

Lower Carboniferous Brachiopods from Sungei Leming District, NW of Kuantan, Malaysia : Contributions to the Geology and Palaeontology of Southeast Asia, CVI : With a Brief Note on the Bryozoans in Association with Brachiopods

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Lower Carboniferous Brachiopods from Sungei Leming District, NW of Kuantan, Malaysia

*Contributions to the Geology and Palaeontology
of Southeast Asia, CVI*

By

Juichi YANAGIDA

With a Brief Note on the Bryozoans in
Association with Brachiopods

By

Sumio SAKAGAMI

Abstract

Seven species of Lower Carboniferous brachiopods, *Punctospirifer* sp. (? sp. nov.), *Antiquatonia* sp., *Setigerites* sp., *Linoproductus* sp., *Streptorhynchus* cf. *S. ruginosum* (HALL et CLARKE), *Pugnax* cf. *P. asiaticus* MUIR-WOOD and *Camarotoechia* ? sp. are described from siltstones of the Lower Carboniferous Calcareous Series of east Pahang, Malaysia. This brachiopod species assemblage has a strong affinity with the Middle Visean fauna of the Russian Central Asia and the Upper Meramecian to Lower Chesterian ones of Central North America. Palaeontological notes on some bryozoans which have occurred associated with the brachiopods are also given as an Appendix.

Introduction

Among the Lower Carboniferous sediments in Malayan peninsula, those of the Kuantan district of Pahang are well known by abundant occurrence of fossils. They were treated by FITCH (1952) as the Calcareous Series and divided into two groups of different lithofacies, the calcareous facies and the argillaceous facies. The former is mainly composed of limestones and the latter of shales, siltstones and quartzites.

Many kinds of fossils including the plant remains were described from the Calcareous Series by MUIR-WOOD et al. (1948). She discussed in detail about their ages and affinity and referred them to be of the Visean age.

The brachiopod fossils herein described were collected by Dr. Sumio SAKAGAMI, Messrs. Tomowo OZAWA and K. N. MURTHY and myself in the 6th Palae-

ontological Reconnaissance Survey of Southeast Asia in February to March of 1968. The following brachiopods were distinguished from two localities, PS₂F 18 and PS₂F 19, along a new road near the Sungei Kuantan (the River Kuantan) at about 30 km NW of Kuantan and about 5 km E of Sungei Lembing.

Loc. PS₂F 18 *Antiquatonia* sp.

Punctospirifer sp. (? sp. nov.)

Setigerites sp.

Streptorhynchus cf. *S. ruginosum* (HALL et CLARKE)

Loc. PS₂F 19 *Punctospirifer* sp. (? sp. nov.)

Camarotoechia ? sp.

Antiquatonia sp.

Setigerites sp.

Pugnax cf. *P. asiaticus* MUIR-WOOD

Linoproductus sp.

Streptorhynchus cf. *S. ruginosum* (HALL et CLARKE)

These brachiopods occur in association with abundant bryozoans and several kinds of pelecypods. The drifted plant remains and crinoid ossicles were also distinguished. The rocks from which these fossils were collected belong to the argillaceous facies.

The rocks exposed at the locality PS₂F 18 are about 60 m thick, and are divided into three part.

The lower part of about 20 m thick is composed of fine sandstone, siltstone and thin bedded alternation of siltstone and fine sandstone. Abundant brachiopods occur from a siltstone, and a small number of bryozoans, pelecypods and plant remains are also associated with brachiopods.

The middle part of about 20 m thick comprises five beds of fine sandstone (about 10 m), each of which ranges from 2 to 4 m in thickness, and siltstone of various thickness.

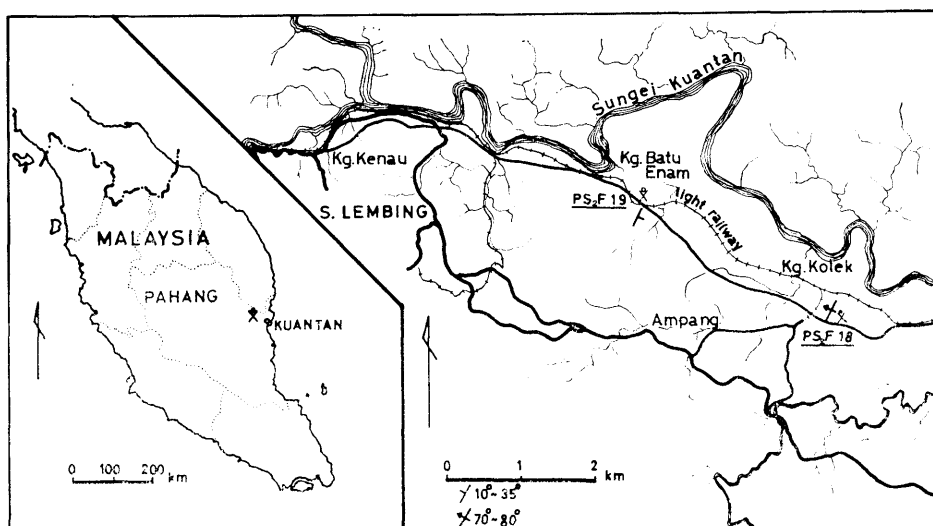


Fig. 1. Map of West Malaysia showing the fossil-locality.

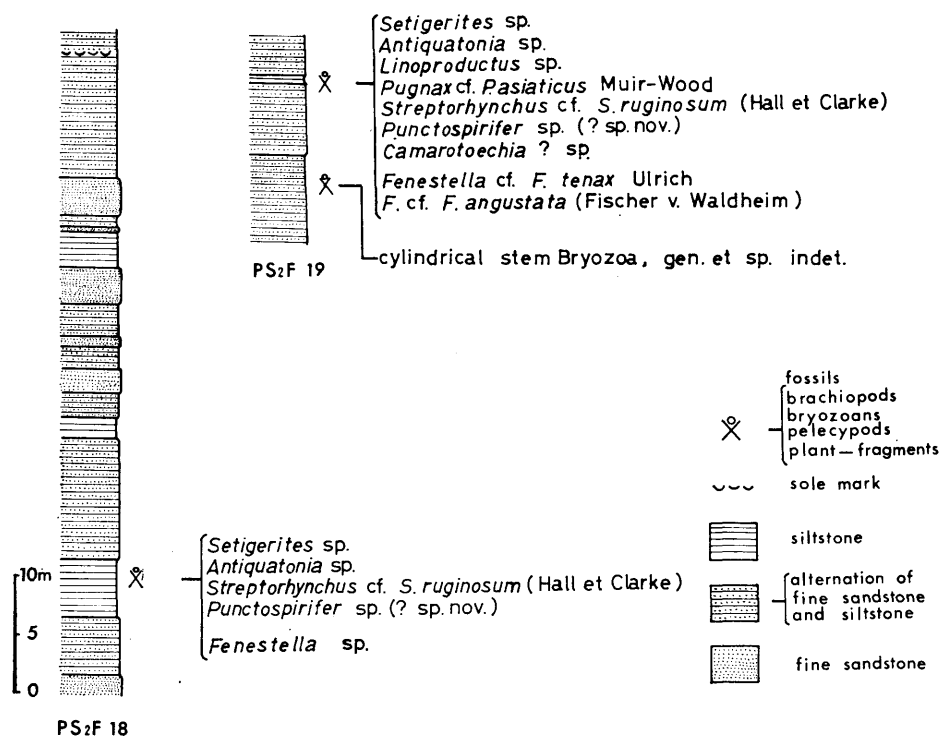


Fig. 2. Columnar sections showing the stratigraphic sequence of the Carboniferous sediments and occurrence of brachiopods and bryozoans at two localities along a new road.

The upper part of more than 10 m thick consists of thin-bedded alternation of fine sandstone and siltstone. Remarkable flute casts are recognized in a bed of the upper part.

The locality PS₂F 19 is at a distance of about 3 km NW of the locality PS₂F 18 and thin-bedded alternation of fine sandstone and siltstone of about 16 m thick is exposed there. A large number of brachiopods occur from the upper part in association with abundant bryozoans and a few pelecypods, plant remains and crinoid fragments.

The beds at PS₂F 18 are homoclinally dipping at 70° NW with a general strike of N 20°E to N 40°E. On the other hand those at PS₂F 19 gently dip to southward with a general strike of EW to NEE, partly showing a low undulation.

These sediments at the two localities are generally dark gray in color and soft. They contain abundant carbonaceous matter and are also uniformly micaceous. They partly show brownish to whitish color by the differential weathering, and abundant clay minerals are distinguished under the microscope. Graded bedding within fine-grained sandstone mainly comprising quartz and siltstone of other fine minerals is frequently observed under the microscope.

The brachiopods from the two localities mentioned above have not been exactly identified specifically due to their poor preservation, but most of them show a close similarity to those of the Visean of the Kuznetsk basin of USSR

and the Upper Mississippian of the Mississippi valley basin of USA. For the age of the species assemblage the Medial Visean of the Early Carboniferous is highly possible.

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Repository: The illustrated specimens in this paper are kept in the Department of Geology, Faculty of Science, Kyushu University, with the registered number using a symbol of GK. D.

Systematic Palaeontology

Superfamily Spiriferinacea DAVIDSON, 1884

Family Spiriferinidae DAVIDSON, 1884

Genus *Punctospirifer* NORTH, 1920

Type-species:—*Punctospirifer scabricosta* NORTH, 1920

Remarks:—CAMPBELL (1959) redescribed three type species of spiriferinids, such as *Punctospirifer*, *Spiriferellina* and *Reticulariina*, based on the type-specimens of them. Subsequently CAMPBELL (1961) described the Australian Carboniferous punctate spiriferoids and established two new genera *Liriplica* and *Spinuliplica* which constantly have a longitudinal groove in the fold and a costa in the sulcus.

There are many species which were described under the name of *Punctospirifer* from the Carboniferous and Permian of various localities in the world. Morphologically it is possible to divide them into two groups. One is the group of species which are provided with the structures similar to the type species and the other group is characterized by having a median costa and a groove in the sulcus and fold, respectively. The latter group also has a world wide distribution. EASTON (1962) discussed the morphology of *Punctospirifer transversus* (MC-CHESNEY), one of the latter group, from the Upper Mississippian of North America and indicated the possibility of separating the species from *Punctospirifer* as a distinct genus.

Although the Malayan species is poorly preserved, following characters have been clearly recognized; a punctate structure, closely arranged growth laminae and a costa in the sulcus and a groove in the fold. A more or less mucronate shell outline and the character and number of lateral costae of the species also well agree with *Punctospirifer*.

On the one hand the spinule character is apparently observed on the shell surface of a rubber replica. This spinose ornament is a generic character of *Spinuliplica*. However, it has been well known that many species, for instance

Punctospirifer transversus, have a spinose character (EASTON, 1962). On the other hand, no micro-ornament except the lirae is discriminated in *Punctospirifer scabricosta*, the type species of the genus. For the time being, I would prefer to treat the Malayan species as *Punctospirifer* until the relation of this plicate ornament on sulcus and fold and the micro-ornament are known in detail on the basis of many well preserved specimens whether the plicate ornament on sulcus and fold would be a criterion in separating the group as a distinct genus or not.

Punctospirifer sp. (? sp. nov.)

Pl. 11, Figs. 1-13

Material:—More than fifty-five incomplete pedicle and brachial valves are at hand.

Description:—The shell is small and the outline is generally transverse throughout all growth stages with acute or slightly mucronate cardinal extremities. The maximum width of the shell is along the hinge line. The pedicle valve is moderately convex with the largest convexity at the posterior half of the valve. The interarea is moderately high and slightly concave. The delthyrium is open and the length of its basal part attains about a fourth the hinge line. The sulcus is broad, about twice the width of bounding costae, and a low rounded costa appears at the mid length of valve, just anterior to the anterior extremity of the median septum of the valve-interior. Each lateral slope of the valve is ornamented with six to nine, rarely eleven, simple subangular costae, averaging eight. The surface is covered with tightly arranged growth lines which are often imbricate usually numbering about three in the distance of 1 mm near anterior margin. Fine spinules counting about 6 to 8 in the distance of 1 mm are observed near the anterior margin of a rubber cast of pedicle valve. The pedicle valve internally has a thin median septum extending anteriorly near the mid length of the valve. The punctae are numerous with fifty to seventy on average in the area of 1 mm² in the anterior part of the valve. The brachial valve is transverse and more strongly convex than the opposite valve. The fold is broadly rounded, about twice the width of the bounding costae and has a shallow rounded groove along the crest of the fold. The groove appears near the umbo. Each lateral slope is ornamented with simple costae which show the same character and number as those of the pedicle valve. The micro-ornaments are also the same as those of the opposite valve. In the interior of the brachial valve only a thin median ridge is discriminated, extending about a third the length of the valve from umbo.

Dimensions of four pedicle and brachial valves in mm and degree are as follows (1-3, pedicle valves; 4-6, brachial valves):

	1	2	3	4	5	6
length	6.5	17.9	10.3	11.0	11.0	7.0
width	12.5	20.8	15.4	23.0	22.3	18.0
width of sulcus or fold at anterior margin	2.5	6.3	5.0	4.9	4.8	3.0

	1	2	3	4	5	6
form ratio (length/width \times 100)	52	86	67	48	49	39
number of costae on lateral slope	8	9	6+ α	9	8+ α	9
angle of cardinal extremity	65°	70°	70°	65°	65°	60°

Remarks:—The Malayan species is characterized by acute, often mucronate cardinal extremities, approximately eight or nine costae on each lateral slope, and a costa and a groove, respectively in the sulcus and fold.

The closely related species to the Malayan one are *Punctospirifer transversus* (MCCHESNEY) from the Upper Mississippian and *P. kentuckyensis* (SHUMARD) from the Pennsylvanian of North America. *P. transversus* is distinguishable from the Malayan species by its more transverse outline, acuter cardinal extremities and more numerous costae. *P. kentuckyensis*, on the other hand, generally has a smaller shell and fewer costae than the Malayan one. These American species have a pair of large bounding costae on both sides of the sulcus. They are not distinguishably strong in the Malayan species. Regarding other characters *P. transversus* and *P. kentuckyensis* are very similar to the Malayan species. Although the present specimens are more or less deformed, the adult shells exhibit some variation in outline, size and number of costae. Some of them show a resemblance to *P. kentuckyensis* and some others, on the contrary, show a closer similarity to *P. transversus*. The Malayan species has intermediate external characters between *P. transversus* and *P. kentuckyensis*, but seems to be closer to *P. transversus*.

MUIR-WOOD (1948) described *Punctospirifer pahangensis* from the Visean of Sungei Terapai district, about 15 km NW of the present locality. In the outline and dimension the present species resembles *P. pahangensis*, although it has more numerous costae on the lateral slopes, attaining approximately eight to nine instead of six to seven of the latter species. *P. pahangensis* clearly lacks a median costa and a groove in the sulcus and fold, respectively.

CHI-THUAN (1968) described similar forms from the Visean of the southern district of Tran-Ninh, Laos under the name of *Spiriferina transversus* (MCCHESNEY). They have, however, acuter cardinal extremities and more numerous costae than the Malayan species.

Punctospirifer kusbassicus BEZNOSOVA from the Tournaisian Nizhnetersian Formation of the Kuznetsk basin is also similar to the Malayan species in external characters. It differs from the Malayan species in having a smaller shell, fewer costae and a higher interarea.

Superfamily Productacea GRAY, 1840

Family Overtoniidae MUIR-WOOD et COOPER, 1960

Subfamily Overtoniinae MUIR-WOOD et COOPER, 1960

Genus *Setigerites* GIRTY, 1939

Type-species:—*Productus setigerus* HALL, 1858

Setigerites sp.

Pl. 12, Figs. 1–17

Material:—About a hundred pedicle and brachial valves are available. Most of them are moulds and more or less deformed.

Description:—The shell is uniformly small and subquadrate with the widest part nearly at the hinge line or slightly anterior to it.

The pedicle valve is moderately convex and has a subcircular visceral disc and a subgeniculate profile. The median sulcus is absolutely absent. The umbo is pointed and slightly incurved over the hinge line. The ears are slightly convex and the cardinal extremities are subrectangular. The flanks are steep and the venter is slightly convex. The trail is rather short and seems to be slightly geniculated near the anterior margin. The rugae are restricted only to the visceral disc and ears, and are more remarkable on the flanks than on the ears and venter where they are weakly traceable. Obscure reticulation is occasionally recognizable in some specimens. The valve is ornamented with fine rounded costellae which rarely increase in number by bifurcation. Small spines scattered on the venter and trail are more or less reclined anteriorly and counted about 10 to 15. A group of erect spines is distributed mainly on the slope near the boundary between the ear and flank, also sparsely on the ear and hinge. Spines scattered on the ears and flanks near the lateral margins are very much stronger than those on the venter and trail.

The brachial valve is transversely subrounded in outline with a circular and slightly concave visceral disc. The geniculation is distinct with short trail. The fine but distinct rugae are tightly arranged on the visceral disc. The surface of valve is covered with costellae which are rarely bifurcated. The spines are rarely observable on the hinge, but they seem to be absent on the other part.

Dimensions of 5 pedicle and brachial valves in mm are as follows (1–3, pedicle valves; 4, 5, brachial valves):

	1	2	3	4	5
length	16.2	14.0	13.0	13.0	12.6
width	14.5	14.2	13.5	20.0	18.0
length of hinge line	14.7	12.3	11.4	17.5	15.9
height	6.5	4.4	3.5	6.5	7.4
length along curvature	24.0	20.0	15.0	15.0	19.0
length/width×100 (form ratio)	111	99	96	65	70

The interior of pedicle valve is unknown. That of the brachial valve is poorly known; only a very weak median ridge and a very small cardinal process are observed in some moulds.

Remarks:—The followings are the characteristic features of the Malayan species: a uniformly small shell with a subquadrate outline, a relatively weak convexity of the pedicle valve, very weak rugae on the visceral disc, anteriorly reclined fine spines on the costellae, and a group of erect spines on the slopes between the ears and flanks. Although the internal characters of the Malayan species are almost unknown and the external characters are also imperfectly known, the above mentioned structures well reveal the characters of *Setigerites*. Among the species of *Setigerites* the Malayan species resembles *Setigerites altonensis* (NORWOOD et PRATTEN) from the Upper Mississippian Salem and

St. Louis limestones of the Mississippi valley basin. The same species was also described by SARYCHEVA et al. (1963) from the Lower Visean Pod'yakovian Formation of the Kuznetsk basin of USSR. Although the Malayan specimens are apparently smaller than both the American and the Russian ones, the former much resembles the American and Russian specimens in the external characters. They may be closely related to each other.

Family Dictyoclostidae STEHLI, 1954

Subfamily Dictyoclostinae STEHLI, 1954

Genus *Antiquatonia* MILORADOVICH, 1945

Type-species:—*Productus antiquatus* SOWERBY, 1821

Antiquatonia sp.

Pl. 12, Figs. 18–22

Material:—Fragmentary specimens mainly of internal and external moulds of pedicle and brachial valves are available. Dimensions of two specimens are as follows in mm: (pedicle valve) width, 35.4; length, 28.0; height, 12.5; surface measure, ca 40; (brachial valve) length, ca 28; width, 37+; height, ca 19; surface measure, ca 35.

Descriptive remarks:—The shell is medium to large, subquadrate in outline with the widest part at the hinge line. The pedicle valve is moderately convex with the umbo slightly incurved over the hinge line. The median sulcus is weakly recognized as a broad depression. The visceral disc is rather narrow. The flanks are rather steep. The ears are slightly convex. The cardinal extremities are subrectangular. The trail is rather short. The surface of the valve is ornamented with rounded costellae, numbering about 9 in the distance of 5 mm on the visceral disc. The rugae are narrow and tightly arranged only on the visceral disc and form a weak reticulation at intersections with costellae. The spines are rarely observed on down flanks and appear to be set on a row. Large, rounded spine bases are also rarely observed on the costellae of the trail. The brachial valve is transversely subquadrate with a remarkable geniculation. The rugae and reticulations are remarkably developed on the visceral disc.

The interior of the pedicle valve is unknown. The brachial valve is internally provided with adductor muscle scars, a median septum, lateral ridges and strainer spines. The cardinal process is not preserved. The anterior adductor scars are slightly elevated and the surfaces are rather smooth. The posterior adductor scars are not clearly shown but the posterior part of the anterior adductor scars shows sculptures of somewhat dendritic pattern. The median septum is distinct, connecting posteriorly with the cardinal process by a broad, rounded posterior platform. It attains almost all the length of the visceral disc and seems to be slightly elevated and narrowed as the septum extends anteriorly. The strainer spines are closely scattered in front of the visceral disc. The lateral ridges are strong and extend laterally along the hinge margin. The lateral margins of them are not observed.

Although the Malayan specimens are all incomplete and more or less deformed, the following characters are recognized from nine specimens; a subquadrate outline with the hinge line at the widest part of the shell, rather steep flanks and convex ears, a broad shallow sulcus, narrow and tightly arranged, weak rugae on the visceral disc only, a geniculated brachial valve with a short trail, smooth anterior adductor scars. These characters well distinguish the Malayan species from species of *Dictyoclostus*. The mode of rugae and spines which are sporadically arranged in a row on the flanks well agrees with that of *Antiquatonia*.

In external and internal characters the Malayan specimens are similar to those of *Antiquatonia insculpta* (MUIR-WOOD) from the Upper Visean of England. Outside England *Antiquatonia insculpta* has been known from the Upper Visean Stesheva and Terussa stage of the Moscow basin (SARYCHEVA, 1949; SARYCHEVA and SOKOLSKAYA, 1952), the Visean and Namurian Ostrogsian Formation of the Kuznetsk basin (SARYCHEVA et al., 1963) and the Upper Visean of Laos (CHI-THUAN, 1969).

Family Linoproductidae STEHLI, 1954

Subfamily Linoproductinae STEHLI, 1954

Genus *Linoproductus* CHAO, 1927

Type-species:—*Productus cora* D'ORBIGNY, 1842

Linoproductus sp.

Pl. 12, Fig. 23

Material.—A single fragmentary mould of the pedicle valve is available, from which a rubber replica has been taken.

Descriptive remarks.—The shell seems to be medium to large in size. The greatest width of the shell may be along the hinge line. The ear is broad, slightly convex with a few weak, broad rugae, which are traceable across the flank. The flank is rather steep making a shallow sulcus between the ear and flank. The Shell is ornamented with irregular costellae, about ten to twelve in 5 mm in the flank. Small spine bases are occasionally observed on the venter.

The present specimen is unfortunately very incomplete for specific determination. The noticeable characteristics are as follows: weakly convex broad ear; rather steep flank; a shallow sulcus between ear and flank; fine costellae; rare spines. Similar characters are also recognized in the specimens reported from the Visean of Yunnan and Kansu of China and Tien Shan and Ferghana of Central Asia under the name of *Linoproductus tenuistriatus* (DE VERNEUIL). In Malayan peninsula the species has been known from the Visean limestone of Bukit Charas, about 6 km SE of the present locality.

Superfamily Rhynchonellacea GRAY, 1848

Family Pugnacidae RZHONSNITSKAYA, 1956

Genus *Pugnax* HALL et CLARKE, 1983

Type-species:—*Terebratula acuminata* SOWERBY, 1822

Pugnax cf. *P. asiaticus* MUIR-WOOD

Pl. 12, Fig. 25

Compare.—

1948. *Pugnax asiaticus* MUIR-WOOD, Malayan Lower Carboniferous fossils, pp. 41–43, pl. 6, figs. 3a–c, 4a–c.

Material.—A single fragmentary specimen with only a posterior part, which gives the following dimension: length, 13 mm+; width, ca 18 mm; thickness, ca 23 mm.

Descriptive remarks.—The shell is rather small for the genus. The pedicle valve is slightly convex with an incurved umbo. The beak is prominent, concealing the umbo of the brachial valve. The brachial valve has a prominent median fold which are slightly convex on both sides. Both the two valves are smooth.

The Malayan specimen reveals the outline only of the posterior half of the shell. The most important external character is seen in the convexity of the pedicle valve in the region of the posterior half. The anterior margin of the brachial valve can not be observed but the outline of the valve suggests a tendency of that the linguiform extension of the opposite valve strongly attains anteriorly and tapers in acute angle. Consequently the brachial valve may probably has a high, acute anterior extremity.

The external characters and the dimension of the Malayan specimen are essentially similar to those of *Pugnax asiaticus* MUIR-WOOD from the Visean limestone of Bukit Tenggek, Pahang, about 13 km NE of the present locality, and the Malayan species may be identical with *P. asiaticus* MUIR-WOOD.

Family Camarotoechiidae SCHUCHERT et LE VENE, 1929

Subfamily Camarotoechiinae SCHUCHERT et LE VENE, 1929

Genus *Camarotoechia* HALL et CLARKE, 1893

Type-species.—*Atrypa congregata* CONRAD, 1841

Camarotoechia? sp.

Pl. 12, Fig. 24

Material.—An incomplete pedicle valve with the following dimension is available: width, 12.5 mm; length, 10.5 mm; apical angle, 100°.

Descriptive remarks.—The shell is small and subtriangular in outline. The greatest width is in slightly anterior to the mid length of the shell. The pedicle valve is weakly convex with a broad median sulcus at the mid part. The median sulcus is shallow, anteriorly distinct and posteriorly indistinguishable from the lateral slopes. The beak is pointed and slightly incurved with a blunt apical angle. The surface of the valve is ornamented with simple sub-rounded costae. The numbers of costae are estimated about fourteen, of which about five are on the sulcus and other four or five on each lateral slope. The costae become very weak towards lateral margin and beak and are no longer

traceable near the beak, although the shell is poorly preserved there. The anterior margin is more or less geniculated and the linguiform extension of the median sulcus slightly projects dorsally. The anterior commissure is weakly serrate.

The generic assignment of the Malayan species is somewhat doubtful. The external characters of it except the mode of costae near the beak are in common to those of *Camarotoechia*. They are very faint in the posterior region and indistinguishable near the beak. But this may be attributable to the exfoliation of the valve and originally the specimen may have had the costae which are continuous to the beak.

Externally the Malayan species closely resembles *Camarotoechia mutata* (HALL) from the Upper Mississippian St. Louis and Salem Limestone and Paradise Formation of North America. *Camarotoechia mutata* was also described from the European and Asian Lower Carboniferous provinces, such as the Visean of Kuznetsk basin (SOKOLSKAYA, 1963) and Tien Shan of Central Asia (SERGUNKOVA, 1935).

Superfamily Davidsoniacea KING, 1850

Family Schuchertellidae WILLIAMS, 1953

Subfamily Streptorhynchinae STEHLI, 1954

Genus *Streptorhynchus* KING, 1850

Type-species:—*Terebratulites pelargonatus* VON SCHLOTHEIM, 1816

Streptorhynchus cf. *S. ruginosum* (HALL et CLARKE)

Pl. 11, Figs. 14–26

Compare.—

1914. *Streptorhynchus ruginosum*, WELLER, Illinois State Geol. Surv., Mon. 1, pp. 71–73, pl. 5, figs. 1–19.
1963. *St. ruginosum ruginosum*, SOKOLSKAYA, in SARYCHEVA et al., Pal. Inst. Acad. Sci. USSR Trans., vol. 95, pp. 103–104, pl. 10, figs. 1–6, text-fig. 31.

Material.—About twenty incomplete or fragmentary specimens of pedicle and brachial valves are available under the heading.

Description.—The shell is medium in size and the brachial valve is much more convex than the pedicle valve. The outline of the shell is transversely subrounded with the greatest width slightly anterior to the hinge line. The pedicle valve is posteriorly convex with the most convex part usually slightly anterior to the umbo. The pedicle valve rapidly decreases the convexity towards the anterior and lateral margins where the valve is nearly flat or slightly concave. The posterior region of the valve is often distorted. The cardinal extremities are subrounded. The interarea is moderately high, and its average height is about one thirds the width of the interarea for six specimens. The delthyrium is covered with a strongly convex pseudodeltidium. The height of it attains about 1.8 times the width of the basal part in four specimens. The brachial valve is strongly convex with the largest convexity slightly anterior

to the umbo. The convexity quickly decreases towards the cardinal extremity, and the shell becomes almost flat at the region.

The ornament of both valves consists of multicostellate to parvicostellate fine ribs which increase in number by intercalation. A few, irregular and remarkable growth-wrinkles are developed on both valves.

The dimensions of five specimens in mm and degree are as follows (1-3, pedicle valves; 4, 5, brachial valves):

	1	2	3	4	5
length	ca 20	12.8	ca 38	25.0	ca 27
width	ca 24	13.5	ca 38	ca 37	ca 36
thickness	ca 6	5.0	ca 9	6.5	ca 11
apical angle	ca 80°	80°			
length of hinge line	ca 16	11.5		ca 25	ca 30
width of delthyrium	6.5	1.5			
height of interarea	8.0	5.5			

The internal structures of both valves are poorly preserved. The pedicle valve internally has neither dental plates nor median septum. The interior of the brachial valve is provided with slightly diverging short septal plates. The median ridge is not observed and the cardinal process is not preserved.

Remarks.—The Malayan specimens have the following characteristics: more or less distorted valves, moderately convex brachial valves, remarkable growth wrinkles on both valves, a relatively high interarea of the pedicle valve, absence of dental plates and median septum in the pedicle valve. In these characters the Malayan species is very similar to *Streptorhynchus ruginosum* (HALL et CLARKE), one of the typical Meramecian and Lower Chesterian brachiopods of North America, described in detail by WELLER (1914) from the St. Louis and Salem limestones and the Batesville sandstone of the Mississippi valley basin. The same species was also described from the Visean Verkotomskian Formation of Kuznetsk and Kazakstan of Central Asia by SARYCHEVA et al. (1963). The size, outline and the external characters of the Asian specimens are also quite similar to those of the Malayan specimens.

Correlation

Among the brachiopods from two localities near Sungei Lembing, four species of four genera, namely *Punctospirifer* sp. (? sp. nov.), *Antiquatonia* sp., *Setigerites* sp. and *Streptorhynchus* cf. *S. ruginosum* (HALL et CLARKE) are common to each other. The two localities, PS₂F 18 and PS₂F 19, are at about a distance of 3 km, and the rocks from which the brachiopods have been obtained mainly consist of siltstone of similar rock-facies. The brachiopods of two localities may be of the same age.

Brachiopods described above are all imperfectly preserved and both valves have been all separated from each other. Exact specific identification of them are therefore impossible, but it is apparent that they are closely allied to brachiopod faunas of several regions in Asia and North America.

MUIR-WOOD (1948) described many kinds of Lower Carboniferous brachiopods (39 species of 23 genera) from limestone hills at Bukit Charas, Bukit Sagu and Bukit Tenggek of the Kuantan district. According to her the brachiopods from each of these limestone hills show a similar species assemblage and belong to the same geologic age. They are composed of the species which has the close allies to the Visean brachiopod faunas of Europe, Australia, central Asia, Indochinese peninsula, southwest China and Japan.

On the other hand, the brachiopods including 8 species of 8 genera from the shale of Sungei Terapai (about 8 km NW of PS₂F 19) have no close similarity to those of the neighbouring provinces but the related species are found in the Visean fauna of England (MUIR-WOOD, 1948). The Sungei Terapai shale yields drifted plant remains as in the Sungei Lembing siltstones and the contained fossils are uniformly small in size. She considered the sedimentary environment of these brachiopods-bearing argillaceous rocks as a restricted area of a near shore condition. She suggested the age of the shale as the Visean and probably older than the limestones mentioned above.

The siltstones of PS₂F 18 and PS₂F 19 of the Sungei Lembing area and the Sungei Terapai shale are not very much different in facies from each other. However, there is no common species between the brachiopod faunas of the two beds. *Punctospirifer* sp. which abundantly occurs in the Sungei Lembing siltstones is replaced by *Punctospirifer pahangensis* in the Sungei Terapai shale. Besides brachiopods there also occur abundant bryozoans from the two beds of which two species are common to each other. Numerous plant remains are also contained in them. It seems to me that the Sungei Terapai shale and Sungei Lembing siltstone are almost indistinguishable in geologic age from each other.

The detailed comparison of faunas between the Sungei Lembing siltstones and the Kuantan limestones is difficult, because *Pugnax* cf. *P. asiaticus* MUIR-WOOD and *Linoproductus* sp. from the Sungei Lembing siltstones are only comparable with *P. asiaticus* of the Bukit Tenggek limestone and *Linoproductus tenuistriatus* (DE VERNEUIL) of the Bukit Charas limestone, respectively. *Punctospirifer* sp. and *Setigerites* sp. of the Sungei Lembing siltstones are absent in the Kuantan limestones.

MUIR-WOOD (1948) indicated that no relation was recognized on the faunas between the argillaceous and calcareous facies. However, the Sungei Lembing brachiopods consist of the specific elements which are common to or closely related to those of both the Sungei Terapai shale and the Kuantan limestones.

Here in the Kuantan district the Sungei Terapai shale is located in the western extremity. On the other hand the Kuantan limestones, such as Bukit Tenggek, Bukit Sagu, Bukit Charas and Bukit Panching, are distributed in the easternmost area, roughly disposing on a line of NNE-SSW direction. Although the geologic structure of this district is complicated, it is probably considered that the Sungei Lembing siltstones are distributed in the middle of the Sungei Terapai shale and the Kuantan limestones.

Summarizing the above, it is concluded that the age of the brachiopod

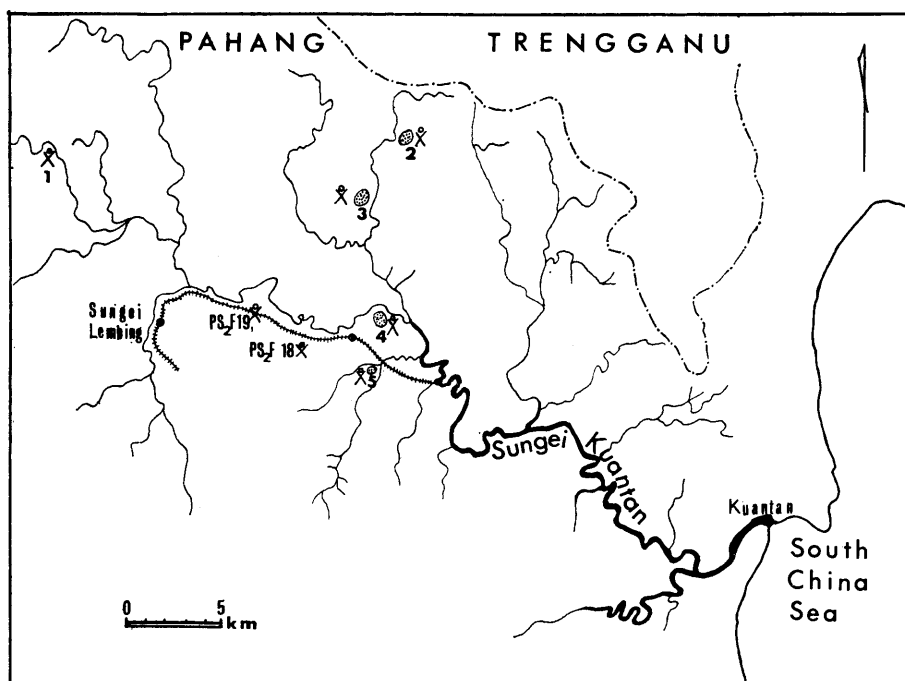


Fig. 3. Map showing fossil localities of brachiopods and others along the River Kuantan (Sungei Kuantan) and its tributaries. 1, Sungei Terapai; 2, Bukit Tenggek; 3, Bukit Sagu; 4, Bukit Charas; 5, Bukit Panching. dotted area—limestone hill

species assemblage from the Sungei Lembing siltstones is probably the Medial Visean and the species assemblage is nearly the same in age with the Sungei Terapai one, but older than the Kuantan limestone fauna. The comments of MUIR-WOOD (1948) are suggestive that the brachiopod fauna of the Sungei Terapai shale and that of the Kuantan limestones respectively belonged to different faunal province. Therefore it is considered that the Sungei Lembing brachiopods and bryozoans belonged to a transitional period from the Sungei Terapai to the Kuantan province in the palaeobiogeographic condition.

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Appendix

A Brief Note on the Bryozoans in Association with Brachiopods

By

Sumio SAKAGAMI

In association with brachiopods described in this article by YANAGIDA from PS₂F 18 and PS₂F 19, many bryozoans are found. These bryozoans are abundant, but they are poorly preserved and most of the internal structures are obscured because the calcareous skeletal parts have been dissolved out.

At PS₂F 19 there are two bryozoan bearing horizons*, namely one composed of siltstone contains many brachiopods, fenestrate bryozoans and plant fragments with some cylindrical stem type bryozoans, and the other horizon at about 10 meters below the upper one, consists of thin alternation of fine sandstone and siltstone and contains only cylindrical stem type bryozoans. At PS₂F 18, bryozoan specimens are rather few in number.

Although these bryozoans are poorly preserved, especially those of PS₂F 18, the following four forms could be discriminated:

From PS₂F 18:

Fenestella sp. indet. (Plate 13, Figs. 3, 4)

The preservation is extremely bad, so that the specific identification must wait until better specimens accumulated.

From upper bed of PS₂F 19:

Fenestella cf. *F. tenax* ULRICH (Plate 13, Figs. 1, 6)

Meshwork formula.—26-28/18-22// 18-22? The microscopic determinations could not be made, but the meshwork formula and general features are the nearest to those of *F. tenax*.

Fenestella cf. *F. angustata* (FISCHER v. WALDHEIM) (Plate 13, Fig. 2)

Meshwork formula.—18-20/ 12-14// ca. 20. The present form is safely identical with *F. cf. F. angustata* which was described from Sungei Terapai near the present locality by OAKLEY (1948). The meshwork formula and the essential characters well agree with each other.

From lower bed of PS₂F 19:

Cylindrical stem Bryozoa, gen. et sp. indet. (Plate 13, Fig. 5)

This form consists of frequently branched cylindrical stem, about 2 mm in diameter and seems to be anastomosed in some cases as shown in the plate. Because the detailed wall structure and presentation of diaphragm could not be observed, no generic name is given.

OAKLEY (in MUIR-WOOD, 1948) has described six species of Bryozoa from the shale member of Sungei Terapai which is situated at about 7 miles WNW

* See the columnar section of Fig. 2 (p. 77)

from PS₂F 19, one of the present bryozoan localities. They are *Fistulipora* sp., *Fenestella* cf. *F. angustata* (FISCHER v. WALDHEIM), *F. cf. F. tenax* ULRICH, *F. cf. F. polyporata* (PHILLIPS), *F. aff. F. plebeia* M'COY and *Cystodictya* sp. It is noted that two species of them, *Fenestella* cf. *F. tenax* and *F. cf. F. angustata* are common between the Sungei Terapai shale and the upper bed of PS₂F 19.

The specimens recorded in the present article will be deposited in the Department of Geology, Faculty of Science, Kyushu University.

Acknowledgement.—Here I wish to record my sincere thanks to Dr. Juichi YANAGIDA of Kyushu University for his kind cooperation in collecting bryozoan samples.

Juichi YANAGIDA

Lower Carboniferous Brachiopods from Sungei Lembing
District, NW of Kuantan, Malaysia

Plates 11, 12

Appendix

Sumio[†] SAKAGAMI

A Brief Note on the Bryozoans
in Association with Brachiopods

Plate 13

Plate 11

Explanation of Plate 11

- Figs. 1-13. *Punctospirifer* sp. (? sp. nov.)Page 79
- 1, 2, 4. Respectively GK. D 30500, 30501 and 30502, from PS₂F 19. Exfoliated pedicle valves, posteriorly showing the mould of median septum, $\times 1.5$, 2 and 2, respectively.
 3. GK. D 30503, from PS₂F 19. A rubber replica of fragmentary pedicle valve, $\times 1.5$.
 - 5a, b. GK. D 30504, from PS₂F 19. Ventral and posterior views of an incomplete pedicle valve, $\times 2$.
 6. GK. D 30505, from PS₂F 18. An incomplete pedicle valve, $\times 1.5$.
 - 7a, b. GK. D 30506, from PS₂F 18. Respectively ventral and posterior views of an incomplete pedicle valve, $\times 2$.
 - 8-13. Respectively GK. D 30507, 30508, 30509, 30510, 30511 and 30512; 9-11, from PS₂F 18; 8, 12 and 13, from PS₂F 19; 12, rubber replica. All incomplete brachial valves, 8, 10 and 11, $\times 1.5$; 9, 12 and 13, $\times 2$.
- Figs. 14-26. *Streptorhynchus* cf. *S. ruginosum* (HALL et CLARKE)....Page 85
- 14a, b. GK. D 30550, from PS₂F 19. Respectively dorsal and posterior views of an internal mould of brachial valve, $\times 1$.
 - 15a, b. GK. D 30551, from PS₂F 18. Respectively posterodorsal and dorsal views of an internal mould of brachial valve, $\times 1.5$.
 - 16a, b. GK. D 30553, from PS₂F 19. Respectively ventral and posterior views of an incomplete pedicle valve, $\times 1.5$.
 - 17a, b. GK. D 30554, from PS₂F 18. Respectively ventral and posterior views of an incomplete pedicle valve, $\times 1.5$.
 - 18, 19. Respectively GK. D 30555 and 30556, from PS₂F 19. Dorsal views of incomplete brachial valves, $\times 1$.
 - 20a, b. GK. D 30557, from PS₂F 19. Respectively posterior and dorsal views of an incomplete brachial valve, $\times 1$.
 - 21a, b. GK. D 30558, from PS₂F 18. Respectively posterior and ventral views of a small pedicle valve, $\times 1.5$.
 - 22a, b. GK. D 30559, from PS₂F 19. Respectively posterior and ventral views of a small pedicle valve, $\times 1.5$.
 23. GK. D 30560, from PS₂F 19. A rubber replica of an incomplete pedicle valve, $\times 1$.
 24. GK. D 30561, from PS₂F 19. An example only showing high interarea and pseudodeltidium, $\times 1.6$.
 - 25a, b. GK. D 30562, from PS₂F 19. Respectively ventral and posterior views of a posteriorly preserved pedicle valve, $\times 1.5$.
 26. GK. D 30563, from PS₂F 19. A rubber replica of incomplete brachial valve, $\times 1$.

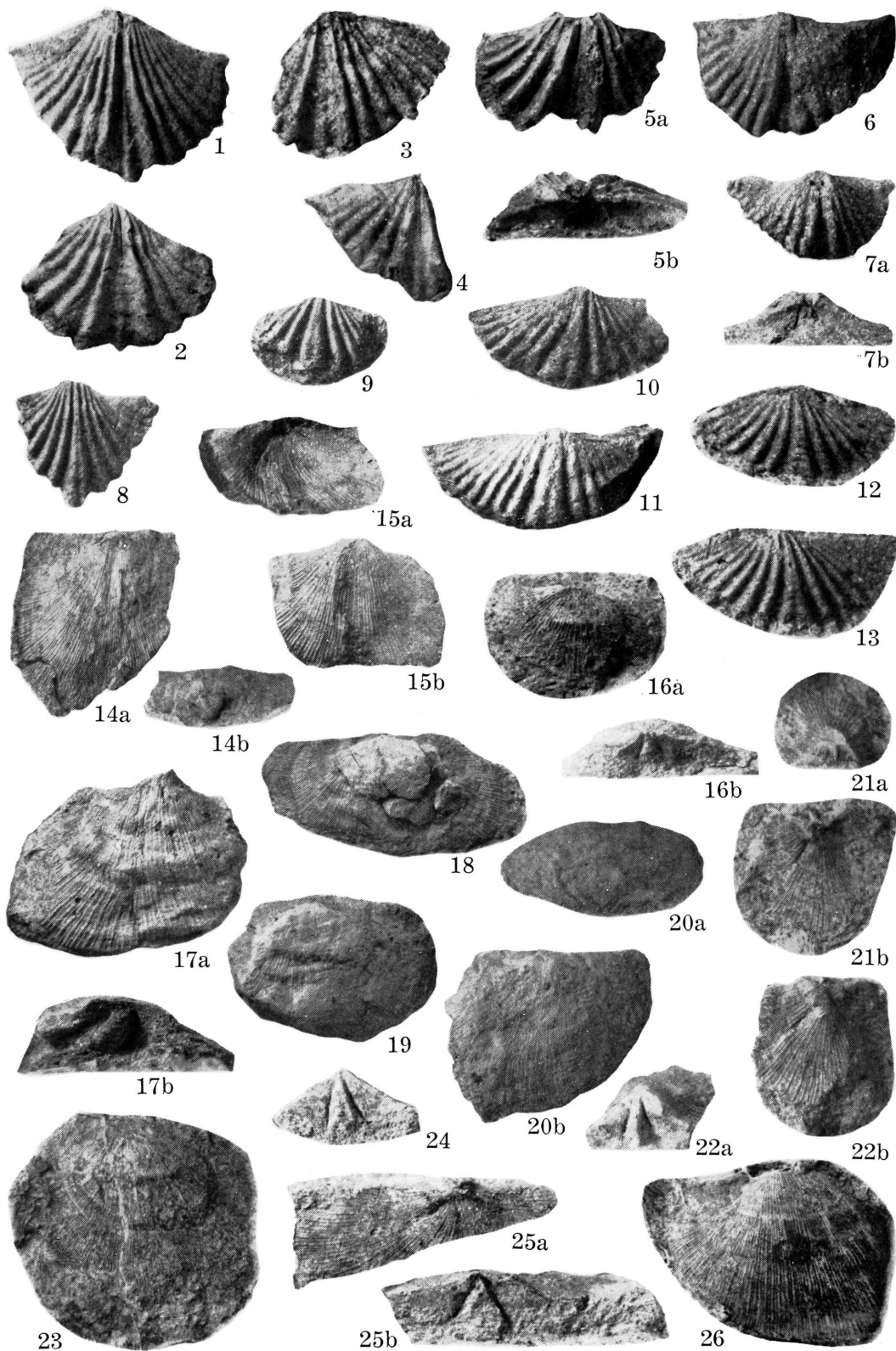


Plate 12

Explanation of Plate 12

- Figs. 1-17. *Setigerites* sp.Page 80
- 1a, b. GK. D 30571, from PS₂F 18. Respectively ventral and posterior views of an incomplete pedicle valve, $\times 1.5$.
 - 2, 3. Respectively GK. D 30572 and 30573, from PS₂F 18. Incomplete pedicle valves, $\times 1.5$.
 4. GK. D 30587, from PS₂F 19. A rubber replica of pedicle valve, showing the arrangement of spines, $\times 1.5$.
 - 5a, b. GK. D 30574, from PS₂F 18. Respectively incomplete pedicle valve and its external mould, showing the external ornamentation, $\times 2$.
 - 6-10, 12-14. Respectively GK. D 30575, 30576, 30577, 30578, 30579, 30580, 30581 and 30582, from PS₂F 19. All incomplete pedicle valves, showing the outline and external ornamentation, $\times 1.5$.
 - 11a, b. GK. D 30583, from PS₂F 18. Respectively anterior and ventral views of an incomplete external mould of brachial valve, showing the external ornamentation and partly impressed mould of cardinal process, $\times 1.5$.
 15. GK. D 30584, from PS₂F 19. A rubber replica of incomplete pedicle valve, showing the arrangement of spines on flank and ear, $\times 1.6$.
 16. GK. D 30585, from PS₂F 18. An incomplete external mould of brachial valve, $\times 1.5$.
 17. GK. D 30586, from PS₂F 19. A partly preserved external mould of pedicle valve, showing the arrangement of spines, $\times 1.5$.
- Figs. 18-22. *Antiquatonia* sp.Page 82
18. GK. D 30671, from PS₂F 19. An incomplete pedicle valve, $\times 1$.
 - 19a, b. GK. D 30672, from PS₂F 18. Respectively ventral and anterior views of an incomplete external mould of brachial valve, $\times 1$.
 - 20a, b. GK. D 30673, from PS₂F 19. Respectively internal view of a brachial valve, and its external mould, $\times 1$.
 21. GK. D 30674, from PS₂F 19. An incomplete pedicle valve, $\times 1$.
 22. GK. D 30675, from PS₂F 19. A rubber replica of brachial valve-interior, $\times 1$.
- Fig. 23. *Linoproductus* sp.Page 83
- GK. D 30680, from PS₂F 19. A rubber replica of a posterior part of pedicle valve, $\times 1$.
- Fig. 24. *Camarotoechia*? sp.Page 84
- GK. D 30681, from PS₂F 19. An incomplete pedicle valve, $\times 2$.
- Fig. 25. *Pugnax* cf. *P. asiaticus* MUIR-WOOD.Page 83
- GK. D 30682, from PS₂F 19. A rubber replica of posteriorly preserved shell, $\times 1.5$.

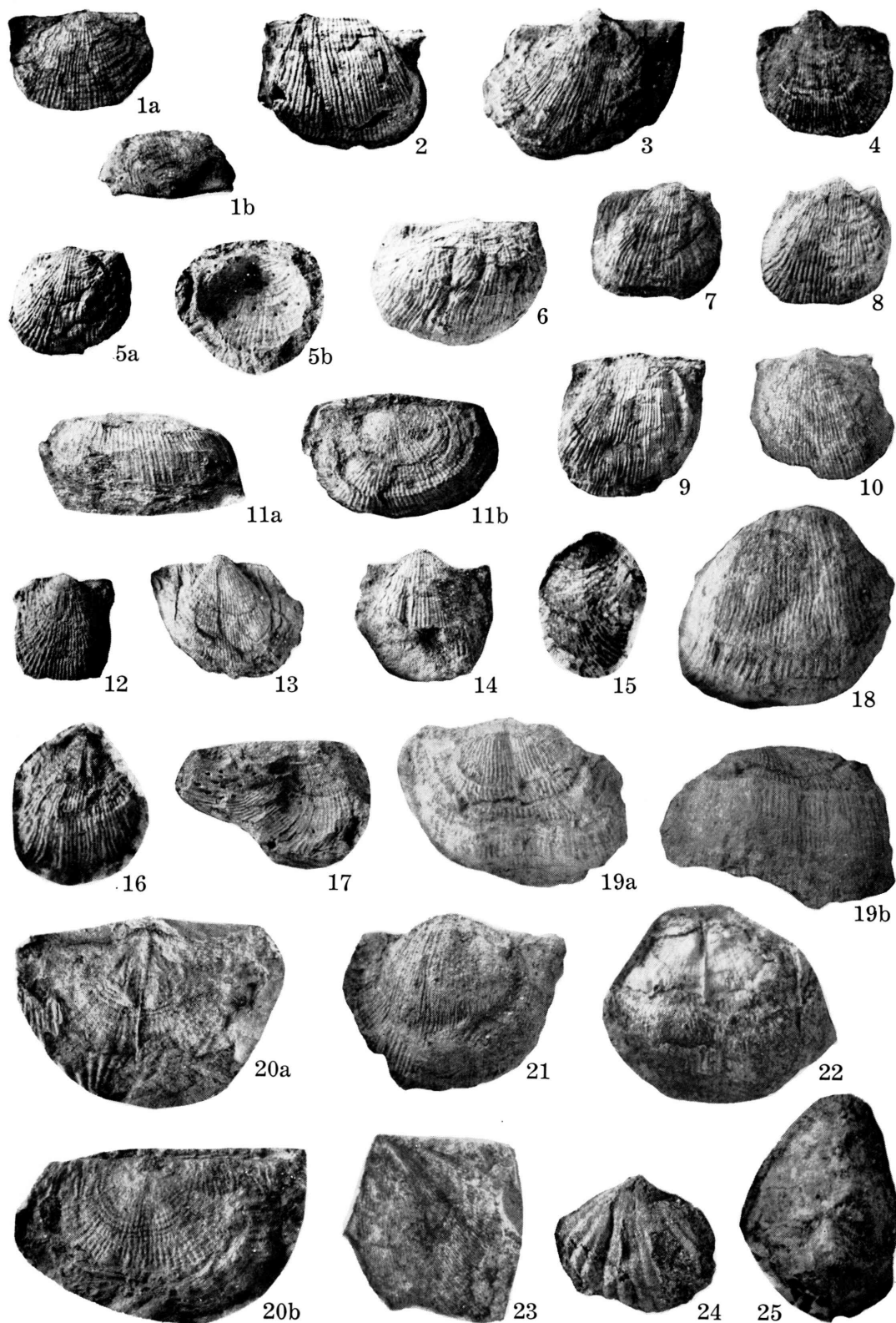
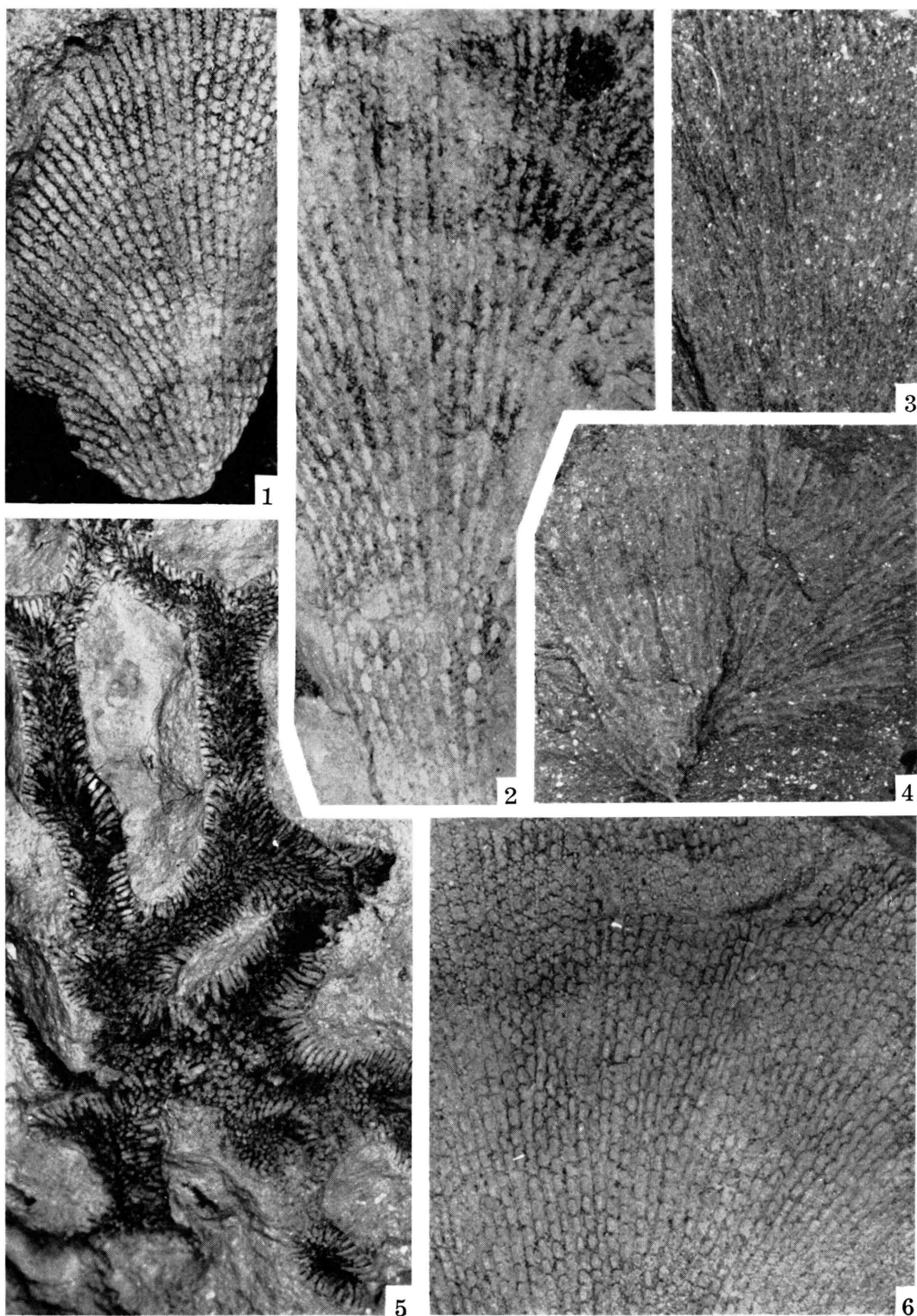


Plate 13

Explanation of Plate 13

- Figs. 1, 6. *Fenestella* cf. *F. tenax* ULRICHPage 90
Weathered surface specimens, $\times 5$, Locality: Upper bed of PS₂F 19,
GK. D 30700A and 30700B, respectively.
- Fig. 2. *Fenestella* cf. *F. angustata* (FISCHER v. WALDHEIM)Page 90
Weathered surface specimen, $\times 5$, Locality: Upper bed of PS₂F 19,
GK. D 30701.
- Figs. 3, 4. *Fenestella* sp. indet.Page 90
Weathered surface specimens, $\times 5$, Locality: PS₂F 18, GK. D 30702A
and 30702B, respectively.
- Fig. 5. Cylindrical stem Bryozoa, gen. et sp. indet.Page 90
Longitudinal break across zoarium, showing numerous moulds of zooecial
tubes, $\times 5$, Locality: lower bed of PS₂F 19, GK. D 30703.



S. SAKAGAMI: Bryozoa from Kuantan Area