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## On a Lower Devonian Fauna from Pahang, West Malaysia

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**Abstract:** A mixed fauna composed of reticulate sponges, inarticulate brachiopods, phyllocarid crustaceans and graptolites is described from the "Foothills formation" of western Pahang State. Graptolites in the assemblage include a monograptid of the *M. hercynicus* type identified as *Monograptus* cf. *praehercynicus* Jaeger. This indicates that the age of the host rock is early Lower Devonian. The fauna has provided the first stratigraphically useful organisms to have been recovered from these rocks. Its discovery implies a Lower Palaeozoic age for the bulk of the "Foothills formation" and underlying schists, and clarifies the structural and stratigraphic position of these units.

### INTRODUCTION

A mixed fauna, composed of planktonic and benthonic elements and consisting of reticulate sponges, inarticulate brachiopods, phyllocarid crustaceans and graptolites, was found in 1965 in western Pahang. The fossils were found in rocks exposed in a road cutting on the Tuan Estate some ten miles south of the town of Karak by Mr. Jaafar Ahmad and his assistants of the Geological Survey Department, West Malaysia, during the systematic geological mapping of this part of Pahang State. The locality is at latitude 3°16'N, longitude 102°07'E or map reference 134 137 on 1:63360 topographical sheet 3C/9 (fig. 1).

The fossils occur in some six feet of strongly weathered and bleached shales which are exposed in a high cutting where the estate road winds through hilly country. Graptolites and fragmentary crustacean remains are the predominant elements of the fauna, which is unevenly distributed through the beds, being abundant on some bedding planes and rare or absent on others. The state of preservation is generally poor. The remains occur as impressions which are normally flat, but in the case of the brachiopods and the jaws of crustaceans some relief is shown. The body material of the organisms has been replaced by a faint film of white mica and finely divided carbon.

The shales from which the fossils were recovered occur near the top of a very heterogeneous group of strata. These rocks were originally mapped as one unit and termed the Foothills formation by Richardson (1946), and this term is used for convenience in this paper (in an informal sense; see comments under "Stratigraphic Significance"). The Foothills formation can be traced south along the flanks of the Main Range granite for over 200 miles from Kelantan through western Pahang and eastern Negri Sembilan to Malacca.

Preliminary details of the fauna were given in Jones, *et al.* (1966, p. 317), where the presence of *Ceratiocaris* sp. and *Monograptus* aff. *vomerinus* Lapworth was re-

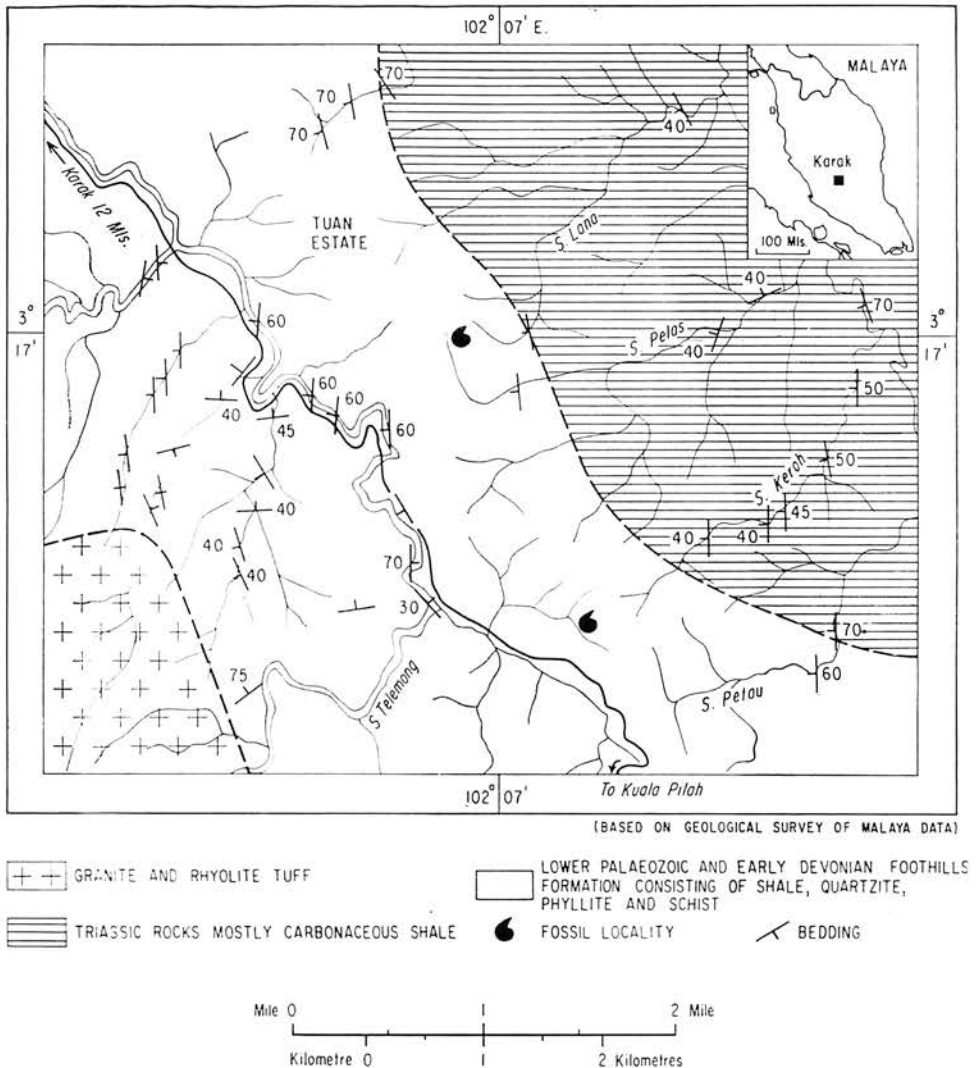


Fig. 1. Geologic map of the vicinity of Tuan Estate, near Karak, Pahang, showing fossil localities.

ported. It was there stated that the age of the fauna based on the graptolite determination was Wenlockian. Subsequent detailed work has shown that the form previously identified as *M. aff. vomerinus* is a monograptid of the *M. hercynicus* type and that the fauna is early Devonian in age.

The fauna which is described below is determined as follows:

Hexactinellida: *Hydrodictya cylix* Hall and Clarke, *Lyrodictya* sp.  
 Inarticulata: *Orbiculoidea sinensis* Mansuy

Archaeostraca: *Ceratiocaris* sp.

Graptolithina: *Monograptus* cf. *praehercynicus* Jaeger, *Linograptus* aff. *posthumus* (Richter)

For many years the age and structural relationships of the Foothills formation have been a matter for conjecture. Although a few fossil remains have been reported in the past they have always been either too poorly preserved for precise determination or of little use as stratigraphical indicators. The present collection has therefore provided evidence of great stratigraphical significance. Not only has the early Devonian age of the fossiliferous strata been ascertained but a general Lower Palaeozoic age for the bulk of the strata composing the Foothills formation has thereby been established.

#### *Acknowledgement*

My thanks are extended to the Director, Geological Survey of West Malaysia for allowing me the privilege of studying this interesting fauna and to Dr. W. D. I. Rolfe of the Hunterian Museum, Glasgow who examined and identified the crustacean remains.

#### AGE SIGNIFICANCE

The precise age of the Tuan Estate beds is established on a basis of the graptolites contained within the fauna. The other members of the assemblage broadly support the age assessment indicated by the graptolites, but in general they belong either to wider ranging forms, or to forms whose value as stratigraphical indicators has not yet been established. The reticulate sponges were first described by Hall and Clarke (1898) from strata of Devonian and Carboniferous age in New York State. *Orbiculoidea sinensis* was a species established from the Upper Silurian of east Yunnan by Mansuy (1912). The phyllocarid genus *Ceratiocaris* ranges through strata of Ordovician to Devonian age.

The commonest graptolite present is a form determined as *M.* cf. *praehercynicus* Jaeger. This is a monograptid belonging to the *M. hercynicus* group which includes some of the youngest graptolites known. The descriptive palaeontology and significance of these graptolites has only recently been made known through the researches of Jaeger (1959, 1962), although Perner (1899) described two species from beds in Bohemia which he thought were possibly Devonian in age. Jaeger (1959) summarized the then known occurrences of these graptolites in Europe, central Asia, Ellesmere Island and Victoria, Australia. Subsequently, Jackson and Lenz (1963) reported a new species of the group from the Yukon Territory, and Berry (1965) noted further occurrences in Nevada and east Canada.

In discussing the correlation of strata containing *M. hercynicus* type monograptids in central Europe with the Ludlow rocks of Wales and the Gedinnian sequence of Western Europe, Jaeger (1962) conclusively demonstrated that the beds were post-Ludlow and could be equated with the Gedinnian and part of the Siegenian Stages. The placing of the Gedinnian with the Devonian is, however, a matter of some debate amongst students of the Silurian-Devonian boundary and its problems. Berry (1965) has summarized the evidence in favour of placing the Gedinnian in the Devonian. He showed that in those areas of central Europe, North America and central Asia where monograptids of the *M. hercynicus* type are found with, or closely associated with, a shelly fauna, the shelly fossils are always of a Devonian rather than a Silurian

aspect. He concluded "an occurrence of *M. hercynicus* type monograptids to be evidence of an early Devonian age for the beds bearing them wherever found until such time as this age span may be increased" (Berry, 1965).

Kraatz (1967) extended the zonal classification based on graptolites which was established to cover the British succession by Elles and Wood (1914). He added a further eleven zones above the uppermost zone (Zone 36 of *M. leintwardinensis*) recognized in Britain to accommodate all those graptolite zones of late Ludlow or post-Ludlow age which had been proposed to cover the sequence in central Europe. The modified and combined classification for Thuringia, Bohemia and Poland is given below:

Classification Bohemia	Extended zonal classification of Elles and Wood	Modified and combined classification for Thuringia, Bohemia and Poland after Jaeger (1962, 1965) by Kraatz (1967)
e $\gamma$	47	Monogr. hercynicus
	46	Monogr. praehercynicus
	45	Monogr. uniformis
e $\beta$ 2	44	Monogr. angustidens
	43	Monogr. transgrediens
	42	Monogr. perneri
	41	Monogr. bouceki
	40	Monogr. lochkovensis
	39	Monogr. ultimus
3 $\beta$ 1	38	Monogr. fecundus
	37	Monogr. fritschi linearis
	36	Monogr. leintwardinensis

Jaeger (1962) produced evidence to show that the e $\gamma$  beds of Bohemia could be correlated with the Gedinnian. If this is accepted it will be seen that the zone of *M. praehercynicus* occurs some way above the base of the Gedinnian.

In the Tuan Estate fauna other graptolite remains are occasionally found associated with the form determined as *M. cf. praehercynicus*. They consist of long slender uniseriate stipes which have affinity with the species *Linograptus posthumus* (Richter). The genus *Linograptus* is frequently associated with faunas containing *M. hercynicus* type monograptids but also occurs in beds of Ludlow age in central Europe, North America and Australia. *L. posthumus* is common in the zones of *M. uniformis* and *M. praehercynicus*.

#### STRATIGRAPHICAL SIGNIFICANCE

The geology in the vicinity of the fossil locality is shown on figure 1. The fossiliferous shales lie between beds of schist above and rhyolite tuff below, all of which strata occur in the upper part of the Foothills formation. The name "Foothills formation" is here used for convenience and on account of its familiarity, to cover a thick sequence of essentially arenaceous strata which lie between the Main Range granite and the Triassic and Permo-Carboniferous rocks to the east. The names "Lower Arenaceous Series" and "Older Arenaceous Series" have also been applied to this unit by various authors in the past. Alexander (1959) renamed the unit the "Bentong Group" but placed it above the Kuantan Group which was ac-

corded an early Carboniferous age. The detailed structure and stratigraphy of the rocks is still incompletely known but it is almost certain that a number of recognizable constituent formations will be proved eventually so that the succession is best regarded as a group rather than a formation. The strata are composed of an irregularly developed sequence of pebbly rocks, grits, phyllites, shales, schists and schistose arenaceous and pebbly rocks. In certain areas the rocks appear to overlie an appreciable thickness of schists. In other areas the schists are either missing or much attenuated.

The geological boundary between the Foothills formation and the younger rocks to the east is a line of very varied and puzzling characteristics. In certain places the Foothills strata seem to dip eastwards conformably underlying the younger rocks. In other areas the younger rocks appear to dip westward under the Foothills rocks in apparent conformable relationship, and again at certain other points there is evidence of an angular unconformity between the two successions, with the development of thick conglomeratic lenses at the top of the Foothills sequence, so that a major depositional break is suggested.

Hence the structural disposition and stratigraphical relationships of the Foothills rocks have been a matter of great controversy. Richardson (1946) reviewed the theories which had been proposed to account for the anomalies and summarized the available evidence. Two main ideas were advanced by geologists. The earlier, propounded by J. B. Scrivenor, favoured a Triassic age for the Foothills formation based on lithological comparison of the rocks with the Triassic beds to the east. Richardson (1946) and J. B. Alexander (*in* Ingham, 1947, p. 38) were convinced that this interpretation was wrong, and that the Foothills rocks were appreciably older than the strata of Triassic and Permo-Carboniferous age which lay to the east. In both theories, where anomalies in the superposition of older upon younger rocks were indicated, the authors invoked inversion of the sequence.

The Tuan Estate fauna has eventually provided the indisputable evidence in favour of the greater antiquity of the Foothills formation. The age of the fauna is early Lower Devonian, from which it is inferred that the bulk of the strata composing the Foothills formation and the underlying schists are Lower Palaeozoic—this with the proviso that the succession in the Tuan Estate is in normal superposition.

#### SYSTEMATIC DESCRIPTIONS

Phylum PORIFERA Grant, 1872  
 Class HEXACTINELLIDA Sollas, 1887  
 Order LYSSAKIDA Zittel, 1877  
 Family DICTYOSPONGIIDAE Hall, 1882  
 Subfamily DICTYOSPONGIINAE Hall, 1882  
 Genus *Hydrodictya* Hall, 1898

*Hydrodictya cylix* Hall and Clarke, 1898

Pl. 1            Fig. 1

1898. *Hydrodictya cylix*, Hall and Clarke, Pal. Reticulate sponges constituting the family Dictyospongiidae. Mem. 2, Univ. State New York, p. 78, p. v, fig's 1-2; pl. XVI, fig. 2; p. LV, fig. 7.

Diagnosis: Simple, broadly expanded, vase-shaped cups without nodes or ridges or other conspicuous surface characters and with no apertural fringe.

**Material:** Two fairly complete flattened impressions representing counterparts of the same individual on slabs numbered 968F and 989F in Geological Survey of West Malaysia central collection of fossils. Part of apertural portion missing due to fracture of block. Lyssacine skeleton fairly well preserved, the spicules showing some relief. Impression sub-symmetrical in appearance owing to oblique manner of repose of the individual.

**Description:** Sub-symmetrical cone-shaped cup rapidly expanding aperturally; length 50 mm., apertural width ca. 40 mm. The reticulum is regular and is built of a primary network of meshes forming a rectangular pattern; the vertical strands of spicules lie at regular intervals of about 2 mm., the horizontal strands at about 3 mm. Between the primary reticulation lies a secondary meshwork of closely spaced spicules which do not appear to be arranged in any regular pattern. The primary, horizontal and vertical meshes are arcuate, being concave with respect to the margins and base of the skeleton, thus indicating its original sub-spherical form.

**Remarks:** The material shows close comparison in shape and size to Hall and Clarke's original specimens from Ontario County, New York. The only difference to be noted is the slightly oblong pattern of the primary reticulum; this may be caused by the oblique manner of repose of the sponge at the time of compression.

**Stratigraphical position:** The original material from New York State came from the lower beds of the Chemung Group of Devonian age. The West Malaysian material is associated with *Monograptus* cf. *praehercynicus* Jaeger which is indicative of the *praehercynicus* Zone of the Gedinnian Stage of the Lower Devonian.

Genus *Lyrodictya* Hall and Clarke, 1898

*Lyrodictya?* sp.  
Pl. 1                      Fig. 2

**Generic diagnosis:** Dictyosponges with regularly expanding, generally smooth exterior, fine network, low erect tufts at wide intervals and very broad thick bundles of rods and clemes with no horizontal bundles of corresponding size.

**Material:** Single flattened impression, on slab numbered 987F in Geological Survey of West Malaysia central collection of fossils, consisting of the upper part of a large dictyospongid. Lyssacine skeleton fairly well preserved, consisting of two stout strands composed of bundles of spicules and an otherwise irregular meshwork.

**Description:** The exact shape of the sponge is unknown but the impression would appear to be from the upper part of a cylindrical or cup-like skeleton; dimensions 80 mm. in length, 73 mm. in width. The skeleton consists of an irregular network of hexacts and two prominent longitudinal strands or lateralia formed of large bundles of diactine spicules. These strands are by far the most striking feature of the skeletal structure. They are each 1-2 mm. wide and are aligned in parallel or slightly converging relationship, 1.7 cm. apart at one end of the impression and 1.5 cm. apart at the other end. The margins of the strands are fairly sharply defined. There are no horizontal bundles of spicules corresponding to the vertical lateralia. The rest of the reticulum is composed of primary coarse spicules and an intervening network of finer closely spaced spicules. This irregular pattern of spicules is denser between the two lateralia. It extends beyond and is impressed upon the inner (?) of the two strands. Within a distance of 1 cm. beyond this inner strand the primary spicules disappear and a close network of fine spicules is all that can be distinguished.



No horizontal or vertical alignment of the spicules exists within the reticulum apart from the development of the lateralia. However, some of the primary spicules do show a tendency towards orientation, being aligned sub-parallel and at an oblique angle to the lateralia. The lines of spicules also bend in to align themselves with the outer (?) lateralium, indicating curvature of the sponge wall.

Remarks: Little can be said concerning the original shape and size of the sponge beyond remarking that it was a large sub-cylindrical or cup-shaped structure. The existence of stout longitudinal strands of spicules within the reticulate skeleton stands out as a diagnostic feature. Such structures as these are known only in the genus *Lyrodictya*. In the absence of further evidence the form is referred tentatively to this genus.

Stratigraphic position: Two species of *Lyrodictya*, *L. romingeri* Hall and *L. ? burlingtonensis* Hall, have so far been described. These were found in the Keokuk and Burlington Groups of New York State which are Carboniferous in age. The associated graptolite fauna indicates that the West Malaysian material is early Lower Devonian.

Phylum BRACHIOPODA Dumeril, 1806  
 Class INARTICULATA Huxley, 1869  
 Order LINGULIDA Waagen, 1885  
 Superfamily DISCINACEA Gray, 1840  
 Family DISCINIDAE Gray, 1840  
 Subfamily ORBICULOIDEINAE Schuchert & Le Vene, 1929  
 Genus *Orbiculoidea* d'Orbigny, 1847  
*Orbiculoidea sinensis* Mansuy, 1912  
 Pl. 1                      Fig.'s 3a-b

1912. *Discina (Orbiculoidea) sinensis*, Mansuy, Étude Geol. du Yunnan Oriental, pt. II, Palaeont. in Mem. du Service Geologique de L'Indochine, vol. I, fasc. 2, p. 33, pl. IV, fig.'s 11a-d; pl. V, fig.'s 3a-b.

1924. *Orbiculoidea* cf. *sinensis*, Grabau, Sil. Faunas E. Yunnan, Pal. Sinica, Ser. B., vol. 3, fasc. 2, p. 31, pl. II, fig. 6.

Material: Impressions of four valves on blocks numbered 997F and 998F in Geological Survey of Malaysia central collection of fossils. The material includes two pedicle valves and two brachial valves, one complementary pair superimposed on each other.

Diagnosis: Both valves small, elliptical, with faint concentric growth lines and sub-central apices.

Description: Both valves are elliptical to semi-elliptical in shape, the greatest diameter measuring 16 mm. Brachial valve slightly convex. Pedicle valve flat, pedicle tract discernible as narrow furrow with foramen running to posterior margin of shell, closed anteriorly by listrum, shell surface showing gentle flexure adjacent to furrow.

Remarks: In details of size, shape and ornament the specimens compare well with the original material from east Yunnan described and figured by Mansuy (1912). They differ from an impression from Yunnan determined as *O. cf. sinensis* by Grabau (1924) in the far greater size of the valves, although Grabau considered his specimen

as a juvenile of the species. *O. sinensis* was first described from strata exposed at Si-Yang-Tang where it occurred abundantly with phyllocarid impressions. It is of interest to note that the West Malaysian material also occurs with abundant remains of *Ceratiocaris* sp.

Stratigraphical position: The strata yielding *Orbiculoidea sinensis* at Si-Yang-Tang in east Yunnan are of Silurian age. Mansuy (1912, p. 36) noted that the new crustacean species *Ceratiocaris pierloti* with which the brachiopods occurred compared with *Ceratiocaris stygia* Salter of Ludlow age. However, Dr. W. D. I. Rolfe informs me (personal communication) that *C. stygia* is indistinguishable from *C. papilio* of Valentian-Wenlock age. *Orbiculoidea* cf. *sinensis* described by Grabau (1924) from the Miaokao Group of Taihaisao was recovered from shales overlying the *Spirifer tingi* beds which are Upper Silurian. The precise age of the West Malaysian specimens is made known by the associated graptolite fauna which includes *Monograptus* cf. *praehercynicus* Jaeger indicating an early Lower Devonian age.

Phylum ARTHROPODA Siebold and Stannius, 1845  
 Class CRUSTACEA Pennant, 1777  
 Order PHYLLOCARIDA Packard, 1879  
 Family CERATIOCARIDIDAE Salter, 1863  
 Genus *Ceratiocaris* McCoy, 1849

*Ceratiocaris* sp.

Pl. 1            Fig's 4a-c

Material: There occur on many of the slabs of shale from this collection numerous faint, often poorly defined impressions identified by Dr. W. D. I. Rolfe, Hunterian Museum, Glasgow as the gnathal lobes of the mandibles, telsons and furcal rami belonging to this genus. The impressions are normally flat but the detached jaws show some relief. Body material is replaced by a fine film of white mica. The material is insufficiently well preserved for specific identification.

Dimensions: Telson, spinose, up to 9 cm. in length. Gnathal lobes generally paired up to 1.5 cm. broad.

Subphylum STOMOCHORDA Dawydoff, 1948  
 Class GRAPTOLITHINA Bronn, 1846  
 Order GRAPTOLOIDEA Lapworth, 1875  
 Family MONOGRAPTIDAE Lapworth, 1873  
 Subfamily MONOGRAPTINAE Lapworth, 1878  
 Genus *Monograptus* Geinitz, 1852

*Monograptus* cf. *praehercynicus* Jaeger, 1959

Pl. 1            Fig.'s 5a-e

Diagnosis: Monograptid of *M. hercynicus* type. Rhabdosome medium sized, mainly straight with slight dorsi-ventral curvature proximally. Thecae 8-12 per cm. of the *unicinatus* type, proximally with well-hooked apertural regions, distally with small apertural excavations covered by thecal hoods.

Material: Monograptids compared with this species are abundant in the collection from the Tuan Estate locality. Impressions on slabs numbered 946F, 949F,



951F, 965F, 967F, 968F, 974F, 985F, 986F, and 988F in the Geological Survey of Malaysia central collection of fossils are used in this description. Preservation poor, as flat impressions in which the periderm is replaced by a faint film of white micaceous material and finely divided carbon; much of the carbon removed by weathering. Structural detail poor, most specimens lacking sicula terminations. Slight variations noted in overall dimensions may have been caused to some extent by lateral compression consequent upon shearing in the host rock.

Description: The length of the rhabdosome averages 4 cm.; the width at the level of th1 is between 0.8 and 1.0 mm. and increases gradually to a maximum of 2.0 mm. In most examples the proximal part of the rhabdosome is bent into a broad S-curve; a dorsal curvature characterizes the first 3 mm. or so, this changing to a gentle ventral curvature over the next 4 to 6 mm., beyond which the rhabdosome straightens. The sigmoid curvature is more pronounced in some impressions than in others. Slight convexity of the dorsal edge of the sicula may suggest further slight ventral curvature at the extreme proximal end of the rhabdosome. No complete sicula is preserved. A specimen on slab numbered 965F shows an almost complete sicula, length 1.5 mm., width to 0.4 mm.; the dorsal edge is convex and is produced to form a small recurved lip; there is also evidence of a spine-like virgella. The initial theca seems to have originated at a distance of 1 mm. from the apex of the sicula. The first few thecae are prominently hooked and measure 1.0 to 1.5 mm. in length, show little overlap and are inclined to the rhabdosome axis at around  $40^\circ$ ; about one third of the thecal length is involved in the apertural hook. The later thecae have the dorsal surface produced into a hood (*hauben*) which covers an apertural excavation; they measure a little over 2 mm. in length, overlap for one half of their length and are inclined to the rhabdosome axis at a little over  $40^\circ$ . Near the ventral edge of the rhabdosome the dorsal surface of the theca bends over to form the slender arcuate hood which protrudes 0.5 mm. beyond the ventral margin of the rhabdosome; the structure is disposed concavely over a semi-elliptical apertural excavation; the excavation is 0.3 to 0.4 mm. in diameter and the apertural margin is straight to concave, everted. The free ventral edge of the theca is straight to slightly concave, vertical or more usually inclined at up to  $15^\circ$  to the rhabdosome axis; it obliquely faces the proximal end, measures 0.8 mm. in length and forms a denticle with the apertural margin.

Remarks: The material is a typical monograptid of the *M. hercynicus* type as defined by Jaeger (1959). In dimensions and thecal count it best compares with *M. praehercynicus* Jaeger, although with the poor state of preservation and slight deformation caused by lateral compression its precise identity cannot be determined. *M. hercynicus* Perner is of similar dimensions but has a highly characteristic sicula with a greatly expanded aperture so that the dorsal wall is markedly concave rather than convex as in *M. praehercynicus*. *M. ramstalensis* Jaeger is another similar form but is much wider. The West Malaysian material also approaches a recently reported monograptid of the *M. hercynicus* type from Eildon, Victoria, Australia. The species is described by Berry (1965) under the name "forma A", the proximal part of the rhabdosome is more strongly curved than in *M. praehercynicus* and the initial two thecae are more erect and isolated.

Stratigraphical position: Monograptids of the *M. hercynicus* type extend from the top part of the e $\beta$ 2 to the e $\gamma$  beds of the Bohemian succession. They are most characteristic of the e $\gamma$  beds, that is Zones 45–47 in Kraatz's (1967) modified Elles and Wood classification. *M. praehercynicus* is the zone fossil of the praehercynicus

Table 1. Quantitative characteristics of specimens of *Monograptus* cf. *praehercynicus* Jaeger from Tuan Estate and *Monograptus praehercynicus* Jaeger (from Jaeger, 1959). All dimensions are given in millimeters.

Sp. No.	Rhabdosome width		Length	Sicula		Thecae per cm.	
	Maximum	At level th1		Length	Width	Distal	Proximal
946F	1.9	1.0	40	—	—	9	—
949F	2.0	1.0	40	—	—	9	11
951F	1.9	—	25*	—	—	7	—
965F	2.0	1.0	54	1.5	0.4	9	12
967F	2.1	—	25*	—	—	10	—
968F	2.2	0.9	32	—	—	9	11
974F	2.0	0.8	20*	—	—	9	11
985F	1.6	—	35	—	—	—	—
986F	1.9	0.8	30*	—	—	8	—
988F	1.5	1.0	35	—	—	10½	12
Jaeger 1959	1.5-2.3	0.7-1.0	30-50	2	0.4	8¼	10

\* Incomplete rhabdosomes

Zone (Zone 46) and it ranges throughout this zone into the bottom layers of the overlying hercynicus Zone (Zone 47). The close comparison between the West Malaysian form and *M. praehercynicus* indicates at least a Gedinnian age for the horizon.

Subfamily CYRTOGRAPTINAE Boucek, 1933

Genus *Linograptus* Frech, 1897

*Linograptus* aff. *posthumus* (Richter, 1875)

Pl. 1            fig. 6

Diagnosis: Rhabdosome compound, consisting of two or more long slender uniseriate stipes; the first branch developing from a normal sicula, the later stipes originating and radiating from sicular cladia. Thecae simple slender tubes expanding somewhat aperturally.

Material: Several blocks of shale from the Tuan Estate locality, notably those numbered 948F, 962F, 963F, 974F, and 989F, show sections of a long slender compound monograptid which is referable to this genus. The material is strongly compressed and ill defined. It occurs as flat impressions in which the periderm is replaced by a fine white micaceous film in which can be distinguished occasional specks of carbon. The structural details are almost completely obliterated by strong chemical bleaching of the impression and the immediately surrounding rock matrix. The fragments under observation consist of sections up to 10 cm. in length.

Description: Rhabdosome compound, but mostly fragmentary, consisting of slender flexed stipes several centimeters in length; the stipes show gentle ventral curvature and measure between 0.4 and 0.9 mm. in width, the thickness being greater distally. One example on slab 989F appears to show four stipes radially disposed about a common point with the thecae of three of the stipes growing away from the point of origin, the thecae on the fourth stipe cannot be discerned. Owing to poor preservation no common sicula can be seen. Thecae 7 to 9 per cm., simple slender tubes inclined at 15° to the axis of the stipe and overlapping for one third to one half of their length. Thecal length 2.5 to 3.0 mm., expanding near the aperture to 0.7 mm. in width in the more mature thecae, free ventral edge straight to concave, apertural margin straight, undulate or convex.

Remarks: Nearly all the material under observation consists of long slender sections of the component stipes but the presence of some examples with stipes radiating from a common origin indicate the genus *Linograptus*. Of the three described species of this genus the West Malaysian material has closest affinity in dimensions and thecal density with *L. posthumus* (Richter) but due to poor preservation it is not possible to identify the material more closely with this species. However, in support of its reference to Richter's species is the fact that *L. posthumus* is common in the zone of *M. praehercynicus* in Europe, which is the stratigraphical level suggested by the associated fauna in West Malaysia. The dismembered stipes also show comparison with *Cyrtograptus carruthersi* Lapworth, but as remarked by Bouček (1933, p. 65) it is impossible to distinguish between the stipes of these forms in the fragmentary state alone. The only previous record of *Linograptus* from Asia is that of *L. posthumus* from the Ural geosyncline (Nikiferova and Obut, 1965).

Stratigraphical position: Jaeger (1959) gives the range of *Linograptus* as Ludlow or possibly high Wenlock to Gedinnian. *Linograptus posthumus* is common in the Central European zones of *M. uniformis* and *M. praehercynicus* and rare in the zone of *M. hercynicus*. Its association here with *Monograptus* cf. *praehercynicus* would suggest the praehercynicus Zone which places it in the early Lower Devonian.

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## PLATE I

- Fig. 1. *Hydrodictya cylix* Hall and Clarke. Impression on block 986F. x1.
- Fig. 2. *Lyrodictya* sp. Impression on block 987F. x1.
- Fig. 3. *Orbiculoidea sinensis* Mansuy.  
3a. Impressions of pedicle and brachial valves partly superimposed on block 997F. x2.  
3b. Impression of pedicle valve on block 998F. x2.
- Fig. 4. *Ceratiocaris* sp.  
4a. Impression of telson on block 981F. x0.8.  
4b-c. Impressions of gnathal lobes on blocks 970F and 950F. x1.5.
- Fig. 5. *Monograptus* cf. *praehercynicus* Jaeger.  
5a-d. Drawings of partially incomplete rhabdosomes on blocks 988F, 994F, 964F and 974F. x2.  
5e. Drawing of complete proximal portion showing sicula on block 965F. x2.
- Fig. 6. *Linograptus* aff. *posthumus* (Richter). Drawing of incomplete compound rhabdosome on block 989F. x2.

JONES: PLATE 1



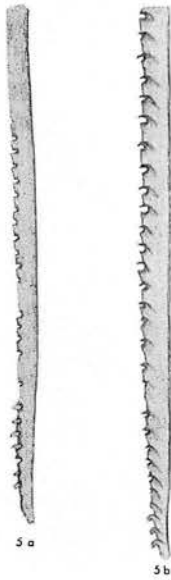
4a



1

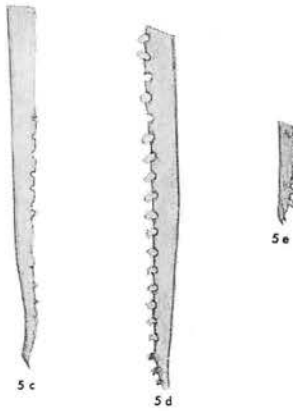


2



5a

5b



5c

5d

5e



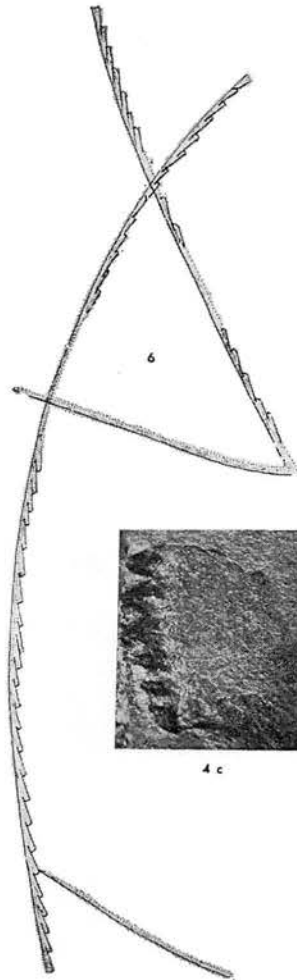
4b



3a



3b



6



4c