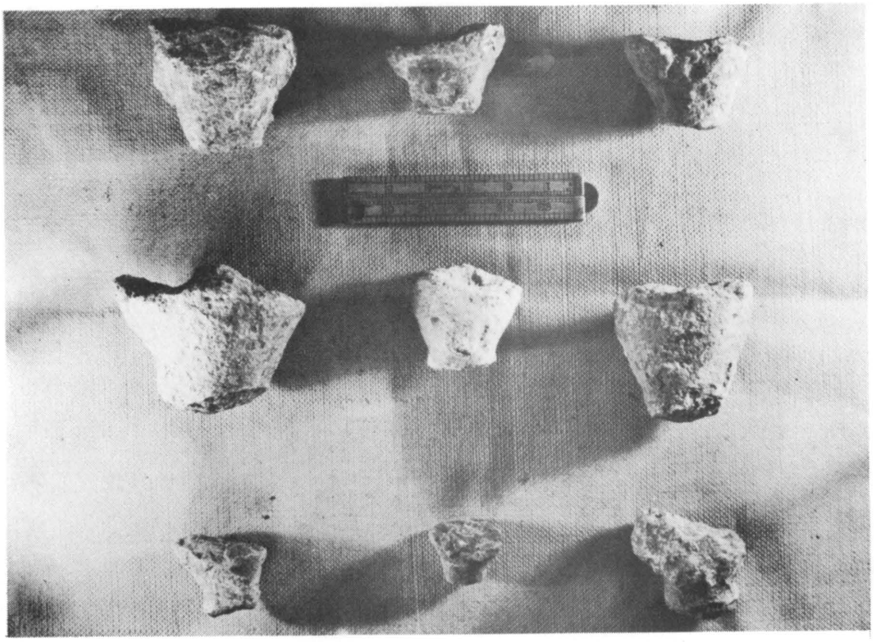


Fig. 1. Nine specimens of Kulindrichnus langi showing the inverted flask form typical of a majority of specimens. (Scale in inches)

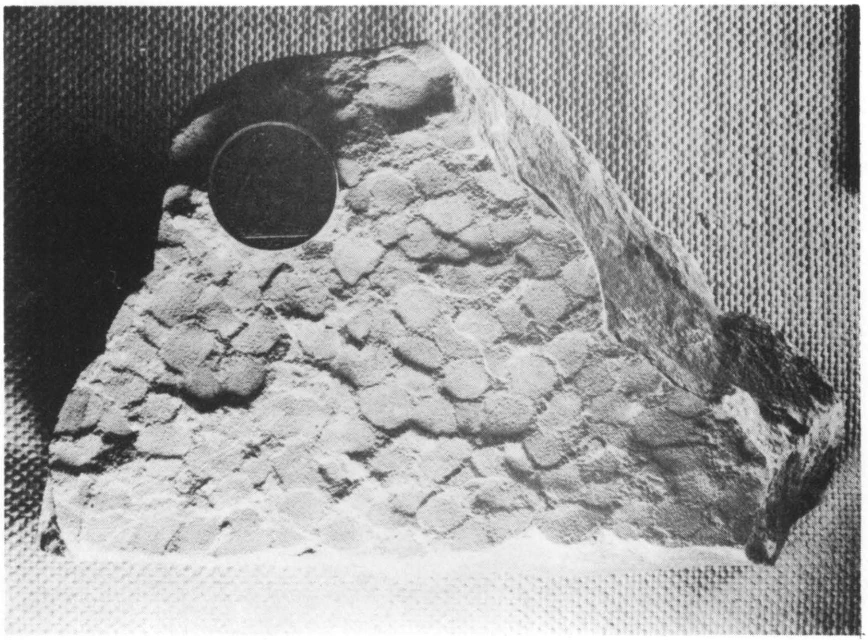


Fig. 2. Superimposed discs thought to be flattened faecal pellets. Scunthorpe Museum specimen P. 2043.

The filling of a sponge cavity will be determined by the sizes if the incurrent and excurrent canals and, at a later stage just before burial, by the shell material that currents can carry above the sea floor. This is likely to be somewhat smaller than the shell material normally dragged along by currents and would be deposited inside the open cavity where it would be protected from further attrition.

A difficulty of the sponge interpretation is the retention of the vertical or subvertical position during burial.

FODINICHNIA, Seilacher, 1953

Genus Teichichnus. Seilacher, 1955

Description. This trace fossil takes the form of horizontal or near horizontal burrows. There is usually inclined stratification within the burrows suggesting that they are enlarged by upward displacement. They are rarely completely straight, and branching burrows are occasionally seen.

Stratigraphy. Teichichnus burrows have been described from the Lower Cambrian rocks of Pakistan, the Middle Triassic to Lower Jurassic rocks of Germany and the Tertiary rocks of Belgium.

The specimens described here are from the Tenuicostatum Zone which in north Lincolnshire coincides with the Transition Bed (Swinnerton and Kent, 1949) immediately above the Marlstone Bed.

Dimensions. Blocks of the Transition Bed were examined at Cleatham (935005) where it was possible to measure the diameters of 50 clearly delineated burrows. A frequency distribution histogram based on this information (Fig. 2) clearly demonstrates a group of related burrows in the 0 to 25 mm.diameter range with an arithmetic mean of 13.3 mm. This figure agreed well with specimens already described (Seilacher, 1955). Possibly the specimens in the 35 to 45 mm.size range could belong to the same population but the diameters larger than this suggest the presence of a larger burrowing organism in the same deposits.

Mode of Occurrence. The Transition Bed is a ferruginous siltstone of very confused sedimentary structure. There is no primary stratification to speak of and the bed shows all the signs of having been reworked several times,as the enclosed severely eroded fossils indicate. The cause of this extensive disturbance appears to be the Teichichnus organism, since the massive blocks examined consisted entirely of its burrows. Many generations were represented since few burrows were not intersected by others. In a few cases,sections were seen showing the inclined laminations filling the burrows which were identical to the surrounding sediment;and in all cases examined,the final burrow was situated on top of the earlier ones, confirming the upward extension of the burrow. If the laminations filling these burrows are produced by the organism enlarging the burrow, then some burrows were re-used at least eight times.

Another feature noted at the locality was some degree of parallelism of neighbouring pairs of burrows. This was suggested by many short lengths of burrows; but four examples were seen where burrows ran parallel for all the exposed length, in these cases between 20 and 30 cm. The distances between burrows in these four examples varied from 25 to 75 mm.

The burrows rarely ran straight for distances of more than 30 cm.but generally curves were broad. The smallest radius of turn observed was 19 mm.although several examples of less than 90 mm.were also measured.

Interpretation. The laminated nature of the filling of the burrows suggests that they were not the work of boring worms but due to some organism pushing back the sediment as it progressed. If the animal was not soft bodied then it must have been small in size (not exceeding 15 mm.in width on average and 35 to 40 mm.in length) to perform a turn of 19 mm.radius without widening the burrow. Since no fossils were found in association with the burrows, little more can be said of the nature of the organism.

Genus Brancichnus ichnogen nov.

Diagnosis. Structure cylindrical and branching; horizontal. Commonly thickest at one end with branches and main structure reducing in diameter to distal regions.

Brancichnus dudleyi sp. nov.

Diagnosis. As for genus with diameter of main cylindrical form from 10 to 50 mm. Length from 8 to 60 cm.

Holotype Specimen P. 2042,lodged in the collections of the Borough Museum, Scunthorpe.

Description. The Brancichnus cylinders are usually preserved in limestones and a feature of those examined in this investigation was the lack of form or ornament on the outer surface, which is of rough texture. The main cylindrical portion is fairly straight, although curved forms were seen bending around other "stems" and "branches". The broad end of the structure is usually a distinctly truncated cylinder but it is almost a feature that the distal ends become indefinite.

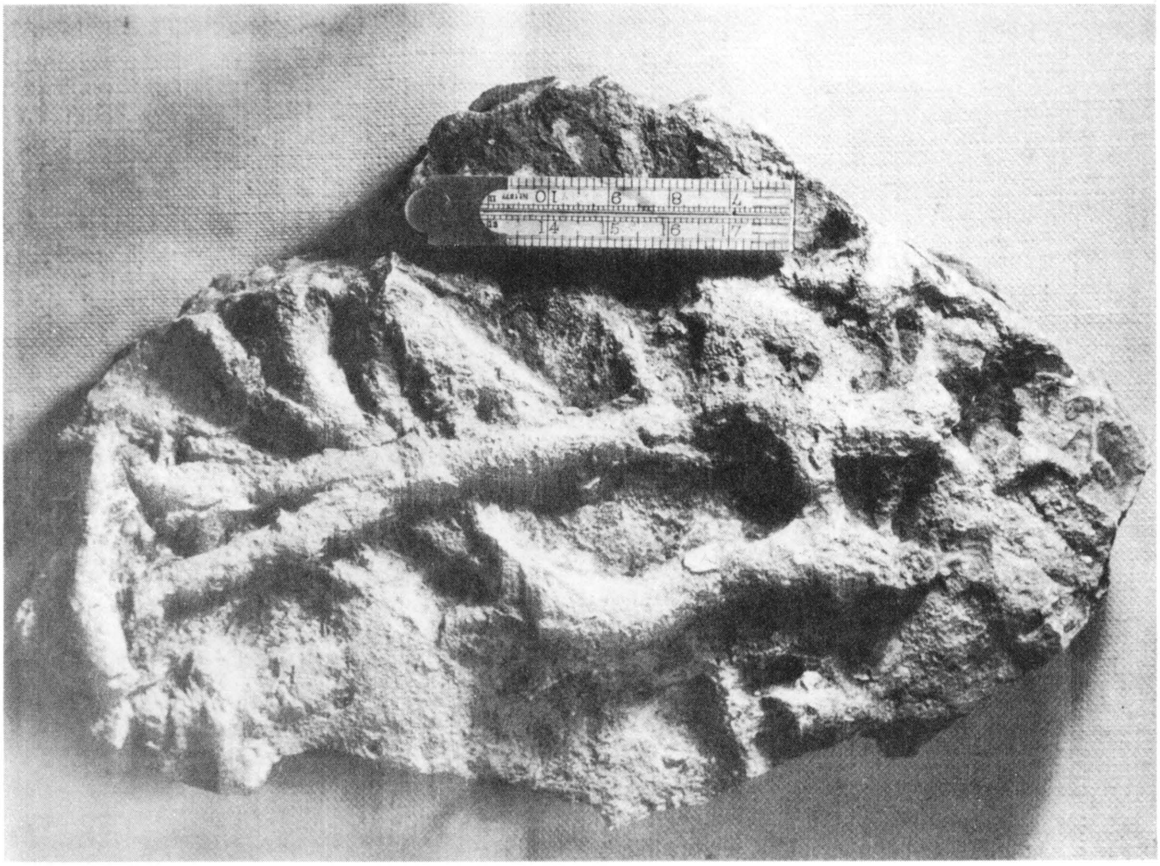
The greatest length seen was 60 cm., but normally the cylinders are much shorter than this. Commonly the structures are very poorly preserved and on many blocks are only detected in favourable light conditions.

Stratigraphy. Brancichnus occurs in the limestones of the Bucklandi Zone in north west Lincolnshire (Dudley, 1942) and may extend upwards into the lower Semicostatum Zone, the base of which is difficult to define in the area. Some indication of its presence was found in the Transition Bed at Cleatham, near Kirton Lindsey,but the material was too poor to make identification certain.

Mode of Occurrence. All remains so far seen have been on the underside of limestone blocks, so that the cylinders have their equivalent moulds in the underlying clay or shale. The moulds must have been the original sedimentary form and, with the change of sedimentary conditions, the calcarenite of the next sedimentary environment occupied the depressions to give the trace fossil now found. It seems likely that similar forms exist in the clays,but the similar nature of mould and filling makes their detection difficult if not impossible.

Interpretation. The first specimens found were ill-defined and seemed to represent some form of substratal lineation probably related to "frondescent" or "cabbage leaf casts" of Ten Haaf (1959, p. 30) and Kuenen (1959, p. 255), but when better material became available this interpretation was abandoned since the cylindrical form was more obvious. Also there was no directional lineation between "stem" and "branches" and in some cases "stems" actually crossed each other almost at right angles (Plate II).

Two interpretations are possible for Brancichnus. Either it can be regarded as a burrow system or it represents the cast of an organic (possibly vegetative) form which became impressed or shallowly buried in the mud of the sea floor. Most of the observed features tend to support the second interpretation. The gradual reduction in diameter is not normally associated with burrows,which either have a constant diameter or a repeated pattern of form along their length. Also in one specimen (P. 2042) three definite levels could be seen where cylindrical forms looped beneath each other. This could represent the flexing of "branches" or "stems" under pressure from the limbs above. Study of burrow systems shows that, in the majority of cases when a burrow approaches a pre-existing burrow, it tends to intersect rather than to descend beneath it. Orientation of shelly material surrounding the cylinders is in most cases normal to the wall of



Underside of limestone block showing Brancichnus dudleyi ger. et. sp. nov. Scunthorpe Museum specimen P. 2042. Here three branching structures lie on top of each other. On the extreme left is the lowest on top of which is a main "stem" crossing the block to the middle right. A third structure lies above this. (Scale in inches)

cylinders, suggesting that the sediment was pushed aside rather than displaced backwards and further strengthening the interpretation of an impression. Since no fossil remains were associated with Brancichnus, it is tentatively interpreted as the remains of a branching marine algae or some form of branching poriferain.

The species is named after the late Harold E. Dudley, one-time curator of Scunthorpe Museum, a self-taught geologist and Worth Medal winner, who did much unrecognised work in north west Lincolnshire.

Pellets in the Upper Lias rocks

Structures occur in the Upper Lias rocks which are probably trace fossils, but material available is not sufficiently well preserved to diagnose a genus.

Description. The normal form of the structures is that of sub-circular discs crowded together. A high proportion of the discs are superimposed on one another (Plate I, Fig. II) and there is no surface ornament of any kind. Although the structures resemble the tube ends of Greysonia (Walcott, 1914), a chemical or sedimentary structure, they differ in having no measurable thickness. The diameter of the discs ranges from 10 to 35 mm.(specimens P. 2042 and P. 2045 a and b) and parameters of populations on slabs from different horizons are unlike.

In the same succession, a nodule was collected in which a number of pellet-like forms were crowded together and slightly compressed in the vertical plane. The smallest of these was 4 mm. in diameter and the largest 15 mm.

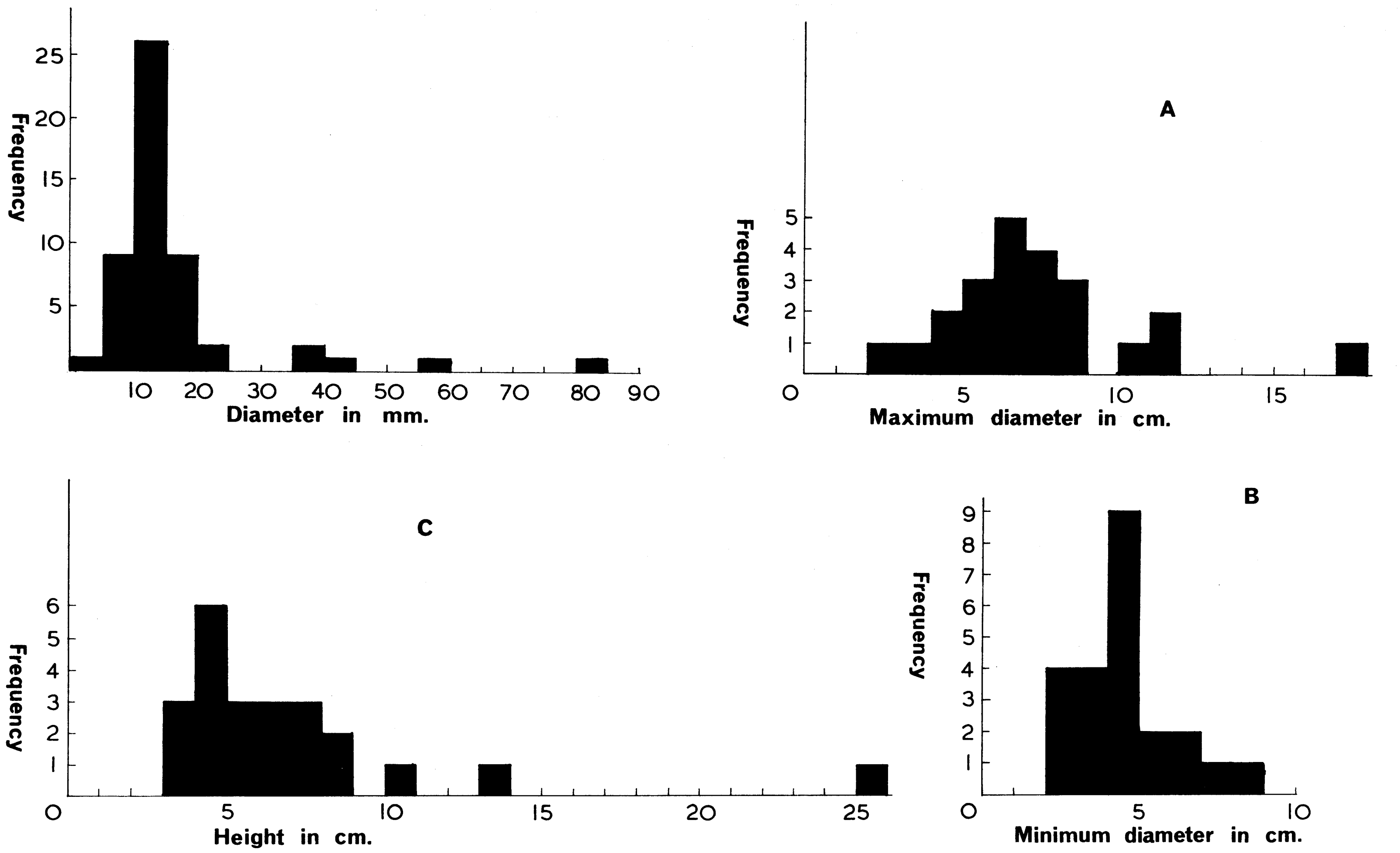
Stratigraphy. The structures have been seen only in the Upper Lias rocks of the area represented in north west Lincolnshire by the Paper Shales, which show a high degree of fissility in the lower beds, tending to become more calcite-rich and nodular towards the top. They are more common in the upper part of the sequence. The ammonite fauna collected from the shales shows that they include parts of the Falcifer and Bifrons Zones.

Mode of Occurrence. The discs only occur in the shales and are preserved best on bedding planes which are slightly more silty than usual. The ammonites enclosed in the same beds, Harpoceras sp. and Hildoceras bifrons, are completely flattened, indicating a high degree of compaction in the sediments. The same fauna collected from the nodules is much better preserved and the ammonites show no distortion. There is little doubt that the discs are the flattened remains of the pellets which have been spread during compaction, the degree of compaction thus explaining the differing parameters.

Interpretation. There is no difference in content between the pellets and discs and the surrounding sediments; this, considered with the size and shape, suggests that they represent faecal pellets of animals which were mud feeders.

Other Trace Fossils

The fossils described are not the only trace fossils known from the Liassic rocks of the area. Hallam (1963) has recognized and described three more from the Frodingham Ironstone. These are Rhizocarllium jenense Zenker, U-shaped tubes with nearly parallel limbs oblique or parallel to the bedding; Diplocraterion parallelum (Torell), U-shaped tubes similar to Rhizocorallium but always perpendicular to the bedding plane; and Zapfella pattei (Saint-Seine), sack-like bore holes observed on Gryphaea shells. In addition, Cylindrites (Goeppert) has been observed in shales and mudstones of the Jamesoni-Ibex Zones and Arenicolites (Salter) in the upper part of the Marlstone.



Text-fig. 1 Top left: Histogram showing frequency distribution of 50 diameters of Teichnichus burrows.
Top right and bottom: Histogram showing frequency distributions for 23 specimens of Kulindrichnus langi:-
A Diameters of larger (upper) ends
B Diameters of smaller (lower) ends
C Heights of specimens

Conclusion

The rocks of north-west Lincolnshire have revealed a variety of trace fossils, little known in Britain, but which may prove useful in elucidating the palaeoecology and possibly the stratigraphy of the Lias. Further investigations of Liassic rocks elsewhere is urged to increase our knowledge of the ichnology of the period and to test the constancy of the fossils if they persist laterally.

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