KULINDRICHNUS LANGI
A NEW TRACE-FOSSIL FROM THE LIAS

by A. HALLAM

Abstract. *Kulindrichnus langi* is the name given to a trace-fossil common in the Blue Lias. This is stumpy cylindrical or conical in shape and is formed of a shell aggregate often enveloped by a phosphatic sheath. It is interpreted as a burrow produced possibly by a cerianthid sea anemone.

THE structures produced by organisms in sediments and their geological significance are fields of study which German palaeontologists, most notably Abel and Richter, have almost made their own. Seilacher (1953) placed the systematic study of these structures on a firm and logical basis, and has given cogent reasons for using the Linnaean binomial nomenclature for the classification of trace-fossils. His proposals are adopted in this paper.

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DOMICHNIA Seilacher 1953

Kulindrichnus langi ichnogen. et sp. nov.

Plate 15

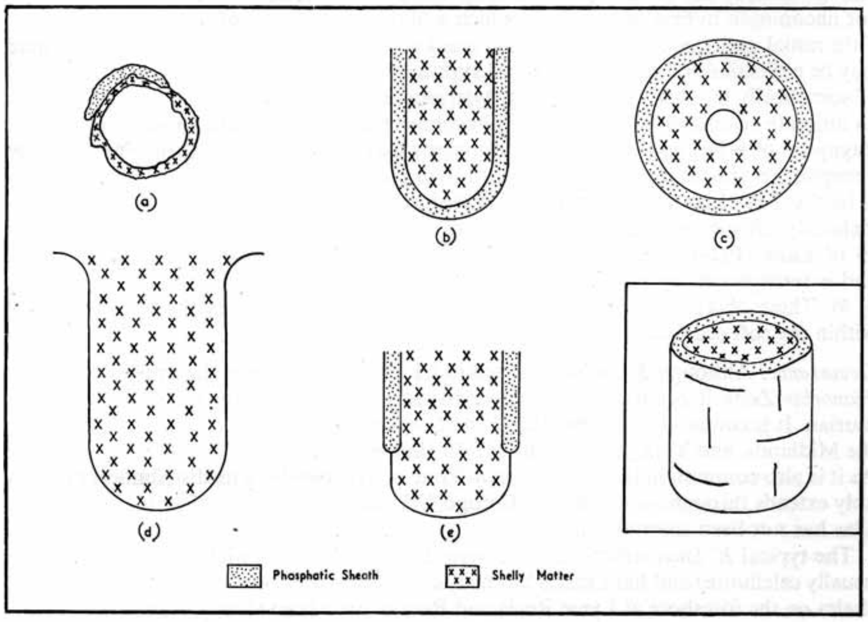
Diagnosis. Structure cylindrical or conical with apex downward; up to 130 mm. long and 75 mm. in diameter. Oriented subvertically in bed. Composed partly or wholly of small shells and shell fragments which may be aligned peripherally to the margin. Matrix sometimes phosphatic. Often bounded by sheath of phosphatic rock up to 10 mm. thick.

Description. The essential structure of *Kulindrichnus* is that of a stumpy cylinder or cone of shelly material. Its long axis in the enclosing bed is always within 20° of the vertical and the structure closes downwards. Although the cylinder is the commoner shape, cones with the apex downward are met with frequently. Whatever the shape there is a tendency to expand at the top (text-fig. 1*d*). The majority of specimens examined during the present investigation have been truncated a little by recent erosion. The few observations made on the upward terminations suggest that they are normally indefinite. Though *Kulindrichnus* extends up to 130 mm. in length and 75 mm. in width it is usually much smaller, the diameter, for example, ranging between 20 and 50 mm. The internal structures can be studied after cutting transverse and longitudinal surfaces which are then polished and varnished; thin sections are also useful.

The shell particles include fragments of pelecypods and echinoderms together with highly variable quantities of ostracods, foraminifera, and minute gastropods. Pelecypod fragments up to 20 mm. long have been observed but in general they are less than 5 mm. The particle distribution varies from complete randomness to a limited degree of order.

[Palaeontology, Vol. 3, Part 1, 1960, pp. 64–68, pl. 15.]

Thus in some specimens there is an axial zone free of shells. This may be of negligible diameter or so conspicuous that the shelly matter forms a mere peripheral ring when viewed in transverse section (text-figs. 1*a*, *c*). Elongate fragments sometimes show a crude alignment with the walls of the structure. The shells may be tightly packed within



TEXT-FIG. 1. *Kulindrichnus langi*. Diagrams (*a*) to (*e*) based on actual specimens, approximately ×½. (*a*) and (*c*) transverse sections showing axial zone free of shelly matter. (*b*), (*d*), and (*e*) longitudinal sections. Inset—reconstruction of burrow indicating calcite-infilled cracks in phosphatic sheath.

the cylinders or only patchily distributed. The internal matrix is invariably a calcareous rock, normally a fine-grained limestone, similar to the external matrix. There might be abundant detrital quartz or glauconite, depending on the nature of the depositional environment. Almost invariably, however, the *Kulindrichnus* structures are much richer in shelly matter than the immediate surroundings.

There is a pronounced association with collophane rock or phosphorite. The limestone of the internal matrix is generally phosphatic to some extent but more characteristically the phosphorite takes the form of a peripheral zone, up to 10 mm. thick, enveloping the cylinder or cone as a sheath (text-fig. 1) which is normally open at the top. This may be due in some instances to Recent weathering, for one specimen from Skye has been seen in which the sheath closed upwards. The sheath usually possesses a sharp inner boundary but its outer boundary is more often than not ill-defined, due to the gradual transition through pale brown rock into normal limestone. An analysis of a sample of the pale brown phosphatic limestone gave a value of 6·2 per cent. P_2O_5, which is greater than that for normal limestones of the Blue Lias by a factor of more than sixty. As might be expected the phosphorite sheath exhibits a high degree of variability. It might be partly or wholly absent (text-figs. 1*a*, *d*). The concentration of phosphate, as indicated by the intensity of the colour, differs a great deal even in the same specimen. Though usually the sheath marks exactly the outer boundary of the shelly core it is not uncommon to find specimens in which a narrow separation of up to 10 mm. exists. Thin radial and tangential calcite-filled cracks are characteristic of the sheaths. There may be indications of more pronounced rupture which has resulted in the 'bursting out' of some shelly material (Pl. 15, fig. 1). Microscopic examination of thin sections reveals an intimate relationship between the phosphorite and small shells. Most significantly, fragments of pelecypod shells convex outwards may be bounded on their inner sides by phosphorite, suggesting that the outward migration of the latter was impeded.

In the Blue Lias of Dorset the relationship of *Kulindrichnus* to other trace-fossils including *Chondrites* and *Rhizocorallium* can be studied with ease, particularly in bed 49 of Lang (1924). The whole fossil, phosphorite sheath included, both transgresses and is transgressed by structures attributable to burrowing organisms (e.g. Pl. 15, figs. 3, 4). These observations prove that the phosphatic part of *Kulindrichnus* developed within the soft sediment.

Occurrence. Although *Kulindrichnus* makes its first appearance in the upper part of the *Planorbis* Zone it occurs most characteristically and abundantly in the Lower Sinemurian. It is common in the *Bucklandi* and *Semicostatum* Zones of Dorset, Glamorgan, the Midlands, and Yorkshire and the *Semicostatum* and *Turneri* Zones of west Scotland. As it is also common in the *Semicostatum* Zone of Württemberg its distribution presumably extends throughout north-west Europe. Whether it occurs at higher horizons in the Lias has not been ascertained.

The typical *K. langi* structures have been discovered only in highly calcareous rocks, usually calcilutites and hard marls but also sandstones (in Scotland). Large exposures of shales on the foreshore at Lyme Regis and Redcar have been closely examined but have yielded only rare, minute phosphatic tubular structures which will be discussed below.

An examination of extensive exposures of limestone surfaces in the British coastal sections reveals that the *Kulindrichnus* structures are, in general, distributed randomly and evenly. There is, however, an occasional suggestion of structures occurring in pairs, separated by less than 50 mm. (e.g. bed 23, Dorset). As they are normally more cal-

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EXPLANATION OF PLATE 15

Figs. 1–4. *Kulindrichnus langi*. 1, Holotype seen in transverse section. ×1. Sedgwick Museum J.47829. This shows up clearly the sharp contrast between the dark phosphatic sheath and the inner shelly part which in one place appears to have burst out of the sheath. 2, Longitudinal section of a paratype. ×1. Sedg. Mus. J.47830. As the base of this specimen was found exposed on a weathered surface it is not certain that the observed downward thinning of the phosphatic sheath is original. 3, Transverse section of a paratype. ×1. Sedg. Mus. J.47831. 4, Longitudinal section of the same specimen. ×1. Both figs. 3 and 4 show clearly (*a*) *Kulindrichnus* transgressing *Chondrites* structures in the matrix and (*b*) a core of comparatively shell-free limestone rimmed by a peripheral zone of shelly material of variable thickness. The phosphatic sheath is developed only in the lower part of the specimen and is therefore only seen in fig. 4.

The holotype and paratypes were all collected by the author from the *Semicostatum* Zone, Dorset (bed 49 of Lang 1924).

careous than the surroundings they tend to weather out as convex protuberances. Those with a phosphatic sheath tend to weather completely free from the matrix so that a collection of free-lying specimens is likely to be biased.

Interpretation. The shape and orientation of *Kulindrichnus* with respect to the bedding indicate some form of burrow occupied by a sedentary organism (text-fig. 1, inset). There are three main problems. The first concerns the origin of the phosphatic sheath and the variably phosphatic interior. The action of sea water alone on the exposed surface of the burrow can be ruled out because phosphatic limestone surfaces are never found elsewhere. Therefore the organism itself must have been responsible, though whether the phosphate enrichment in the sediment is due to the presence of a faecal lining or to the decay of the organism is not clear. As regards the mechanism of phosphatization the evidence mentioned earlier points strongly to a radial migration outwards from the burrow of phosphorus-rich material and a chemical interaction with and/or surface adsorption on grains in soft calcareous mud. An interesting comparison can be made with the remains of prehistoric men who are sometimes found enveloped in a matrix rich in vivianite. This must owe its origin to an outward migration of phosphate from the bones (T. W. Farrer, personal communication). The mechanism probably involves preferential adsorption on mineral matter in the matrix, a phenomenon utilized in chromatography. No clear relation has been established between the presence of phosphorite and the lithology of the rock.

The second matter relates to the origin of the small shells and shell fragments. Undoubtedly the burrows are greatly enriched with respect to the surrounding rock. The uniformly small size of the shell particles and the traces of organized structure in some specimens point to activity on the part of the animal that inhabited the burrows. The disorganized structure of the majority of specimens could be due partly to the collapse of the shelly walls after the organism had decayed or vacated the burrow. It is impossible to exclude, however, some adventitious filling of the empty burrows by the action of currents operating close to the sea floor, especially in those cases in which they are packed to the top with shells. In any case the limy infilling probably originated in this way. There is no indication that the burrow-inhabiting organisms were selective for anything other than particle size. The evidence suggests that any available material was used to line the burrow. Thus one specimen from Redcar was found to be enriched in grains of glauconite.

Finally there is the problem of the organism itself. At the present time there are only two groups of marine organisms that inhabit subvertical burrows which they line with shells and other resistant materials—terebellid worms and cerianthid sea anemonies. The dimensions of *Kulindrichnus langi* do not suggest terebellids. The ratio of the diameter to the length and the absolute size of the diameter are too high even when allowance is made for the fact that sometimes the shell lining exceeds the core in thickness. One is therefore led to consider the cerianthids. *Cerianthus*, described by Schäfer (1956), is a mud-inhabiting sea anemone that builds a vertical tube, much wider than itself, which is lined with sand grains and shell fragments. Even this genus is probably too wormlike. *Saccanthus*, however, is a more stumpy member of the same family that has about the right proportions. It may be tentatively suggested, then, that *K. langi* represents the burrow of a cerianthid.

Related structures. Thick shale beds in the *Bucklandi* Zone of Redcar, Yorkshire, have yielded a small number of phosphatic tubes up to 13 mm. in diameter. They usually lie close to the plane of the bedding and are squashed parallel to this plane, indicating that the phosphorite did not harden before compaction. If *Kulindrichnus* occurs in the Blue Lias shales it must be represented by these structures, which would suggest dwarfing. Similar phosphatic tubes lying oblique to the bedding have been found in limestones of the *Johnstoni* Subzone in Dorset and Glamorgan. They extend up to 10 mm. in diameter and exceed 30 mm. in length. Throughout the bottom four zones of the Lias small irregular clumps of shell debris can be found. By their size and their occasional association with phosphorite they could represent collapsed *Kulindrichnus* structures.

The only mention known to the writer in the literature of structures like *Kulindrichnus* is that of Klüpfel (1918, p. 183), describing the *Gryphaea* beds of Lias α in Lorraine (*Bucklandi* and *Semicostatum* Zones). 'Nicht selten', he remarks, 'enthält der Kalk harte, faustgroße, walzen- oder tonnenförmige Körper, die mit Muscheldetritus erfüllt und hier und da von einem hellgrauen phosphoritischen Mantel umgeben sind. Andere von Fossildetritus erfüllte sehr zähe Knollen haben eine kegelförmige Gestalt oder zeigen Formen, die an den Hals einer Flasche erinnern. Diese Bildungen, die nicht an einen bestimmten Horizont gebunden zu sein scheinen, sind in aufrechter Stellung mit der oft knolligen Spitze nach oben dem Kalk eingewachsen und lösen sich beim Zerschlagen heraus.'

The species is named after Dr. W. D. Lang, who has done much distinguished work on the Lias of Dorset.

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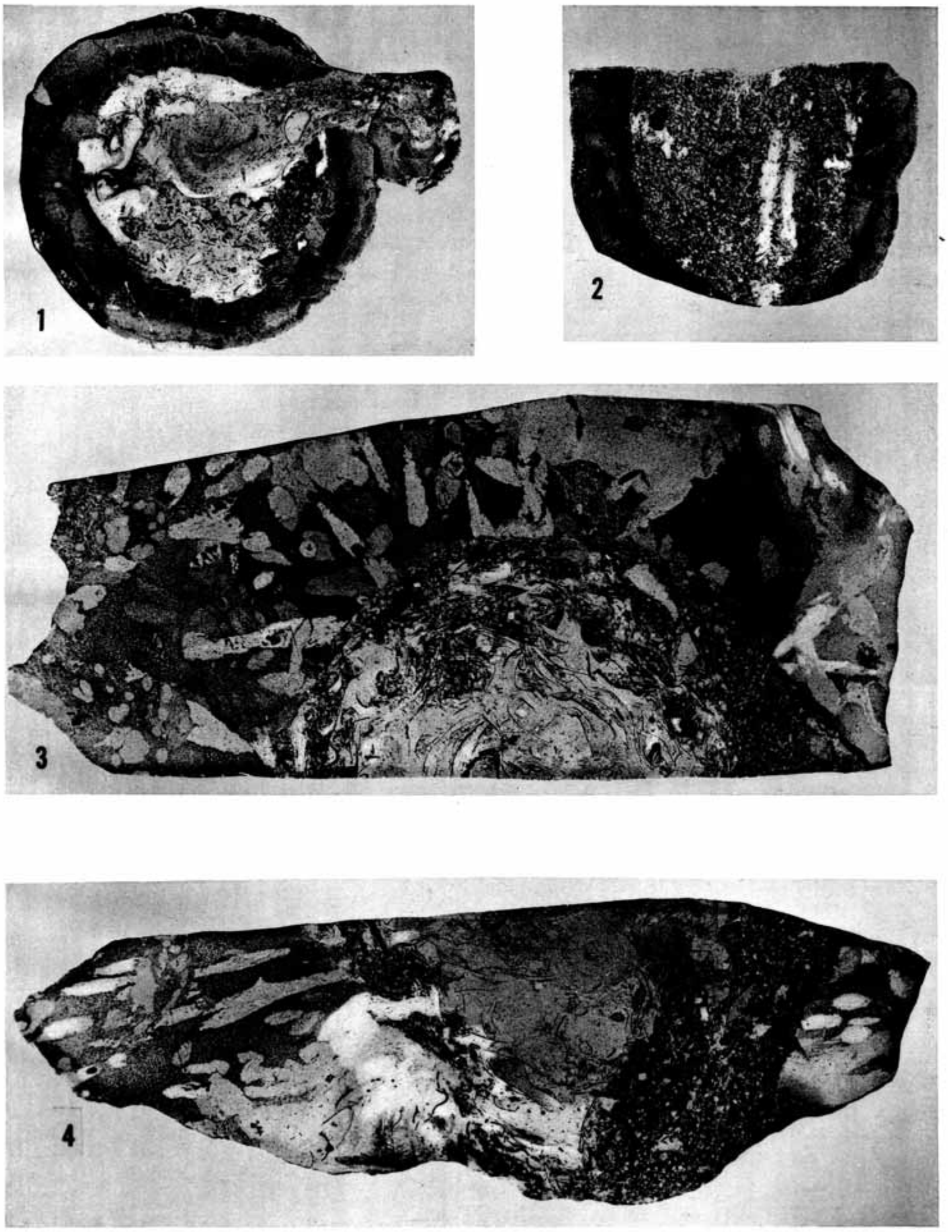

HALLAM, *Kulindrichnus*