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Permian Brachiopod Fossils of Timor

(Palaeontological Study of Portuguese Timor, 3)

By

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Abstract

Paleozoic brachiopod fossils of Timor collected by the Scientific Research Party of the Kyoto University are described, 17 species are distinguished, and compared with those of the lower to middle Permian faunas of Asia.

Introduction and Acknowledgements

This is a report on the Permian brachiopod fossils of the Timor presented to the writer from the Scientific Research Party of Kyoto University. This island is well known for its abundant fossil occurrences and complicated geological structure, on which many studies have been carried out. The Scientific Research Party of Kyoto University carried out a preliminary survey on the geology of the eastern Timor (Portuguese Timor) in 1961, and collected many paleozoic, mesozoic and cenozoic fossils. Paleozoic fossils are fusulines, corals, pelecypods and brachiopods and others. Fusuline fossils were described by Dr. Yasuo NOGAMI of our Institute in 1963. On the other fossils studies are being carried. The writer intends to describe paleozoic brachiopods in this report.

The paleozoic formations are all Permian in age as their fossil evidences show, and are divided into two complexes from their apparent occurrences, namely, authochtonous complex and decken complex. Brachiopod fossils are obtained from both complexes.

In the authochtonous complex, fossils are collected from the river bed of the Sumasse at Cribas (Loc. No. 1), where they are contained in tuffaceous shale, reddish brown or purplish brown in color. Brachiopods are associated with many pelecypods, gastropods, cephalopods and corals. Brachiopod species are as follows:

Plicatifera minor (SCHELLWIEN)
Linoproductus cora (D'ORBIGNY)
Martinia elonagata WAAGEN
Athyris semiconcava WAAGEN
Spirigerella grandis WAAGEN

From these fossils the fossil bearing formation can be correlated to the lower Permian.

In the decken complex, fossils are collected at many localities. At Hato Dame (Loc. No. 3), fossils are collected from tuffaceous, sometimes argillaceous limestone and shale, purplish or reddish brown in color. Brachiopods are associated with many fossils of crinoids, cephalopods, pelecypods and corals. This place is very famous for its abundant fossil occurrences, and WANNER (1956) distinguished 34 species (10 cephalopods, 14 coelentelates, 6 brachiopods, 4 crinoids). Nine species of brachiopods are distinguished by the writer as follows:

Plicatifera minor (SCHELLWIEN)
Linoproductus cora (D'ORBIGNY)
Stenoscisma "purdoni" (DAVIDSON)
Stenoscisma sp.
Squamularia lineata (MARTIN)
Matinia nucula ROTHPLETZ
Martinia sp.
Dielasma nummulus WAAGEN
Dielasma elongata var. *orientalis* GRABAU

These fossils are also correlated to those of the lower Permian. In the east of Vemasse (Loc. No. 5) *Dictyoclostus gratiosus* (WAAGEN) and *Linoproductus cora* (D'ORBIGNY) were colletced from white limestone blocks. At Hato Dame (Loc. No. 4), south of Viqueque, many beautiful samples of "*Productus*" were collected from reddish brown limestone. Two species of *Dictyoclostus* are identified as follows:

Dictyoclostus semireticularis (MARTIN)
Dictyoclostus spiralis (WAAGEN)

These two species possess long spines in well preserved condition. Many specimens of *Spiriferella* sp. were collcted from reddish tuffaceous rock at Hato Builico (Loc. No.2).

From these fossils, paleozoic formations of the eastern Timor are correlated to the lower to middle Permian in general.

Before going into description the writer wishes to express his sincere thanks to Professor Keiji NAKAZAWA, chief of the Party and Mr. Hiroyuki SUZUKI, a menber of

the Party, who kindly offered the materials and geological informations for study. He is also indebted to Professor Susumu MATSUSHITA for his kind guidance and encouragement given in the course of study.

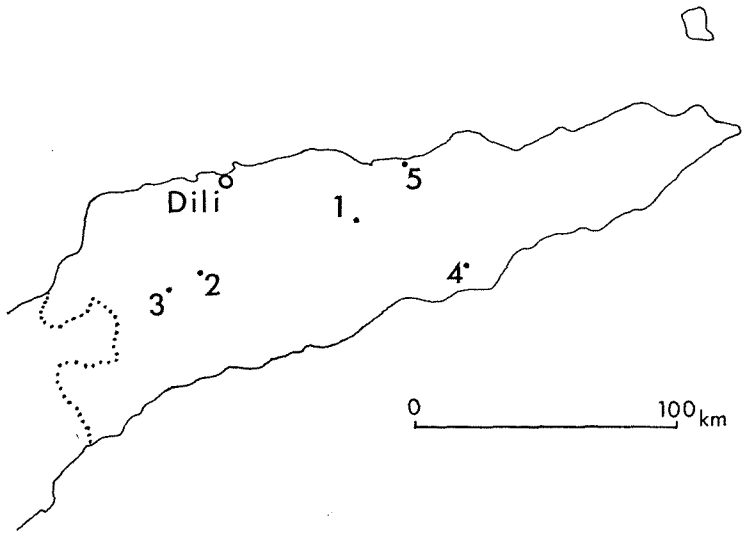

Figure 1. Index map of Portuguese Timor.
Fossil localities 1. Cribas, 2. HatoBuilico, 3. Hato Dame
4. Hato Hada, 5. Vemasse

Description of species

Superfamily Productacea WAAGEN 1884

Family Overtonidae MUIR-WOOD and COOPER 1960

Subfamily Plicatiferinae MUIR-WOOD and COOPER 1960

Genus *Plicatifera* CHAO 1927

Plicatifera minor (SCHELLWIEN)

Pl. 1, figs. 1-8.

1883 *Productus* sp. KAYSER, RICHTHOFEN's China, Vol. IV, p. 104, Pl. XIV, fig. 4.

1911 *Productus intermedius* ABICH var. *subplicatus* FRECH, ibid, Vol. V, p. 140, pl.XIX, fig.5, Pl.XXV, fig.2.

1931 *Plicatifera? minor* (SCHELLWIEN), HUANG. Late Permian Brachiopoda of Southwest China,I. Pal.Shinica, Ser.B, Vol.IX, pp.38—39, Pl.III, figs.1—4,

Three ventral valves of this species are obtained. Shell is globose and subovate in outline. Ventral valve is very strongly inflated. The longitudinal curve is regular near the apex to the middle, and from where the shell curves rather acutely, in other words, it is geniculated. Frontal part of the shell forms more slender curve. Transversely the shell is strongly vaulted, and sloping almost vertically to the lateral margins. Hinge line is straight and shorter than the greatest width of the shell. The ears are small and flattened. No sinus is found. Surface of the shell is covered by concentric wrinkles or plications which is round and irregular. These wrinkles are developed over the visceral part of the shell, and almost obsolate on the marginal part. Many small spine bases occur along these wrinkles. Only fine concentric growth lines are visilbe on the anterior part of the shell, and spine bases are not found as far as the shell is preserved.

Dimensions:

(in mm.) Specimen	A	B	C
Length of the visceral part	15.6	18.0	13.5
Breadth of the shell	17.7	23.2	17.7
Thickness of the visceral part	8.8	7.7	5.7

Remarks: This species is identical to HUANG's species by its general outline and surface ornamentations. Although Huang's figures not clearly show minute surface characters, we can observe more finely preserved surface ornamentations in the latest two literatures.[1] The present larger specimen much resembles with Huang's species although the latter has a sinus. The smaller specimen is charactersed by quite circular outline than the former species and may be a variety of the species.

Family Dictyoclostidae STEHLI 1954

Subfamily Dictyoclostinae STEHLI 1954

Genus *Dictyoclostus* MUIR-WOOD, 1930 emended

Dictyoclostus semireticulatus (MARTIN)

1861 *Productus semireticularis* MARTIN, DAVIDSON. British Carboniferous Brachiopoda, p.149, Pl. XLIII, figs.1—11; Pl.XLIV, figs.1—4.

1883 *Productus semireticularis*, KAYSER, in RICHTHOFEN's China, Vol. IV, p. 181, Pl.XXV, figs.1—4.

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1) 1955 *Plicatifera minor*. YANG and WONG, Index Fossils of China, Invertebrata, Pt.2, Brachiopoda, p.160, Pl.92, figs.5—7. (in Chinese)
1964 "*Plicatifera*" *minor*. WANG et al., Chinese Brachiopod Fossils, Pt. I, p.263—264, Pl. 40, figs.4—6, 9—11, 20. (in Chinese)

1897 *Productus semireticularis.* DIENER, The Permocarboniferous Fauna of Chitichun, No. 1, Pal. Indica, Ser.XV, Himalayan Fossils, Vol.I, No.I, No.1, p.18, Pl.III, fig.2.
1916 *Productus semireticulatus.* BROILI, Die Permischen Brachiopoden von Timor. Pal. von Timor, XII, p.8, Pl.CXVI, figs.14—16.

This species in hand presented by one incomplete specimen, broken both lateral sides. General outline of the shell is transversely subquadrate oval. Hingeline is straight, but its lateral ends are not preserved.

The ventral valve is moderately vaulted in both directions with less curved trail. The beak is incurved and overhangs the hinge line but slightly. Shallow sinus commences at a short distance from the apex, and gradually becomes broad and somewhat deeper towards the front. The apical region is vocered by reticulate sculpture, which extends from the apex in a distance 25 mm. along the curve, and not extends on the trail. Frontal and lateral parts of the valve is covered by low and round radiating ribs.

The dorsal valve is less concave in the visceral portion with very low fold, and is very strongly geniculated following the curve of the opposite valves and forms a rather straight trail. In the lateral sides, the geniculation is not so acute. The valve is also covered by reticulations in the visceral part, but some of concentric ribs in reticulation are slightly thick rather than the others. The fold is not provided near apex, but in the frontal half of the visceral part.

Dimensions:	Length of the shell (visceral part)	23.4 mm.
	Breadth of the shell	32. mm.+
	Thickness of the visceral part	10.8 mm.

Remarks: This specimen is unfortunately incomplete in form, but it has some specific characters of this species. Especially specimens cited above are closely identical to the present specimen by their less prominent beak and rather shallow sinus.

Dictyoclostus spiralis (WAAGEN)

Pl. 1, figs. 18-23.

1889 *Productus spiralis* WAAGEN. Productus Limestone Fossils. Pal. Indica, Ser.XIII, Vol.1, Pt.4, pp. 681-683, Pl.67, fig.6; Pl.68, fig.3; Pl.69, figs.1—3.
1916 *Productus spiralis.* BROILI, Die Permischen Brachiopoden von Timor, Pal. von Timor, Vol.XIII, pp. 11—12, Pl. CXVII (3), figs. 1—5.

This species is characterised by its very strongly inflated and enrolled ventral valve, and chiefly by the large, narrow and spiral wings at the ends of the hinge line. Present specimen is not completely preserved, but the specific characters can be found.

The ventral valve is strongly and very equally curved. Longitudinally the curve forms a very regular open spiral, and transversely it forms a high arch, which is somewhat impressed on top, and flattened on both sides towards the wings. The apex is little prominent and overhangs the hingeline but very slightly. The hinge line is straight and has the greatest width of the shell, although its extremities are not preserved. The wings are narrow and spirally enrolled. A strong sinus commences at a short distance from the apex and extends over the trail down to the frontal margin. On the trail the sinus becomes more deep but narrow and forms a furrow like depression and distinguished from the remainder of the shell. The whole shell is covered by strong radiating ribs and near the apex concentric plications cross the ribs forming remarka ble reticulation. Reticulated sculptures extend for a distance of 25 mm. from the apex along the curve. On the trail many long erect spines are provided and their directions are not regular. Almost of them has 1.3 mm. diameter in whole extension.

The dorsal valve is almost flat, somewhat concave in the visceral portion with a median fold towards the front, and is very strongly geniculated forming a trail. The hinge line is long and straight and probably possesses the greatest breadth of the shell. The wings are large and flat near the apex, but their whole outline is not found. The visceral part is covered by sharp reticulated sculpture, and the trail is characterised by radiating ribs, especially near the geniculation. These ribs become low near front, where the shell is almost smooth. The wings bear only irregular concentric wrinkles.

Dimensions:	Length of the shell	27.6 mm.
	Breadth of the shell (exclude wings)	34.0 mm.
	Thickness of the visceral part of the shell	13.4 mm.

Remarks: The present specimen is identical with *Productus spiralis* WAAGEN of the Salt Range, and also with *Productus taiyuanformis* GRABAU (described by CHAO) of China. The writer hardly distinguishes the two species. This species is most characteristically possesses spirally curved form and spiral long wings, and the present specimen is enough to identify to the species, although it is not completely preserved.

Dictyoclostus gratiosus (WAAGEN)

Pl. 1, figs. 9-12.

1884 *Productus gratiosus* WAAGEN. Productus Limestone Fossils, Pal. Indica, Ser.XIII, Vol.I, Pt.4, pp. 691—693, Pl.LXXII, figs.3—7.

1897 *Productus gratiosus.* DIENER, The Peroocarboniferous Fauna of Chitichun, No. 1. Pal. Indica, Ser.XV, Himalayan Fossils, Vol.I, p.23, Pl.III, figs.3—7.

1936 *Productus gratiosus.* BROILI. Die Permischen Brachiopoden von Timor. Pal. von Timor. Vol.XII, p.12, Pl.CXVI(2), figs.4,5,7—13.

1927 *Productus gratiosus*. CHAO, Productidae of China, Pt.1, Pal. Sinica, Ser.B, Vol.5, pp.44—47, Pl.IV, figs.6—10.

1961 *Productus* (*Dictyoclostus*) *gratiosus*. SHIMIZU, Brachiopod Fosils from the Permian Maizuru Group. Mem. Coll. Sci., Univ. Kyoto, Ser.B, Vol.XXVII, No.3, pp.323—324, pl.15, figs.19—21.

This species is presented by one well preserved ventral valve, which is characterised by its strong geniculation. The shell is inflated, the apical part is rather flattened and covered by reticulation. Then the shell is geniculated and forms regular curve to the front. Transversely it is depressed slightly in the middle and steeply curves to both sides. The apex is pointed and bent not so much on the hinge line. Near apex a shallow sinus commences and becomes more deep and somewhat broad towards the frontal argin. The whole surface is covered by beatiful reticulation near apex and by round radial ribs on the middle and frontal part. This species is described by many authors and it is little to add them.

Dimensions:	Maximum height of the valve	more than 19.0 mm
	Length of the hinge line	18.0
	Width of the valve	23.8
	Depth of the valve	18.8

Family Linoproductidae STEHLI 1954

Subfamily Linoproductidae STEHLI 1954

Genus *Linoproductus* CHAO

Linoproductus cora (D'ORIBIGNY)

Pl. 2, fig. 16-23.

1863 *Productus cora*. DAVIDSON. British Carboniferous Brachiopoda, p.148, Pl.36, fig.4; Pl.42, fig.9.

1884 *Productus cora*. WAAGEN. Productus Limestone Fossils. Vol.I, pt.4, Pal.Indica, Ser. XIII, p.677, Pl.66, fig.3; Pl.67 figs.1,2.

1892 *Productus cora*. SCHELLWIEN. Die Fauna des karnischen Fusulinen Kalkes. I, Palaeontographica. Bd. 39, p.21, Pl.3, fig.3.

1916 *Productus cora*. BROILI. Die Permischen Brachiopoden von Timor, Paläontologie von Timor, Bd. XII, pp.1—22. Pl.1, fig. 14; Pl.2, figs. 1—3.

1927 *Linoproductus cora*. CHAO. Productidae of China, Pt.I. Pal. Sinica, Ser.B, Vol.5, pp.132—134, Pl.XIII, figs.17—18; Pl.XIV, figs.1—34.

1932 *Linoproductus cora*. HUANG. Late Permian Brachiopoda of Southwest China. Pal. Sinica, Ser. B, Vol.IX, pp.41—42, Pl.III, fig.6.

1960 *Linoproductus cora*. MUIR-WOOD & COOPER. Productidae. Geol. Soc. Amer., Mem. 81, pp.296—298, Pl.111, figs.3—6.

This widely distributed species are presented by many specimens from Timor. The ventral valve is strongly and regularly inflated. Longitudinally the shell is more

regularly vaulted near apex and the curvature becomes weak to the front. Transverse curve is very regular, with no sinus nor flattening over whole shell. Beak is pointed, enrolled, but only slightly bent over the hinge line, which marks the greatest width of the valve. Ears are not so large, flat and not so remarkably marked off from the remainder of the valve. Surface is covered by numerous radial ribs, which are round and equally in width on all surface. They increase in number by bifurcation and interruption, and on the other hand some ribs are jointed anteriorly.

The dorsal valve is represented by some ill preserved external moulds. They are cancave and suboval in outline with round and not prominent beak.

Dimensions:	Maximum height of the ventral valve	24.5+	21.5+
(in mm)	Length of hinge line	18.0	20.5
	Width of the shell	23.0	24.0
	Depth of the valve	13.0	15.0

Remarks: Linoproductus cora (D'ORBIGNY) has many allied species and described by former writers. The present species is distinguished from *Productus lineatus* WAAGEN of the Productus Limestone of the Salt Range by its circular or transverse outline, without flattening near apex. Chao discriminated *Linoproductus tenuistriatus* (VERNEUIL) from *Productus cora* by its more elongated and narrow outline, constantly shorter hinge line, and strongly but regularly enrolled apical region and less inflated front. He also described theat *Linoproductus simensis* (TSCHERNYSCHEV) is characterised by its shorter hingeline, elongated outline, tube-shaped frontal part and particularly by its low apical region which ascends very steeply at first and then becomes strongly geniculated downwards. These characters not compared with the present species.

Superfamily Stenoscismatacea OEHLERT 1887 (1883)

Family Stenoscismatidae OEHLERT 1887

Subfamily Stenoscismatinae OEHLERT 1887

Genus *Stenoscisma* CONRAD 1893

Stenoscisma "purdoni" (DAVIDSON)

Pl. 1, figs. 24-28; Pl.2, fig. 1-10.

1892 *Camarophoria pinguis* WAAGEN. ROTHPLETZ, Die Perm-, Trias-, u. Juraformation auf Timor u. Rotti im Indischen Archipel. Palaeontographica. Vol.39, p.48, Pl.X, figs. 3,7,8.

1916 *Camarophoria purdoni* DAVIDSON. BROILI, Die Permischen Brachiopoden von Timor,

Paläontologie von Timor, Vol. XII, p. 55, Pl. 11. figs. 7—23 (non 15, 17—23)

1965 *Stenoscisma purdoni* (DAVIDSON). GRANT, The Brachiopod Superfamily Stenoscismatacea, Smithsonian Misc. Coll., Vol.148, No.2, p.149, Pl.20, figs.1—4.

Shell is inflated and oval in outline. The ventral valve is less inflated and regularly curved in longitudinal direction and the curve is laterally less vaulted with almost flattened in the middle part of the shell. The beak is thick, erected and bent over the other valve. Shallow sinus commences from the middle of the shell, and slightly more wide to the frontal margin, and its both sides are restricted by very weak furrows. The surface of the shell is almost flat and covered by very fine concentric growth lines. In the sinus of the frontal margin, weak four ribs are visible.

The dorsal valve is much inflated, its curve is regular in both directions. The apex is not so prominent and entirely concealed by the bending beak of the ventral valve. A broad fold is provided only in the frontal margin of the shell, and it is covered by five low and round ribs. This fold, corresponding the sinus of the ventral valve, forms a rather quadrate arch of the suture line. The ribs of both valves meet a zigzag line in the middle of the front. The anterior margin show clearly the former presence of stolidia, although the stolidia are not preserved in the present specimen.

Internally, this species is characterised by spodilium and camaropholium as shown in text figure.

Diemensions:	(in mm.)	specimen	A	B
	Height of the shell		18.5	14.0
	Breadth of the shell		23.0	18.5
	Shell thickness		15.0	10.5

Remarks: ROTHPLETZ had described *Camarophoria pinguis* from Timor and lately BROILI included it in *Camarophoria purdoni* with many specimens. The specimen in hand is identical to their specimens in general form, inflated dorsal valve, shallow sinus of the ventral valve, and especially weak ribs of the valves. Those characters

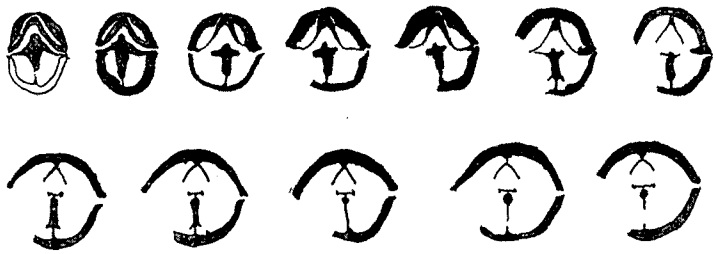

Figure 2. Apical serial sections of *Stenoscisma "purdoni"* (×1)

rather distinguish their species from *C. purdoni*, *C. pinguis* and other species. REED also ponited that, (Brachiopoda and Mollusca from the Productus Limestone of the Salt Range, Pal. Indica, N.S. Vol. XXIII, No. 2, p. 133) "The form from Timor which BROILI attributed to DAVIDSON's species, seems to be distinct, and judging from the figures he seems to include more than one species under this name, while the Timor from which he termed *C. gigantea* DINER is much more like the Salt Range form of *C. purdoni* and the closely allied *C. hunbletonensis* HOWSE." GRANT (1965) says, "These specimens correspond closely to those called *C. purdoni* by BROILI (1916). However, they bear little resemblance to DAVIDSON's (1863, Pl. 2, fig. 4) Salt range specimens of that name. Correct specific identification would require study and comparision of adequate collections from Timor and the Salt Range: therefore, BROILI's name for the species is used, advisedly, without citing the comprehensive synonymy that appears in his book." The present specimen has very weak ribs, especially on the lateral wings and much resembles GRANT's specimen (especially fig. 1). These specimens from Timor (of ROTHPLETZ, BROILI, GRANT, and the present) distinguished from the former species and may be new.

Stenoscisma sp.

Pl. 2, figs. 11-15.

cf. 1961 *Camarophoria purdoni* DAVIDSON, BROILI, Die Premischen Brachiopoden von Timor, Palaontologic von Timor, Vol. XII, p. 55, Pl. 11, fig. 15

This large shell is transverse oval in outline and much inflated. The ventral valve is flatly convex transversely and more strongly convex logitudinally through sulcus. Beak is thick, less prominent and not bent over with sharp apex. Antero-lateral part of the valve is slighty curved down to the dorsal valve. Sinus commences from the middle of the shell and becomes broader and very deep along the curvature. In the sinus two very sharp ribs are provided and the dorsal valve is strongly convex in both directions. Beak is blunt and somewhat covered by the bending apex of the opposite valve. A fold provided from the middle part towards the frontal posterior margin. The fold and sinus form a very highly arched commisure line. The fold is broken in this specimen. Whole surface of the valve is covered by fine concentric growth lines and interruptions.

Internal structures of this species are not known.

Dimensions: Height of the shell 24.5 mm. Breadth of the shell 32.2 mm. Thickness 23.2 mm

Remarks: This specimen is remarkably distinguished from the other species by its distinclly arched commissure line and high fold of the dorsal valve. *Broili*'s specimen (*Camarophoria purdoni*, Pl. 11, Fig. 15) resembles to this specimen, but not identical.

Superfamily Spiriferidea WAAGEN 1883

Family Spiriferidae KING 1846

Subfamily Reticulariinae WAAGEN 1883

Genus *Squamularia* GAMMELLARO 1898

Squamularia lineata (MARTIN)

Pl. 3, figs. 14-18, 23-29.

1858 *Spirifera lineata* MARTIN. DAVIDSON, British Carboniferous Brachiopoda, Part 5. Palaeontological Society. p.62, Pl.XIII, figs.1—13.

1883 *Reticularia lineata*. WAAGEN, Productus Limestone Fossils, Pal. Ind., Ser. XIII, Vol. I, pt. 4, p. 540, Pl.42, fig.6—8.

1916 *Spirifera* (*Reticularia*) *lineatus* MARTIN. BROILI. Die permischen Brachiopoden von Timor, Paläontologie von Timor, Vol. XII, p.40—43, Pl. 7, fig. 4, 6—8, Pl. 8, figs. 1—16.

General outline of the shell is transversely oval, with rather inflated valves. The beak is not very prominent.

The ventral valve is slightly inflated, and its curve is very regular in both directions. The beak is not very prominent, thick and slightly bent over, but pointed. The area is small and occupied in the middle by triangular fissure, which is bordered by fairly raised ridges of the area. The hingeline is shorter than the greatest width of the shell. Very shallow sinus is found at the middle of the shell towards the front. The frontal part of this shell is not preserved.

The dorsal valve is slightly less inflated, and regularly curves in both directions. The apex is very little prominent, slightly bent over. Area of this valve is not well preserved.

The surface of the valves are covered by concentric line which is composed of very fine reticulation. The shell ornamentation of the present specimens are not so clear.

Dimensions: (in mm.)	specimen	A.	B.
Length of the shell		22.5+	12.5
Breadth of the shell		22.0	12.0
Thickness of the shell		15.0	8.0

Remarks: The species is decribed by many authors from many localities of the world, and it varies in shape and other characters. The present specimen is distinguished by

english specimens (DAVIDSON) by its circular outline and almost obsolate sinus and fold. This specimen most resembles with those of the Salt Range (by WAAGEN) and from Timor (by BROILI). The internal structures and fine surface ornamentations are not found in the present specimen, and so the writer tentatively included it in *Squamularia*. This species is distinguished from *Sq. indica* WAAGEN, by its elongated beak. Same species of Mongolia described by GRABAU not identical with WAAGEN's original and rather similar to *Sq. lineata*.

Subfamily Spiriferinae SCHUCHERT 1913

Genus *Spiriferella* TSCHERNYSCHEW 1902

Spiriferella rajah (SALTER)

Pl. 3, figs. 1-11.

1860 *Spirifer rajah*. DAVIDSON, Note on some Carboniferous Brachiopoda collected by Captain Godwin Austin, Q.J.G.S. London, Vol.22, p.40, Pl.II, fig.3.

1892 *Spirifer interplicatus* ROTHPLETZ. Die Perm-, Trias-, u. Jurafromation auf Timor u. Rotti. Paläontogr. Vol. 39, p.78, Pl.IX, fig,6.

cf.1899 *Spirifer rajah*. DIENER, Anthlacolithic Fossils of Kashmir and Spiti, Pal. Indica, Ser.XV, Vol.I, pt.2, p.68, pl.IV, figs.1—7, Pl.V, fig.1.

1916 *Spirifer rajah*. BROILI, Die Permischen Brachiopoden von Timor. Paläontologie von Timor, Vol. XII, p.34, Pl.5, figs.1—11, Pl.6, figs1—6.

cf.1931 *Spiriferella rajah*. (SALTER). GRABAU, Permian of Mangolia, Nat. Hist. Central Asia, p.48, Pl.XXII, figs.1,2.

Shell is longitudinally oval in outline, and hingeline is shorter than the greatest width of the shell.

Ventral valve is convex with erected beak. A narrow sinus extends from the extremity of the beak to the front, and along the center of which there exists a narrow thread like rib. The surface of the valve is ornamented by ribs, of which the two central ones are the largest as well as the most prominent and bifurcate at the short distance from apex. Between the ribs bifurcated, a small ribs inserted at the middle of the valve extending to the front. Fine concentric growth lines are also preserved over whole surface of the shell. Beak is prominent and incurved, and area is not so large and divided in the middle by a triangular fissure. In some specimens beak are much incurved and the areas are completely concealed.

Dorsal valve is convex, but less than the ventral. This valve is transversely oval in outline. slightly wider than long. Median fold is well defined. Whole shell is covered by round radiating ribs, of which ribs near fold are larger and more widely spaced and ones of lateral sides are smaller and narrowly spaced. Fine concentric lines are

also preserved.

Dimensions: Length of the shell 22 mm. Length of the dorsal valve 19.0 mm. Breadth of the valve 21.0 mm. Thickness of the shell 14.5 mm.

Remarks: This species has very short hinge line and narrow sinus than those of DAVIDSON's specimen. *Spirifer interplicatus* ROTHPLETZ has more circular outline and rather long hinge line (it possesses almost four fifth width of the shell) and rather shalow sinus. BROILI's species are identical with the present specimens, by its semi-circular outline, short hinge line and deep sinus. Mongolian specimen described by GRABAU is not completely preserved and insufficient to compare the present specimens.

Spiriferella sp.

Pl. 3, figs. 12-13.

The general outline of this species is transversely oval, with a hinge line shorter than the greatest breadth of the shell. The ventral valve is much inflated in both directions. The beak is prominent, and pointed, but little bent over. The sinus begins at the apex of the beak, but it is very shallow, and rounded. The radiating ribs are rounded on the top, not very thin and not numerous.

This species is most nearly related to *Spirifer wynnei* WAAGEN described from the Salt Range, in its transversely oval outline, and numerous ribs, but in the latter species the ribs are rather regular in shape and more numerous. *Spiriferella salteri* described by TSCHERNYSCHEW from Ural and Timan and the same species and allies of Grabau's report can be compared, but not identified with this species.

Subfamily Martininae WAAGEN 1883

Genus *Martinia* MCCOY 1844

Martinia elongata WAAGEN

Pl. 3, figs. 19-23.

1883 *Martinia elongata* WAAGEN. The Salt Range Fossils, Vol. I, pt. 4 Pal. Indica, Ser. XIII, p. 532, Pl. XLIII, figs.5,7.

The general outline of the shell is slightly transverse oval, and it is rather pentagonal. Sinus and median fold are broad and flat, the hinge line is comparatively long. The valves are but little inflated.

The ventral valve is very regularly curved in both directions. The beak is but little prominent, small and not much bent over. The area is vary small, triangular and can-

cave. This area is trancated by very large triangular fissure. The sinus is very broad, flat and entirely limited to the frontal region. On both sides of the sinus two round folds are placed.

The dorsal valve is equally curved as the ventral one, and its bending is very regular in both directions. The apex is very little prominent. At both ends of the hinge line little wings are developed. The median fold is very broad, low and strongly flattened at the middle. Numerous fine concentric lines are well observable.

Dimensions: Length of the shell 16.0 mm. Breadth of the shell 17.0 mm. Shell thickness 11.0 mm.

Remarks: Our specimen is identical with Waagen's species by its general outline, but much inflated than the latter. Besides, our specimen is also comparable with *Martinia warthi*, and *M. chideruensis* WAAGEN, but it is distinguished from the latter two species by its general outline, low, broad and strongly flattened median fold and comparatively longer hingeline.

Martinia nucula ROTHPLETZ

Pl. 4, figs. 1-7.

1892 *Martinia nucula* ROTHPLETZ. Die Perm-, Trias-, u. Juraformation auf Timor und Rotti im indischen Archipel. Paläontographica, Vol. 39, p. 80, Pl. IX figs. 3, 7.

1897 *Martinia nucula*. DIENER, The Permocarboniferous Fauna of Chitichun. No.1. Paleontologia Indica, Himalayan Fossils, Vol.I, Pt.3, p.50, Pl.VIII, figs.5,6.

1916 *Martinia nucula*. BROILI, Die Permischen Brachiopoden von Timor, Paläont. von Timor, XII, p.43, Pl.CXXII(8), figs.17—21, Pl.CXXIII(9), fig.1.

The shell is transversely oval in outline, with equally inflated both valves. The ventral valve is inflated, the longitudinal curvature is more regular. Transversely the shell is slightly depressed on the top. The hingeline is straight and shorter than the greatest width of the shell. The area is rather large, concave and distinguished from the remainder of the valve by round margins. In the midst of the area a large triangular fissure is provided. The sinus is very broad, but shallow, which commences near apex and becomes broad to the frontal margin, forming a flattened depression. This flat sinus is extended to the opposite valve. The sinus is bordered by low but distinct ridges on both sides and they diverge to the front.

The dorsal valve is equally inflated as the ventral one. The longitudinal curve is very smooth, but the transverse curvature is acute at the middle and gently curves down to both sides. Then a round but narrow fold is provided from apex to the front, which form a U-shaped arch of frontal line meeting the extended sinus of the ventral valve.

The whole surface of the shell is covered by fine concentric growth lines. Internal structures are not known.

Dimensions: (in mm)	specimen	A.	B.
Length of the shell		24.0	29.0
Breadth of the shell		24.0	26.0
Thickness of the shell		19.0	23.0

Reamrks: The specimen in hand are not completely preserved, one is broken its apex of the ventral valve, and the other is very strongly depressed. Although the ill preservation of the shell, these specimens are identical with *Martinia nucula* ROTHPLETZ of Timor and India. This species is characterised by short hingeline and highly elevated tongue shaped curve of the frontal line.

Martinia sp.

Pl. 3, figs. 30-32.

The general outline of the shell is elongated oval, with inflated both valves, eapesially the ventral one is much inflated.

The ventral valve is elongated and much inflated, the curve is equal in both longitudinal and transverse directions. The beak is erected and not bent over. The area is small and slightly concave and excavated by a triangular fissure in the middle. From the middle to the front of the valve a narrow and shallow sinus is provided, besides a sharp, but fine furrow commences near apex and reaches to the frontal margin through the midst of the sinus. The surface of the valve is covered by fine growth lineo and less numerous growth interruptions.

The dorsal valve is almost circular in outline and less inflated than the other valve. Longitudinaly it curves rather regularly near beak, and then becomes gradually almost flat near the margin. Transverse profile is more regular. The frontal one third of the valve forms a triangular, broad and low fold, and which meets the sinus of the opposite valve, forming a V shaped arch of the frontal line. This valve is also covered by fine growth concentric lines.

Dimensions: Length of the shell 11.5 mm., length of the dorsal valve 10.0 mm, breadth of the shell 9.5 mm., thickness of the shell 7.5 mm.

Remarks: The present specimen is compared with *Martinia* cf. *krafti* BITTNER described by REED (1944) from the Productus Limestone of the Salt Range, but his figure not show the specific characters, except general outline and sharp sinus of the ventral valve. *Martinia acutomarginalis* DIENER described from Himalaya (1897), is distingush-

ed from the present specimen, by its acute outline, shallow and broad sinus, and rather quadrate frontal line.

Superfamily Rostrospiracea SCHUCHERT et LE VENE 1929

Family Athyridae PHILLIPS 1841

Subfamily Athyrinae WAAGEN 1883

Genus *Athyris* McCOY 1844

Athyris cf. *semiconcava* WAAGEN

Pl. 4, figs. 8-17.

cf.1883 *Athyris semicancava* WAAGEN. Productus Limestone Fossils. Pal. Ind., Ser.XIII, Vol.I, Pt.4, pp. 481—482, Pl.XLI, figs.4—6.

cf.1916 *Spirigera royssi* LEVEILLE. BROILI, Die Permischen Brachiopoden von Timor. Paläont. von Timor. Vol.XII, pp.49—51, Pl.CXXIV(10), figs.10—11.

The shell is biconvex and transversely oval in outline. The ventral valve is less inflated than the dorsal one. The frontal line is very strongly bent up. The ventral valve curves regular in both directions, and excavated in the middle by a rather deep sinus, which commences from the middle of the valve as a flattened part and becomes broad and deep forming a triangular depression towards the frontal line. The beak is thick and slightly bent over the hinge line. Area is very narrow and not so distinct. Hinge-line is straight and short. Whole surface of the valve is covered by very fine concentric growth lines, of which some ones are rather remarkable and form growth inter-ruptions.

The dorsal valve is much inflated and curvature of it is regular in both directions. A medain fold is very indistinct and slightly strongly marked only at the front. This valve is also covered by fine concentric growth lines.

Dimensions: (in mm)	specimen	A	B
Length of the shell		17.5	18.5
Breadth of the shell		22.5	18.5
Shell Thickness		12.5	13.0

Remarks: This species is much transverse oval in outline and characterised by very broad sinus, and corresponding median fold in the dorsal valve, which form a strongly bent up frontal line. These characters are compared with those of WAAGEN's *Athyris semiconcava*, but the latter has more flattened ventral valve and narrow sinus. *Athyris royssi* described by many authors are more inflated and has rather circular outline,

Among the figures of BROILI's *Sprigera royssi*, some specimens (figs. 10, 11) are rather similar the present specimens, and they are rather comparable with WAAGEN's species.

Genus *Spirigerella* WAAGEN 1883

Spirigerella grandis WAAGEN

Pl. 4, figs. 18-21, 24-25.

1883 *Spirigerella grandis* WAAGEN. Produstus Limestone Fossils, Pal. Ind., Ser.XIII, Vol.I, Pt.4, pp. 461—465, Pl.XXXVI, figs.5—7; Pl.XXXVII, fig.1.

1916 *Spirigera timorensis* ROTHPLETZ. BROILI. Die Permischen Brachiopoden von Timor, Vol.XII, p.48, pl.CXXIII(9), figs.7—12; Pl. CXXIV (10), fig. 1.

The shell is biconvex and strongly inflated, and outline is oval or rather pentagonal.

The ventral valve is as high as it is wide and strongly inflated. It curves regularly in both directions, and only frontal part is slightly flattened. The beak is not prominent, pointed and very quickly tapering. It is entirely bent over and firmly apressed to the apical part of the dorsal valve. The sinus is not developed and produced only as a flattened margin which is bordered by two sharp but low fold-like ridges. The folds commence at the middle of the valve and become distinct to the frontal margin. The valve is covered by numerous fine growth lines, and some of these are rather thick.

The dorsal valve is strongly vaulted as the ventral one, having rather leterally elongated pentagonal outline. The curves of this valve are more regular rather than those of the ventral valves. A low and broad fold commences near the middle of the valve and becomes more broad towards frontal margin. This fold is bordered on both sides by shallow furrows and low folds. They are slightly distinct especially near margin. Those furrows and folds corresponding to the folds of the ventral valve, form a remarkable zigzag frontal line. The apical part of this valve is almost concealed by the bending apical part of the opposite valve. The surface ornamentations are same as those of the ventral valve.

The internal structures are not known.

Dimensions:	Length of the shell	14.0 mm.
	Length of the dorsal valve	13.0
	Breadth of the shell	14.2
	Shell thickness	9.9

Remarks: This species is characterized by its very inflated form, rather pentagonal outline and undulating frontal suture line. The general form of the shell is comparable

with *Athyris timorensis* in BROILI's work, besides the original species of Rothpletz is distinguished by its more circular outline and sinus of the ventral valve from the present specimens. *Spirigerella grandis* WAAGEN of the Salt Range has most identical characters. Especially full grown specimens of Waagen's species are most comparable with the present species in general outline and frontal features. Some of BROILI's species may be included in WAAGEN's species. This species is also distinguished from *Spirigerella media* WAAGEN by its elongated form. The present species are characteristic by its small form and undurating frontal suture line. REED had distinguished *Spirigerella timorensis* from *Sp. grandis* by their subcircular outline and usual absence of any fold and sinus on the valves. The writer follows Reed's definition of the species, although specific definitions of the two species are not so clear between the originals by ROTHPLETZ and DAVIDSON and the latters by BROILI and WAAGEN.

Superfamily Terebratulacea WAAGEN 1883

Family Dielasmatidae SCHUCHERT 1929

Subfamily Dielasmatinae CLOUD 1942

Genus *Dielasma* KING 1859

Dielasma nummulus WAAGEN

Pl. 4, figs. 31-34.

1882 *Dielasma nummulus* WAAGEN. Productus Limestone Fossils, Pt.4, Pal. Ind., Ser.XIII, Vol.1, Pt.4, p.344, Pl.XXV, fig.9.

cf.1931 *Dielasma acutiangulatum* var. *minor* GRABAU. The Permian of Mongolia. Nat. His. Central Asia, Vol.VIII, p.70, Pl.VII, figs.4,9,10.

1963 *Dielasma nummulus*. SHIMIZU. Permian Brachiopod Fossils of the Maizuru Group found on the North of Okayama City, Japan. Mem. Coll. Sci., Univ. Kyoto, Ser. B, Vol. XXX, No. 2, pp. 75—76, pl.5, figs.13—15, 25.

The general outline of the shell nearly circular, very little elongated, biconvex, especially the ventral valve is much inflated. The ventral valve is a little elongated with rather thick beak, and regularly vaulted, especially in longitudinal direction. Transversely the valve is slightly flattened at the middle and then steeply curved down towards both lateral sides. Consequently near anterior margin the shell forms a flattened part.

The dorsal valve is almost circular in outline and less inflated than the other valve, its curve is almost regular in both directions. The frontal part of this valve is also slightly flattened. The apex of the valve is truncated by rather large round foramen,

Dimensions: Length of the shell 11.5 mm.; length of the dorsal valve 9.5 mm.; breadth of the shell 9.5 mm.; shell thickness 6.5 mm.
Remarks: This specimen is slightly inflated rather than the original and Japanese ones, although their general forms quite resemble. GRABAU's species are, except the largest specimen (fig, 11), not produce a faint emergination in the frontal suture line, and rather identical with *Dielasma nummulus*. From *Dielasma minor* WAAGEN of the Salt Range, the present specimen is distinguished by its more circular outline and pointed apex.

Dielasma elongatum SCHLOTHEIM var. *orientalis* GRABAU

Pl. 4, figs. 28-30.

1931 *Dielasma elongatum* SCHLOTHEIM var. *orieutalis* GRABAU. The Permian of Mongolia. Nat. His. of Central Asia, Vol. VIII, p. 72, Pl. VII, figs. 5,7

This shell is very small biconvex and elongated oval in outline. The greatest width of the shell is the anterior third and frontal line is regularly rounded.

The ventral valve is quite regularly vaulted in both directions. The beak is thick and slightly bent over. No sinus is provided in this valve.

The dorsal valve is less convex than the other valve, and transversely it curves regularly. Longitudinaly the valve convex near apex to one third of the length of the valve, and from where rather flattened towards the frontal margin. The surface of both valves are covered by fine concentric growth lines.
Dimensions: Length of the shell 7.0 mm.; length of the dorsal valve 6.0 mm.; breadth of the shell 5.0 mm.; thichness 3.0 mm.
Remarks: This shell is identical with GRABAU's species by its outline and general shell form, but the present specimen is slightly large in shape. SCHLOTHEIM's species are reported from Ural and Timor, and these species are not identical with the present specimen. WAAGEN's *Dielsama truncatum* of the Salt Range can be compared, although it has slightly arched frontal line.

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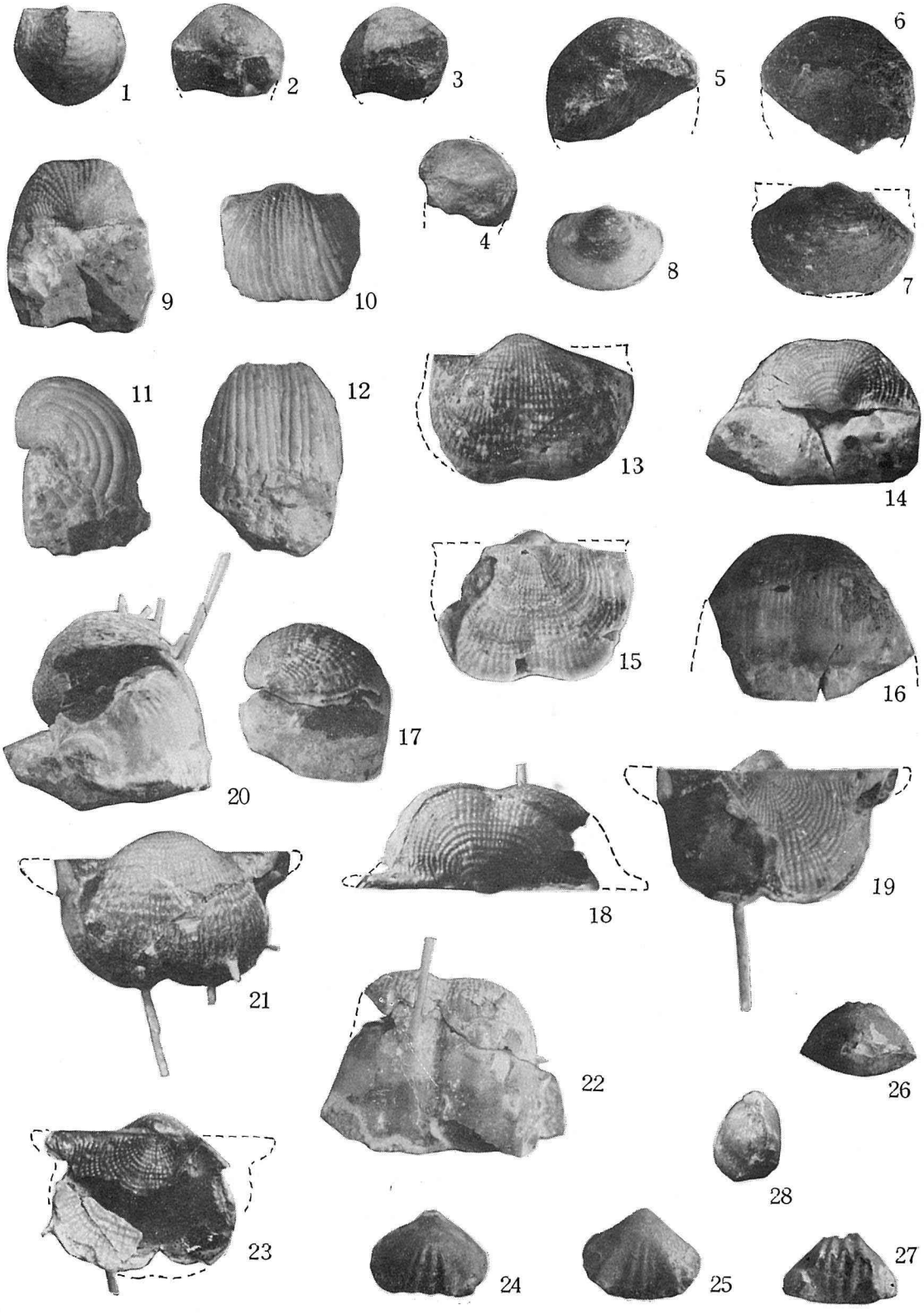
Explanation of Plate 15

(all natural size)

Figs. 1- 4. *Plicatifera minor* (SCHELLWIEN), ventral, apical, frontal and lateral views.
Figs. 5- 7. *Plicatifera minor* (SCHELLWIEN), apical, frontal and ventral views.
Fig. 8. *Plicatifera minor* (SCHELLWIEN), ventral view.
Figs. 9-12. *Dictyoclostus gratiosus* (WAAGEN). apical, ventral, lateral and frontal views.
Figs.13-17. *Dictyoclostus semireticularis* (MARTIN), ventral, apical, dorsal, frontal and lateral views. fig. 17 shows strong geniculation of the dorsal, valve.
Figs.18-23. *Distyoclostus spiralis* (WAAGEN), 18. apical, 20 lateral, 21 ventral, 22 frontal and 23 dorsal views, fig. 19 shows remakable surface ornamentation of the external mould of the dorsal valve with frontal part of the ventral valve.
Figs.24-28. *Stenoscisma "purdoni"* (DAVIDSON). dorsal, ventral, apical, frontal and lateral views of rahter small specimen.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Explanation of Plate 16

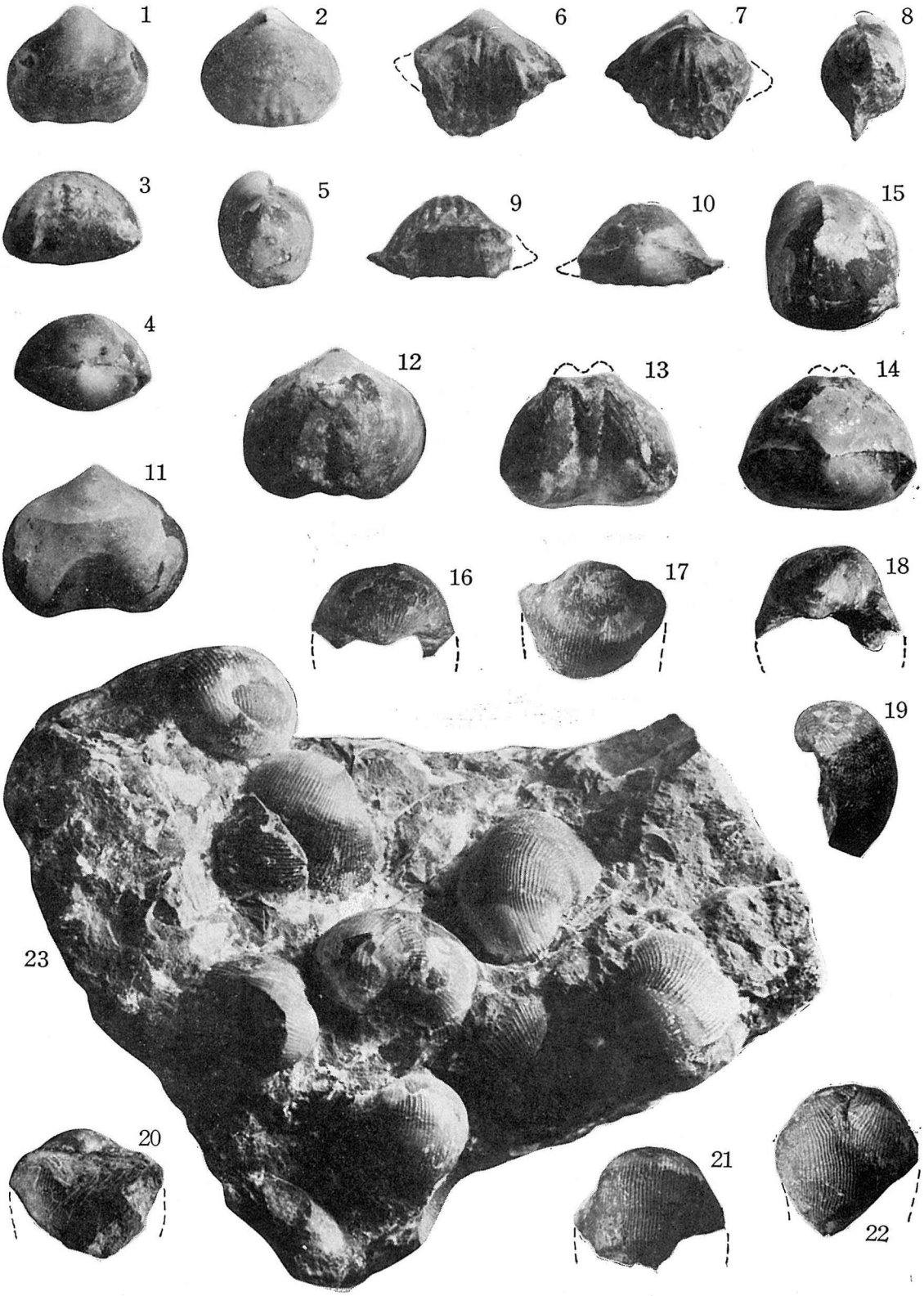
(all in natural size)

Figs. 1- 5. *Stenoscisma "purdoni"* DAVIDSON.
ventral, dorsal, frontal, spical and lateral views of rather alrge specimen.

Figs. 6-10. *Stenoscisma "purdani"* DAVIDSON.
ventral, dorsal, lateral, frontal and apical views of rather small specimen with well preserved stolidium.

Figs.11-15. *Stenoscisma* sp.
ventral, dorsal frontal apical and lateral views.

Figs.16-23. *Linoproductus cora* (d'ORBIGNY).
fig. 23 shows occurrences of this species.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Explanation of Plate 17

(all in natural size, except figs. 28,29)

Figs. 1- 5. *Spiriferella rajah* (SALTER).
dorsal, ventral spical, lateral and frontal views.

Figs. 6- 8. *Spiriferella rajah* (SALTER).
ventral, apical and lateral views of a rather large specimen.

Figs. 9-11. *Spiriferalla rajah* (SALTER).
ventral, apical and dorsal view of one incomplete ventral valve.

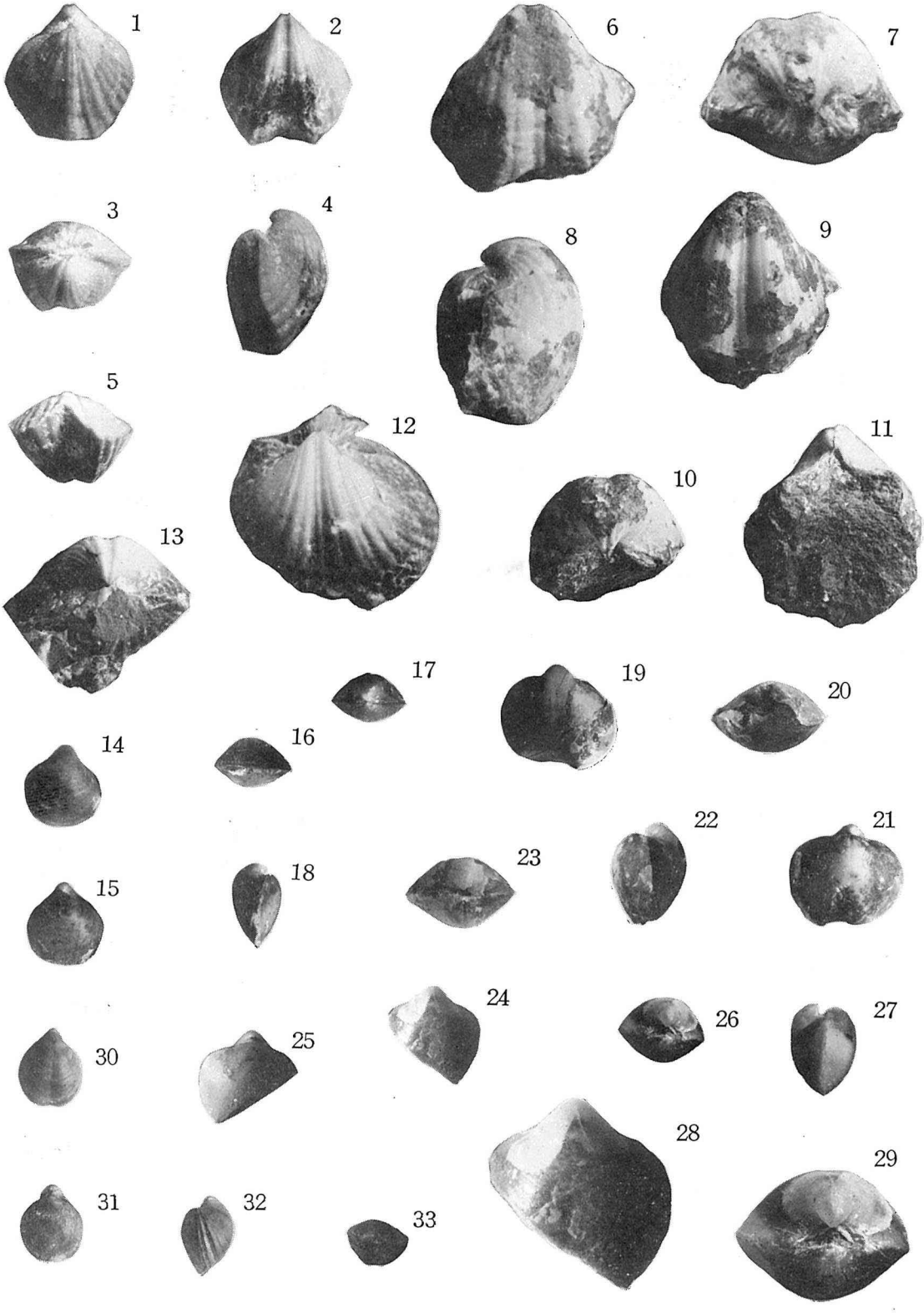
Figs.12-13. *Spiriferell a* sp.
ventral and apical views of one ventral valve with deformed dorsal valve.

Figs.14-18. *Squamularia lineata* (MARTIN)
ventral, dorsal frontal apical and lateral views of a small specimen.

Figs.19-23. *Martinia elongata* WAAGEN
ventral, frontal, dorsal, lateral and apical views

Figs.23-29. *Squamularia lineata* (MARTIN)
ventral, dorsal, apical and lateral views of a incomplete specimen. figs. 28,29 enlarged. ($\times 2$)

Figs.30-32. *Martinia* sp.
ventral, dorsal, lateral and frontal views.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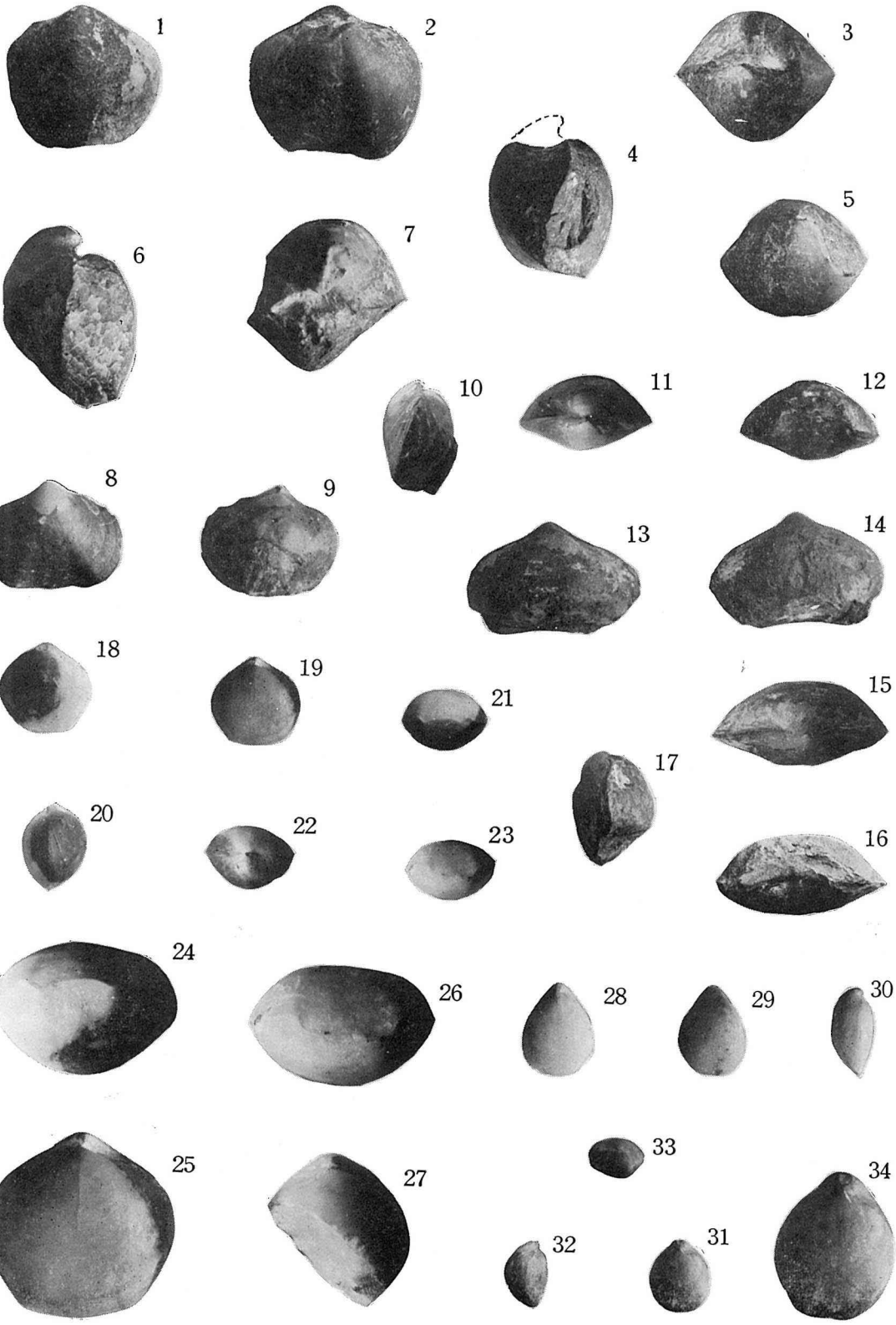
Explanation of Plate 18

(all in natural size, except figs. 24-27, 34)

Figs. 1- 5. *Martinia nucula* ROTHPLETZ
dorsal, ventral, apical, frontal and lateral views of imcomplete specimen.
Figs. 6, 7. *Martinia nucula* ROTHPLETZ
lateral and apical views of deformed specimen.
Figs. 8-12. *Athyris* cf. *semiconcava* WAAGEN
ventral, dorsal, lateral, apical, and frontal views.
Figs.13-17. *Athyris* cf. *semiconcava* WAAGEN
dorsal, ventral, apical, frontal and lateral views of slightly large but incomplete specimen.
Figs.18-21,24,25. *Spirigerella grandis* WAAGEN
ventral, dorsal, lateral, frontal and apical views. figs. 24,25, enlarged of the same.
Fig. 23. same species frontal views.
Fig. 26. same enlarged. (×2)
Fig. 27. same species, enlarged (×2),
Figs.28-30. *Dielasma elongatum* SCHLOTHEIM var. *orientalis* GRABEU
dorsal, ventral, and lateral views
Figs.31-34. *Dielasma nummulus* WAAGEN
dorsal, lateral, and frontal views.
fig. 34 is the same of fig. 31 enlarged (×2).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