DICTYOCLOSTUS DERIVED FROM THE MIDDLE PERMIAN KANOKURA SERIES AND THE LOWER PERMIAN SAKAMOTOZAWA SERIES OF THE KITAKAMI MOUNTAINS, JAPAN

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(1) Abstract.

Two species of *Dictyoclostus* from the lower Kanokura series and six from the lower Sakamotozawa series of the Kitakami Mountains are described with illustrations in this short note. The species are as follows:

A) from the lower Kanokura series

Dictyoclostus aff. *spiralis* (WAAGEN)

Dictyoclotsus sino-indicus (FRECH)

B) from the lower Sakamotozawa series.

Dictyoclostus aff. *gruenewaldti* (KROTOW)

Dictyoclostus taiyuanfuensis var. *loczyi* n. var.

Dictyoclostus cfr. *inflatiformis* var. *expansus* (GRABAU)

Dictyoclostus sp. A.

Dictyoclostus aff. sp. A

Dictyoclostus grabaui n. sp.

(2) Introduction

There are recognizable three horizons free from calcareous sediments in the Permian succession of the Kitakami district, viz., the Toyoma series, the lower Kanokura series and the lower Sakamotozawa series in descending order. All these formations are composed mainly of conglomerates, sandstones and slates, and are characterized by rich molluscan and brachiopod remains.

From the assortment of the brachiopods, the lower Kanokura series of the Kitakami district seems to be safely correlative with the lower half of the *Neoschwagerina* zone and the upper half of the *Parafusulina* zone of the limestone facies in southwestern Japan, although no kinds of foraminiferal remains except *Parafusulina matsubaishi* FUJIMOTO have been determined as co-existent in those two formations.

On the other hand, the lower division of the Sakamotozawa series may be equivalent to the *Pseudoschwagerina* zone of the southwestern Japan limestone facies from the faunal assemblage of some brachiopods and

the frequent occurrence of *Pseudoschwagerina* both from the upper and lower divisions of this series.

From the lower Kanokura series plenty of brachiopod species including *Dictyoclostus vishnu* (WAAGEN) have been known to occur prior to the present study, while from the lower Sakamotozawa series only very few, exclusive of *Dictyoclostus*, have been described up to the present.

Dictyoclostus specimens from the Kanokura series are characterized by their very thick visceral cavities and strongly inflated ventral valves. And the surfaces of them are ornamented by very coarse radial and concentric markings.

On the other, the ventral valve of those from the Sakamotozawa series are depressed or moderately convex. Surface ornaments are finer than those of the former except *Dictyoclostus* aff. *inflatiformis* var. *expansus* (GRABAU) and the visceral cavities between two valves are usually very thin.

The Kanokuran *Dictyoclostus* now described are divided into two groups.

A) The visceral disk of the dorsal valve very transverse and strongly geniculate at its anterior margin. The surface of the visceral disk ornamented by coarse radial costae and concentric ribs. Visceral cavity thick. Ventral valve strongly but naturally inflate.

Dictyoclostus aff. *spiralis* (WAAGEN)

B) The visceral disk of the dorsal valve trapezoid or triangular in shape and strongly geniculate to form considerably long trail. Radial costae coarse. Ventral valve loosely spirally enrolled.

Dictyoclostus sino-indicus (FRECH)

On the other hand, the Sakamotozawan species are classified as follows mainly by the curvature and the ornament of the dorsal valve.

A) Length nearly equal to width. The visceral disk of the dorsal valve transversely subquadrate in outline, almost flat or faintly concave, moderately geniculate to form very short trail or upturned rim. Median fold vaguely noticeable. Ears very small and ambiguously divided from the visceral disk. The surface is covered by very fine costae and ribs.

Dictyoclostus sp. A
Dictyoclostus aff. sp. A.

B) Length nearly equal to width. The visceral disk of the dorsal

valve quadrate with rounded base in outline and a little concave, bluntly geniculate to form rather short trail. Median fold clearly remarkable. Ears moderately large and divided from the visceral disk. Radial costae are characteristically coarse.

Dictyocolstus aff. *inflatiformis* var. *expansus* (GRABAU)

C) Shell moderate in size. The visceral disk of the dorsal valve almost flat and at its anterior extreme strongly geniculate at right angle, forms a more or less long trail. Radial costae become rather coarse on the trail.

Dictyoclostus taiyuanfuensis var. *loczyi* n. var.

D) Shell moderate in size. The visceral disk of the dorsal valve faintly concave and bluntly geniculate to form rather long trail. Median fold begins to appear just below the beak. Ears moderately large. Radial costae flexuous and fine at all growth-stages.

Dictyoclostus aff. *gruenewaldti* (KROTOW)

Although the dorsal valve of *Dictyoclostus grabaui* n. sp. is unknown, the species may belong to the 3rd group.

(3) Acknowledgements

Before going into description, the writer wishes to express his hearty thanks to Professor MASAO MINATO for his kind guidance in the course of the present study.

Thanks are also due to Messrs. H. TAKEDA and M. HARADA who collected plenty of materials with the writer himself and offered them for his study.

For making the photographs for the plates the writer is greatly indebted to Mr. SUMIO KUMANO.

Description of species

Genus *Dictyoclostus* MUIR-WOOD, 1930

Dictyoclostus aff. *spiralis* (WAAGEN)

Pl. 1, Figs. 1–2; Pl. II, Figs. 1a–c.

Reg. nos.: 12378, 13555, 13556.

Materials: Three specimens are available for study. Two of them

are preserved as the external and internal mould of both valves, while the other is represented only by the considerably deformed external mould of dorsal valve.

Description: All the shells which have been collected are considerably large in size, and trapezoid in outline. Hinge-line is straight and occupies the greatest width of the shell. Visceral cavity is very thick.

Ventral valve is strongly and uniformly inflated in longitudinal direction and more or less gently convex in transverse direction.

In the latter direction it becomes somewhat flattish in the middle because of the occurrence of a longitudinal median sinus, and both lateral flanks are moderately sloped down to lateral margins. The umbo is rounded and strongly incurved, the apex is projecting for some distance beyond the hinge. Ears must be very prominent and largely convex although they do not show distinctly tube-like shape. They are separated from the visceral disk by a shallow depression. Median sinus is broad and very shallow.

Surface ornamentation is very poorly observable because of the ill state of preservation.

The radial costae are fairly coarse and rounded; they increase in width very gradually towards the anterior margin. Especially finer and lower costae compared with the rest are to be found on the surface of the sinus. Increase in the number of costae is not seen anywhere in the materials. The sulci between two costae are always nearly equal in width throughout their growth-stages. Concentric ribs develop as strongly as the radial costae on the umbonal region. But they become weak in strength as the shell gets older. Hollows left by spines are frequently noticed on the entire surface of the shell, especially on the apical region they are more or less numerous comparing those on the other regions, besides, along the hinge one series of regularly arranged hollows are perceived.

The interior of the ventral valve shows one pair of dendritic adductor muscle-scars and large flabellate diductor muscle-scars which are much elongated.

The visceral disk of the dorsal valve is very transverse in outline gently concave in both directions, and geniculation occurs at its anterior extension, to form a nearly straight trail, which is as long as or a little longer than the visceral disk and is almost in contact with the trail of the ventral valve. Ears are narrow and very prominent, and can be ambiguously differentiated from the visceral disk by the low rounded fold. A very low and broad median fold begins to appear at some distance from

the beak and entirely flattens out half-way down the trail.

The ornamentation of the dorsal valve is almost the same as that of the ventral valve. The concentric ribs develop only on the visceral disk and beyond the geniculation they seem to disappear. The hollows which were filled up originally by spines are fewer than those of the ventral valve.

The interior of the dorsal valve can be rather well observed. At first a median septum which becomes thick at its anterior terminal is observed. A pair of elongately trigonal dendritic adductor muscle-scars are closely placed at both sides of the posterior of the median septum and two oval impressions left by the brachial ridges are situated at the antero-lateral portion of each muscle-scar. Besides, traces of cardinal and lateral ridges are slightly preserved as furrows.

Remarks: *Productus spiralis* originally described by WAAGEN in 1883 from the lower *Productus* limestone of Salt-range, India, is referable to the specimens now being considered in the general outline and the curvature of the dorsal valve, but the vertical profile of the ventral valve in the Indian form is quite different from that of the Japanese one.

The specimen figured by DINNER as *Productus spiralis* on his plate VI, Fig. 2 from the Himalaya is safely concluded to differ specifically from the shells figured by WAAGEN by its vertical curvature of the ventral valve. The ventral valve of the Himalaya reminds the writer of that of the Japanese species in the vertical convexity. But, the sinus found in the ventral valve of the former is more distinct than that of the latter and the sulci between the radial striae of the Himalayan form are narrower than those of the latter. Then these two forms are considered not to be identical with each other.

As above-mentioned, although the Japanese specimen now dealt with is similar to both Indian and Himalayan specimens in each feature, it does not perfectly agree with them. But the materials are too poor in preservation to propose a new specific name for them. The writer now decides to describe them as an affinity of *Dictyoclostus spiralis* (WAAGEN).

Hor.: Lower Kanokura series.

Loc.: Imo, Yahagi machi, Rikuzentakada city, Iwate Pref.

Coll.: K. NAKAMURA.

Dictyoclostus sino-indicus (FRECH)

Pl. II, Figs. 2–4; Pl. III, Figs. 1a–f.

1911. *Productus sino-indicus*, FRECH: RICHTHOFEN's China V, p. 162, Taf. 22, Fig. 1a–b, cet. excl.

Reg. nos.: 12602, 13553, 13554.

Materials: Three specimens, one of which is obtained in almost complete state of preservation. The remaining two are represented only by the crushed ventral valve.

Description: Shell characterized by its extremely large size and very strongly elevated visceral part. Hinge-line shows the greatest width. Visceral cavity is considerably thick.

Ventral valve cylindrical in form and very strongly inflated in both longitudinal and transverse directions. It becomes flattish vertically in the middle, while in the early and mature stages it is incurved more or less strongly. Beak large and rounded, and strongly enrolled to develop much over the hinge. Median sinus narrow but conspicuous, it begins to appear at a little distance below the beak. Ears are clearly separated from the posterior extension of the lateral flanks by a sharp geniculation, they are moderate in size and very much convex.

The entire surface of the ventral valve is covered by rather coarse but regular radial costae on which the marks of erect spines are sometimes found, besides, only on the umbonal region concentric ribs are to be seen, where the surface of the shell shows a reticulate appearance. The costae in the sinus are finer and lower than those found on the two rounded shoulders. Increase in number of the costae is little observed.

The interior of the ventral valve is rather clearly shown in the present materials. The large longitudinal striated diductors and the narrow dendritic adductors which are much elongated are almost completely seen on the interior surface of the mould of the ventral valve.

Dorsal valve is very characteristic in shape. The visceral disk of it is of inverse triangle shape with roundness in outline and slightly concave. At its anterior terminal it abruptly bends at a right angle, from where it is continued to a long trail which follows the contour of that of the ventral valve. A median fold present but somewhat weak in this specimens.

The ornamentation is almost identical with that of the ventral valve.

Dorsal interior is rarely seen and shows a trified cardinal process, which may be continued anteriorly as a median septum although a median septum is not observed because it is covered by the partly preserved dorsal cast. The adductor muscle-scars are dendritic and elongated. The brachial impressions are given off at the antero-lateral extremity of the adductor-scars.

Remarks: FRECH in 1911 figured two distinct species from Salt-range, India, and Nanking Hill, South China under the same name of

"*Productus sino-indicus* sp. nov." Of these, the Chinese shell seems to be conspecific with the Japanese species, while the other is considered to be distinguished from the Chinese and Japanese forms by its vertical profile of the ventral valve. Moreover, the dorsal valve of the Indian form is easily distinguished from that of Japanese one by its different shape. The specimens from the Nanking Hill and the Kitakami Mountains are characterized by having the ventral valve which is flattish vertically in the middle portion and the anterior and posterior are strongly incurved.

On basis of the above-described descriptions, the specimens figured in 1883 by WAAGEN as *Productus spiralis* resemble both Chinese and Japanese shells, but the former is ornamented by coarse and irregular radial costae, some of which intend to disappear in the sinus. But, the radial costae of the latter two are finer than those of the former and develop towards the anterior in parallel with each other. Furthermore, WAAGEN's *spiralis* possesses a very transverse dorsal valve, which is greatly different from that of the Japanese species in the view-point of shell outline.

Hor.: Lower Kanokura series.
Loc.: Imo, Yahagi machi, Rikuzentakada city, Iwate Pref.
Coll.: K. NAKAMURA.

Dictyoclostus aff. *gruenewaldti* (KROTOW)

Pl. IV, Figs. 1a–e.

Reg. no.: 12377.

Material: Only one specimen which is preserved as imperfect external and internal moulds of both valves is available for study.

Description: Shell medium or large in size. Hinge-line shows the greatest width of the shell. The visceral cavity more or less thin.

Ventral valve is very poorly preserved, since almost all of it had been broken off and was never found. The visceral disk is long and slightly depressed, and is separated from the rather short trail by a rounded geniculation. The trail is more highly convex than the visceral disk. A shallow sinus develops anteriorly at about 10 mm. from the umbo and is extending without increase of depth and width.

The radial costae are developed finely and weakly on the surface of the visceral disk and increase only very slightly in width on the trail. They are counted to the number of about 13 in 10 mm. at distance of 10 mm. below the umbo. They increase in number in the anterior region sometimes by means of bifurcation. The sulci separating the costae are rather shallow and rounded, nearly equal to the costae in width. Con-

centric ribs are developed only on the visceral disk, while on the trail they seem to be untraceable. The ribs increase in width as they approach to the frontal margin and are counted about 14–15 in 10 mm. in the anterior part of the visceral disk. The radial costae and the concentric ribs are mutually crossed to show a reticulate appearance on the visceral disk.

Traces of spines are scattered all over the surface, but especially on the trail they are seen to be more in number and coarser than those on the other parts. They constantly stand on the top of each radial costa. In the interior of the ventral valve no remarkable features are preserved at all.

The visceral disk of the dorsal valve is slightly concave, and possesses a flat portion along the cardinal slopes. Ears become tapering towards the cardinal extremity. The concavity of the shell increases anteriorly. A rounded geniculation is developed at the anterior extension of the visceral disk to form a rather short trail, and decreases in strength towards the cardinal margin. The trail is in contact with that of the ventral valve only at the anterior end and the lateral margins of the shell. An angular median fold corresponding to the sinus of the ventral valve begins to appear at a short distance from the umbo and is continuous to the anterior margin.

The ornamentation is similar to that of the ventral valve, but the sulci are considerably narrower than the costae. Ears are covered neither by concentric ribs nor radial costae but never smooth owing to the presence of some flexuous undulations.

In the interior of the dorsal valve there is a long but narrow median septum, and shallow grooves which increase their depth and slightly enlarge at their extremity are to be found. On both sides of the posterior end of the septum, a pair of adductor muscle-scars is vaguely traceable. Many minute holes marked by spines are arranged on the internal surface without regularity. No traces of brachial ridges are observed.

Remarks: The present species from the lower Sakamotozawa series of the Kitakami Mountains bears superficial resemblance to the *Dictyoclostus gruenewaldti* (KROTOW) figured by CHAO in 1927 in respect to its general outline and the fine striae developed on the shell surface. The striae hardly increase in width towards the anterior. The former species is distinguished from the latter by the more sharply geniculated dorsal valve and its considerable size. Also the present species is quite allied to *Dictyoclostus taiyuanfuensis* and its variety, *Dictyoclostus taiyuanfuensis loczyi* n. var., but the latter two are distinguishable from the former by its more concavity of the visceral disk of the dorsal valve, and the coarser

as well as stronger costae found on the trail than those of the former one species.

Now, the writer wishes to describe the species under consideration as an affinity of *Dictyoclostus gruenewaldti* (KROTOW), since the specimen is too ill preserved to justify giving a new distinct name for it. Further, it is somewhat different from *Dictyoclostus gruenewaldti* (KROTOW) in having a slightly more strongly geniculated dorsal valve but not as much as *Dictyoclostus taiyuanfuensis* at the anterior extension of visceral disk in each dorsal valve.

Hor.: Lower Sakamotozawa series.

Loc.: Nakadaira, Yahagi machi, Rikuzentakada city, Iwate Pref.

Coll.: H. TAKEDA, K. NAKAMURA and M. HARADA.

Dictyoclostus taiyuanfuensis var. *loczyi* n. var.

Pl. IV, Figs. 2–3.

1899. *Productus semireticulatus* (MARTIN) LOCZY. Wiss. Ergeben. der Reise des Grafen B. Szechenyi in Ostasien III, p. 59, pl. 1, figs. 28–30.

Reg. nos.: 12378, 13074, 12599.

Materials: Two specimens are available for study; one of them is preserved as the external moulds of both valves, but from the ventral just a part of the surface ornamentation can be imperfectly observed. The other is preserved as the external mould of dorsal valve and somewhat crushed "steinkern".

Description: Shell medium or large in size. Visceral cavity seems to be rather thin.

Ventral valve is not fully available for study because only a part of it is obtained as the crushed external and internal moulds of this valve. On the trail of the material a large erect spine is traceable as a hole on the top of one costa.

The visceral disk of the dorsal valve is nearly flat with some unevenness and is geniculated at its anterior extension to form a long trail which is in close contact with that of the ventral valve. The ears are clearly divided from the visceral disk by a rounded fold situated between them at an angle of 30° with hinge; they are rather large and gradually become tapered towards the cardinal extremities. Hinge-line nearly straight, occupies the widest point of the shell. The umbonal region is a little excavated and tapers to an acute extremity. The median fold which probably corresponds to the median sinus of the opposite valve starts from a distance of about 10 mm. from umbo. On the visceral disk

it is only fairly observable, but beyond the geniculation it becomes remarkably traceable as a deep groove on the external mould of dorsal valve. Both sides of lateral flanks fall away very steeply towards the respective lateral margins. The radial costae rather fine on the visceral disk, but increase slightly in width and show somewhat irregular in the interval between each pair of costae. Increase in the number of costae never occurs; sometimes two posterior costae can be observed gradually to converge towards the anterior to coalesce into a new coarser one. Accordingly the width of the costae increases gradually towards the anterior especially beyond the geniculation. Concentric ribs develop only on the visceral disk especially in early stage and they may show reticulate appearance, on the other hand, on the trail no concentric markings are traceable. The interval of each rib increases in width as the shell gets older. The surface of the ears not clearly observed owing to bad state of preservation of this materials. From them, however, it is presumed that no concentric and radial sculptures were originally present. Costae are counted about 10 in 10 mm. at distance of 20 mm. from the umbo and 6 in the same space on the trail, while the concentric ribs number about 14 on the center of the visceral disk. Spinose ornamentation is not seen at all.

The internal mould of the ventral valve does not show any characteristic appearance for this species. The internal mould of the dorsal valve shows lateral ridges extending along the hinge. The long median septum increases in hight towards the anterior end is continued from a rather low cardinal process. The adductor muscle-scars and the brachial impressions are hardly observed. Many minute spines are developed on the internal surface of the dorsal valve with somewhat regularity.

Remarks: The specimens which had been described and figured by LOCZY as *Productus semireticulatus* (MARTIN) were lately made conspecific with *Productus gruenewaldti* KROTOW by CHAO, OZAKI and others. However, the present writer believes that they made a great mistake, namely that *Productus semireticulatus* LOCZY is not at all conspecific with *Productus semireticulatus* (MARTIN). There is no more need to discuss the matter; further ROCZY's species is not assignable into *Productus gruenewaldti* KROTOW.

Unfortunately, the writer can not see the two description and figure of the type specimen of *Dictyoclostus gruenewaldti* (KROTOW), but according to IVANOV and OZAKI who had a chance to see the figure and the description of the original example by KROTOW, the dorsal valve of that specimen was gently concave or less sharply geniculate as CHAO stated in the remarks on the description of his *D. gruenewaldti*, too. Following

such definitions of *D. gruenewaldti* (KROTOW), not only LOCZY's *Productus semireticulatus* but CHAO's in his plate VIII, figs. 14 and 15 must not be made conspecific with *D. gruenewaldti* (KROTOW). Moreover, the radial costae of the species by LOCZY fairly increase in coarseness as shell grows older; on the contrary, those of *D. gruenewaldti* (CHAO) little change their width throughout life. This is also a distinguishing character between these two species.

Now, the specimens from the Kitakami Mountains are quite similar to *Prod. semireticulatus* described by ROCZY from southern China; these two Chinese and Japanese forms are most like to *Prod. taiyuanfuensis* (GRABAU) CHAO in respect to surface ornamentation, the concavity of the dorsal valve and other minor structures. But as the former two are more or less larger than the latter which is constantly small to medium in size, the writer wishes to separate them from *D. taiyuanfuensis* (GRABAU) CHAO as a variety.

Hor.: Lower Sakamotozawa series.
Loc.: Nakadaira, Yahagi machi, Rikuzentakada city, Iwate Pref.
Coll.: H. TAKEDA, K. NAKAMURA and M. HARADA.

Dictyoclostus cfr. *inflatiformis* var. *expansus* (GRABAU)
Pl. V, Fig. 3.

Reg. no.: 13071.
Material: External moulds of both ventral and dorsal valves, while "steinkern" is missing.
Description: Shell is medium in size. Hinge-line is nearly straight and a little shorter than the greatest width of the shell. The visceral cavity between the two valves is very thin.

The posterior portion of the ventral valve is gently convex for about 15 mm. from the umbo. Then the ventral valve becomes somewhat flattish or slightly depressed owing to deformation and at the most frontal region it shows moderate convexity again. A shallow but distinct sinus is developed at a distance below the beak and increases slightly in depth and width as the shell becomes older. In early growth-stage the width of the shell except ears is largely in excess of the length, but the relative length to the width gradually increases towards the anterior. The flanks more or less steeply decline to each side. The ears are moderate, trigonal and flat with bluntly pointed cardinal extremities, and each is separated from the abruptly rising visceral disk by a deep sulcus.

In the early stage the costae are weakly developed on the visceral

disk except for the ears, while the ribs are more or less strongly sculptured on the shell surface including the ears. Increase in the number of costae never occurs but increase in both their strength and coarseness is to be found considerablly. The ribs are almost non-apparent on the trail. The costae suddenly become very coarse on the trail but never prominent. They are constantly rounded and are separated by narrow sulci. The costae are very coarse and are to be counted, on an average, about 3 to 4 in 10 mm. at the anterior margin of the visceral disk. Besides, very fine striae are sometimes perceived. The traces of spines are not observed on the visceral disk and the trail; only the right ear shows about ten of those spines in this example. Besides, along the cardinal margins of the ears, a few marks left by cardinal spines seem to be developed.

The dorsal valve is more perfectly preserved than the opposite one. The curvature of this valve is entirely the same as that of the ventral valve. The visceral disk is nearly flat with a median fold corresponding to the sinus of the ventral valve. A rounded geniculation which separates the visceral disk from the curved trail occurs at the border of reticulate ornament. Narrow lateral and antero-lateral shell expansions are fairly observed in this valve.

The ornamentation is quite similar to that of the ventral valve.

Internal characters entirely unknown.

Remarks: The present species is similar to *Productus inflatiformis* var. *expansus* having been described and illustrated from Yunnan of south China by GRABAU in 1936 in that it showing the lateral expanding feature of the shell, although in the Japanese form it is a little preserved; also they possess very coarse costae abruptly developed in width on the anterior of shell surface. But the former easily distinguished from the latter by absence or more faint appearance of the sinus.

According to GRABAU (1936), his Yunnan shell can be compared with *Productus inflatiformis* described by himself, from the Fengninian formation of China, and also with the specimen from the Kankarin limestone of Sinkiang, which is, according to his remarks, essentially of the age of the Maping limestone and the Uralian of Russia.

Now, comparing the writer's shell on the basis of the remarks offered by GRABAU, the specimen from the Kankarin limestone seems to be most closely allied to his species by its distinct sinus, showing the expanding feature of the shell and developing very coarse costae on the surface. But unfortunately the writer has had opportunity for seeing neither the specimen itself nor the figure of it.

Hor.: Lower Sakamotozawa series.

Loc.: Nakadaira, Yahagi machi, Rikuzentakada city, Iwate Pref.
Coll.: H. TAKEDA, K. NAKAMURA and M. HARADA.

Dictyoclostus sp. A.
Pl. V, Figs. 4–5.

Reg. nos.: 12597, 12598.

Materials: Two specimens, one of which probably represents the young form of the other. Both specimens are composed only of the external moulds of dorsal valve.

Description: Shell is medium in size. Hinge-line is nearly straight and a little shorter than the greatest width of the shell, which is situated at about two-fifths the distance of the whole length from the umbo.

Ventral valve is unobtainable.

Dorsal valve is trapezoid with roundness in outline. The visceral disk of this valve is almost flat except the umbonal region which is moderately excavated, and is roundly geniculated at its anterior extremity, from where a remarkably short trail or upturned rim begins to grow. The ears are evenly flat, and each is ambiguously divided from the visceral disk by a shallow and broad sulcus. A very low longitudinal median fold probably corresponding to the sinus in the opposite valve is to be seen only from the point of geniculation.

The surface of the shell is covered with radial costae, concentric ribs and a few spines. The costae are very fine and low in early stage, but increase in width toward the anterior to become a little coarse and prominent. Besides, as it gets older, costae seem to show considerable irregularity in width as well as in hight and in arrangement. Increase in number of the costae on the visceral disk occurs only as a result of bifurcation of the originally found costae. The sulci between the costae are nearly equal to the costae themselves both in width and in depth. They are counted about 17 in number in a space of 10 mm. at a distance of 20 mm. from the umbo. The concentric ribs are to be seen mainly on the visceral disk and the ears. The surface of the visceral disk shows reticulate feature. The latter sculptures are very numerous and nearly equal to the costae in prominence on the visceral disk, while on the rim they are hardly observed. On the ears, radial costae are more weakly developed than the ribs. The ribs are counted about 16 in 10 mm. at a distance of 20 mm. vertically below the umbo. Holes left by spines are not traceable on the surface of the visceral disk but are sparsely noticed on the surface of the rim.

Remarks: The species now under discussion is distinguished from other allied species of *Dictyoclostus* by having the dorsal valve covered by very fine, flexuous radii as well as the concentric ribs and by the considerably short upturned rim. Also it is characterized by the peculiar form of the visceral disk of the dorsal valve, which is ambiguously divided from the ears.

As far as the writer recalls, the specimen described and figured by PAECKELMANN in 1931 as *Productus* sp. nov. aff. *pinguis* MUIR-WOOD from the Ober Kohlenkalk is most like to the present species among the *Dictyoclostus* spp. already described by the previous writers.

PAECKELMANN's species was distinguished from *Dictyoclostus pinguis* (MUIR-WOOD) by having a dorsal valve which was longer than that of the latter and covered by finer radial costae than those of MUIR-WOOD's species. The specimen from the Kitakami Mountains are also distinguishable from *Dictyoclostus pinguis* (MUIR-WOOD) in the same respects.

Moreover, the present species is distinguished from *Productus* sp. nov. aff. *pinguis* (MUIR-WOOD) of PAECKELMANN by the differences of their outlines and ornaments. The latter shows ¾ circular in outline and is covered by entirely regular radial costae, while the Japanese form is transversely subquadrate in outline and ornamented by somewhat irregular radial costae.

Besides, the following mentioned two American and Himalayan species, *Productus arkansanus* var. *multiliratus* GIRTY, and *Prod.* sp. indet. by DINNER remind the writer of the present species in respect to the general outline and the curvature of the dorsal valve. But in the early growth-stage the dorsal surface of the former two are covered by the discontinuous costae instead of the continuous costae of the Japanese form. Furthermore, in the American and Himalayan species, the median fold is not traceable; on the other hand, in the Japanese one, a trace of a median fold is found.

Although the species under discussion is not specifically assignable into any other previously described species, the material is not in sufficiently good preservation to propose a new specific name for it.

Hor.: Lower Sakamotozawa series.

Loc.: Nakadaira, Yahagi machi, Rikuzentakada city, Iwate Pref.

Coll.: K. NAKAMURA.

Dictyoclostus aff. sp. A

Pl. V, Fig. 6.

Reg. no.: 13072.

Material: An external mould of the dorsal valve.

The present species is distinct from the preceedings by having a little smaller shell and by the ears of the former being larger than those of the latter.

Furthermore, the radial costae are developed more regularly and are little more coarse than those of the *Dictyoclostus* sp. A, and the visceral disk of the dorsal valve is more strongly geniculate at its anterior margin than that in the case of the former.

Hor.: Lower Sakamotozawa series.

Loc.: Nakadaira, Yahagi machi, Rikuzentakada city, Iwate Pref.

Coll.: H. TAKEDA, K. NAKAMURA and M. HARADA.

Dictyoclostus grabaui n. sp.

Pl. V, Figs. 1–2.

1936. *Productus gruenewaldti* (KROTOW) GRABAU. Early Permian Fossils of China, Pt. II. Fauna of the Maping Limestone of Kwangsi and Kueichow. Palaeont. Sinica ser. B, vol. VIII, fasc. 4, p. 103, pl. VI, fig. 2.

Reg. nos.: 12379, 12600.

Materials: Two specimens; one of which is preserved as the external mould of ventral valve, and the other is represented by the external and internal moulds of ventral valve.

Description: Shell above medium in size, trapezoid in outline. Hinge-line shows the greatest width of the shell.

Ventral valve is moderate in curvature; a rounded geniculation occurs when the shell gets of considerable size. Visceral part is somewhat depressed. Beak is somewhat prominent and develops slightly over the hinge. Ears are moderate and each is divided from the visceral disk by a deep sulcus. Median sinus begins to appear from about 5 or 10 mm. distance from the apex; it is rather deep and increases in depth towards the anterior margin.

Surface ornamentation consists of radial costae and concentric ribs. On the surface of the visceral part and the ears, both radial and concentric markings develop to show the fine reticulate appearance. Beyond the reticulated area the concentric ribs entirely disappear and the radial costae become suddenly considerably coarse. At the same time the costae get a little irregularity in width. And they often increase in number by intercalation. Some reliquae of strongly erect spines are to be found on the entire surface of the ventral valve as deep holes. Especially on the ears the holes are crowded, while on the trail part they are distributed sparsely.

The internal mould of the ventral valve does not give any character-

istic appearance for this species.

Remarks: The specimen now under consideration is quite similar to that described and figured in 1936 by GRABAU as *Productus gruenewaldti* from the Maping Limestone of Kwangsi, South China, but the median sinus of the Japanese form is more distinct than that of the Chinese one. From the view-point of the size and the surface ornament, GRABAU's specimen figured in his plate VI as well as the Japanese one must be separate specifically from the *Productus gruenewaldti* which has been already described by CHAO.

In the former two specimens, shell is large in size, and their surface is covered by a little irregular coarse radial costae; in the latter, shell medium in size and the shell surface is covered by fine, flexuous costae at all growth stages.

Although the dorsal valve is unknown to the writer, the Japanese form and the specimen of GRABAU, his plate VI, seem to be probably new to science.

Hor.: Lower Sakamotozawa series.

Loc.: Nakadaira, Yahagi machi, Rikuzentakada city, Iwate Pref.

Coll.: H. TAKEDA, K. NAKAMURA and M. HARADA.

Reference

CHAO, Y. T. (1927): Productidae of China, I. Palaeont. Sinica, ser. B, vol. 5, fasc. 2, part 1.

DINNER, C. (1913): The Anthracolithic Faunae of Kashimir, Kanaur and Spiti. Pal. Indica, N.S., vol. V, Mem. no. 2.

FRECH, F. (1911): Richthofen's China, V.

GIRTY, G. H. (1911): Fauna of the Moorefield Shale of Arkansas. U.S.G.S. Bull., 439.

GRABAU, A. W. (1936): Fauna of the Maping Limestone of Kwangsi and Kueichow. Pal. Sinica, ser. B, Vol. 8, fasc. 4.

HAYASAKA, I. (1922): Some Permian Brachiopods from the Kitakami Mountains, Japan. Japan. Jour. Geol. Geogr., vol. 2, no. 2.

IVANOV, A. P. (1935): Brachiopoda of the middle and upper Carboniferous of the Moscow Basin, part 1. Trans. Moscow Geol. Trust, fasc. 8. (in Russian).

LOCZY, L. von (1889): Wissenschaftliche Ergebnisse der Reise des Grafen Bela Szechenyi in Ostasien, Bd. III, Wien.

MINATO, M. et al. (1954): Zur Biostratigraphie der permischen Formation des Setamai-Geländes im Süd-Kitakami Gebirge. Jour. Geol. Soc. Japan, vol. 60, no. 708. (in Japanese).

——— (1959): On the Volcanic Rocks in the Japanese Palaeozoic, 3rd Report: Permian. Jour. Geol. Sci. Japan, vol. 65, no. 763. (in Japanese)

MUIR-WOOD H. M. (1928): The British Carboniferous Producti, II *Productus*; *semireticulatus* and *longispinus* groups. Mem. Geol. Surv. Great Britain, Palaeontology, vol. III, part. 1.

——— (1930): The classification of the British Carboniferous Brachiopod Subfamily Productinae. Ann. Mag. Nat. Hist., ser. 10, vol. V.

OZAKI, K. (1931): Upper Carboniferous Brachiopods from North China. Bull. Shanghai Sci. Inst., vol. 1, no. 6.

PAECKELMANN, W. (1931): Die Brachiopoden des deutschen Unterkarbons 2 Teil. Die Productinae und *Productus*-ähnlichen Chonetinae. Abh. Preu. Geol. Landes., Neue. Folge. Heft. 136–138.

SCHELLWIEN, E. (1892): Die Fauna des Karnischen Fusulinenkalk. Palaeontographica, 39.

WAAGEN, W. (1883): Salt-range fossils, Brachiopoda. Palaeont. Indica, ser. XIII.

Explanation of Plate I

Explanation of Plate I

(All figures in natural size)

Figs. 1-2. *Dictyoclostus* aff. *spiralis* (WAAGEN).

1a. External mould of dorsal valve together with the ventral external mould. Reg. no: 13556.

2a. Restoration of ventral valve.

2b. Lateral view of the same.

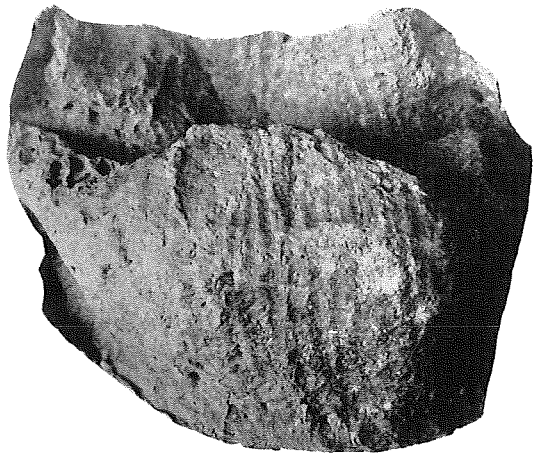
2c. Internal mould of dorsal valve.

2d. Internal mould of ventral valve.

2e. External mould of dorsal valve.

2f. Lateral view of the same.

Reg. no.: 13555.



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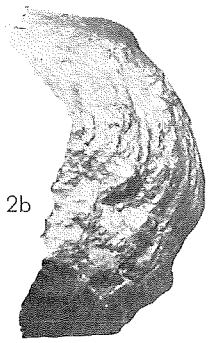

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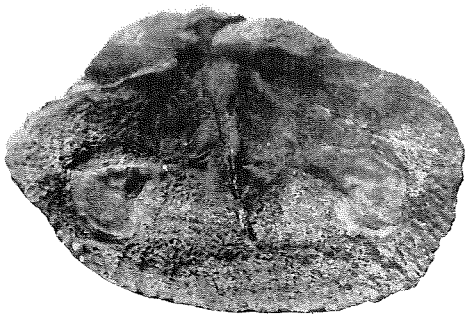

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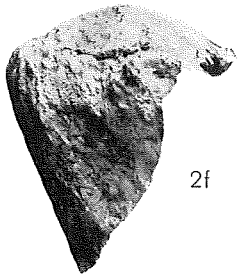

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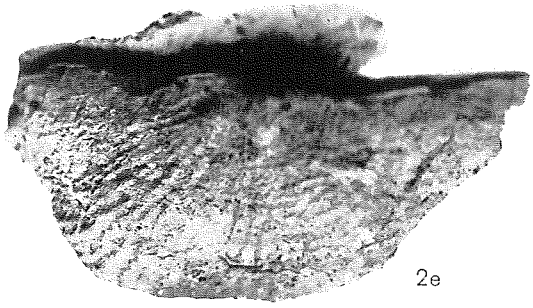

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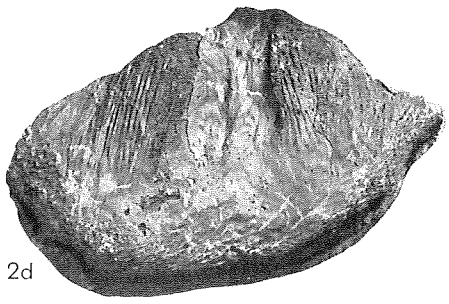


2d

K. NAKAMURA Photo.

Explanation of Plate II

Explanation of Plate II

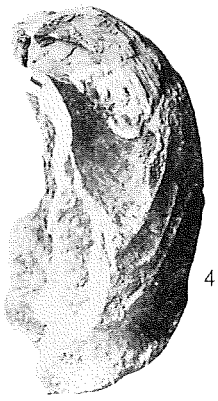
(All figures in natural size)

Figs. 1a-c. *Dictyoclostus* aff. *spiralis* (WAAGEN).
1a. Ventral view of "steinkern".
1b. Dorsal view of the same.
1c. External mould of dorsal valve together with the internal mould of the apical region in ventral valve.
Reg. no.: 12373.

Figs. 2-4. *Dictyoclostus sino-indicus* (FRECH).
2. Internal mould of ventral valve.
Reg. no.: 13554.
3. Internal mould of ventral valve.
Reg. no.: 13553.
4. Lateral view of "steinkern".
Reg. no.: 12602.

1a

2



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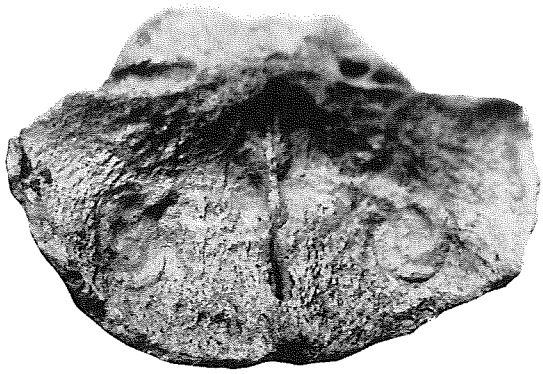

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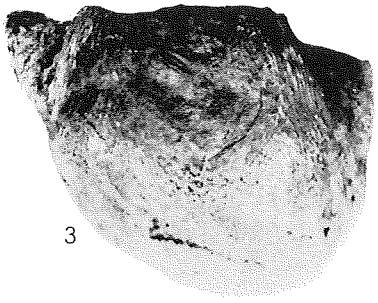

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K. NAKAMURA Photo.

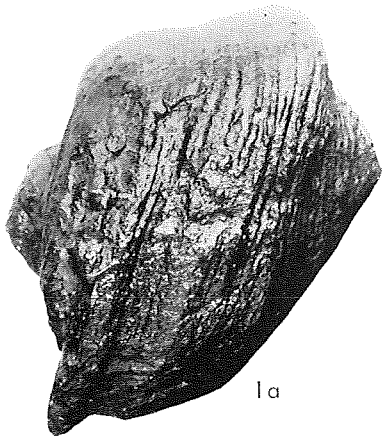
Explanation of Plate III

Explanation of Plate III

(All figures in natural size)

Figs. 1a-f. *Dictyoclostus sino-indicus* (FRECH).

1a. Restoration of ventral valve.
1b. Ventral view of "steinkern".
1c. External mould of dorsal valve.
1d. Lateral view of the same.
1e. Dorsal view of "steinkern".
1f. Lateral view of 1a.
Reg. no.: 12602.



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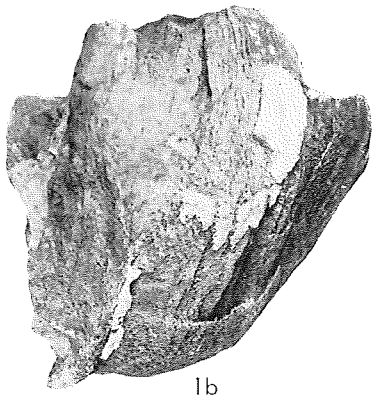

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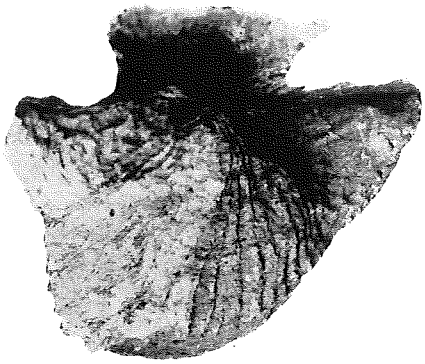

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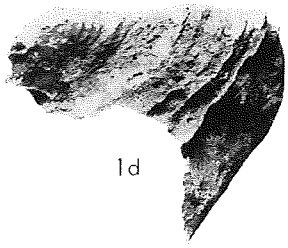

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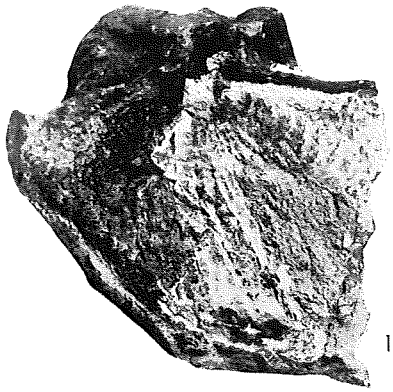

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1f

K. NAKAMURA Photo.

Explanation of Plate IV

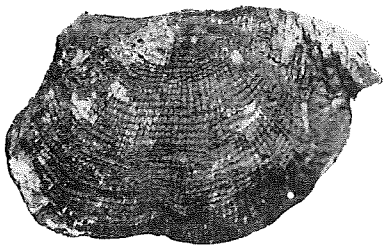
Explanation of Plate IV

(All figures in natural size)

Figs. 1a-e. *Dictyoclostus* aff. *gruenewaldti* (KROTOW).
1a. External mould of dorsal valve.
1b. Frontal view of the same.
1c. Restoration of ventral valve.
1d. Dorsal view of "steinkern".
1e. Ventral view of the same.
Reg. no.: 12377.

Figs. 2-3. *Dictyoclostus taiyuanfuensis* var. *loczyi* n. var.
2. External mould of dorsal valve.
Reg. no.: 13074.
3a. External mould of dorsal valve.
3b. Lateral view of the same.
3c. Frontal view of the same.
Reg. no.: 12378.

2



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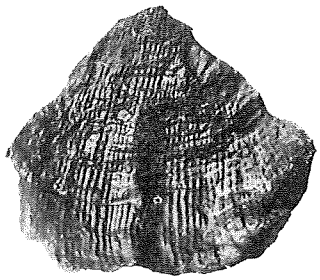

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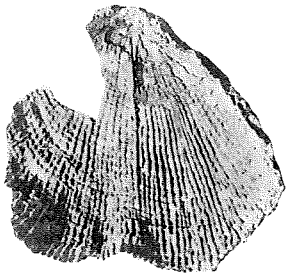

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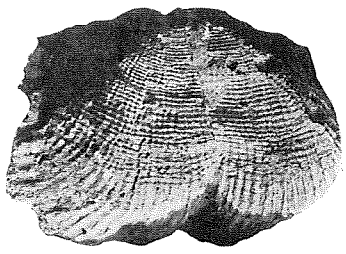

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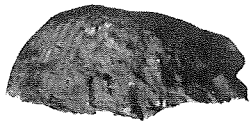

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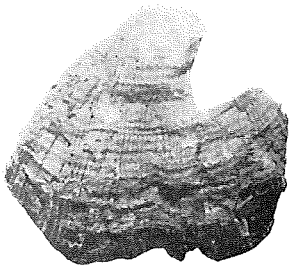

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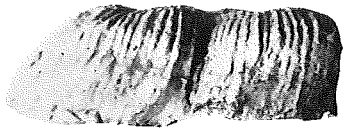


3c

K. NAKAMURA Photo.

Explanation of Plate V

Explanation of Plate V

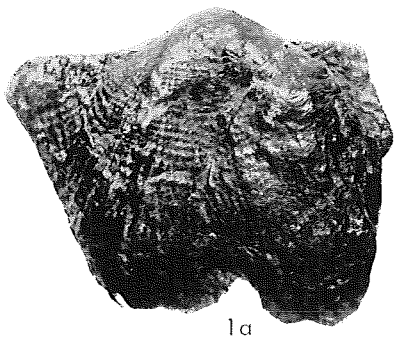
(All figures in natural size)

Figs. 1-2. *Dictyoclostus grabaui* n. sp.
1a. Restoration of ventral valve.
1b. Cardinal view of the same.
Reg. no.: 12373.
2a. Internal mould of ventral valve.
2b. Lateral view of the same.
Reg. no.: 12600.

Fig. 3. *Dictyoclostus* cfr. *inflatiformis* var. *expansus* GRABAU.
3. External mould of dorsal valve.
Reg. no.: 13071.

Figs. 4-5. *Dictyoclostus* sp. A.
4. External mould of dorsal valve.
Reg. no.: 12597.
5. External mould of dorsal valve in young specimen.
Reg. no.: 12598.

Fig. 6. *Dictyoclostus* aff. sp. A.
6. External mould of dorsal valve.
Reg. no.: 13072.



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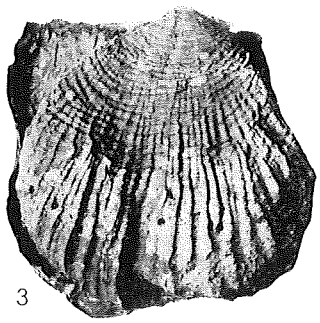

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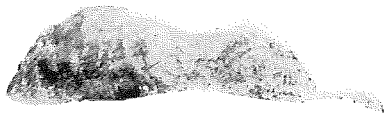

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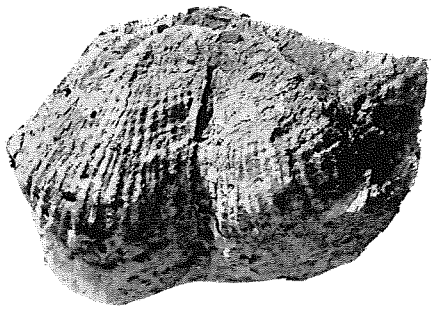
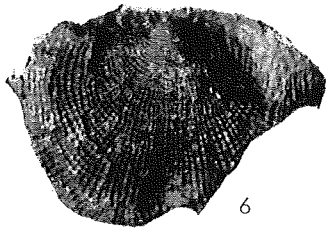


2a

2b



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5

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