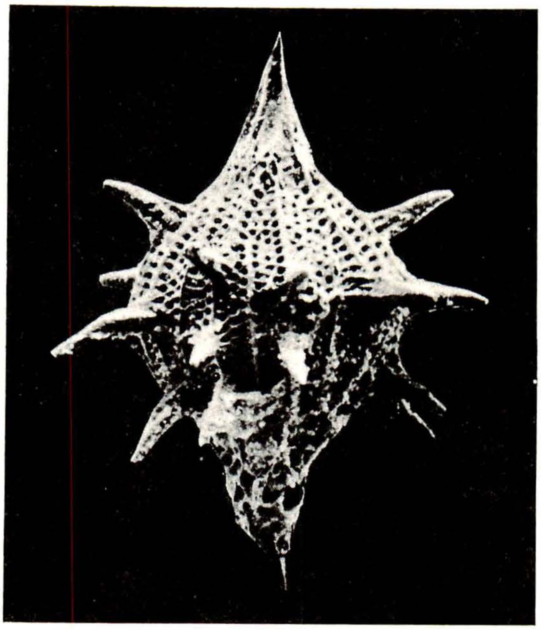
ISSN 0031-0204

日本古生物学會 報告・紀事

Transactions and Proceedings of the Palaeontological Society of Japan

New Series No. 142



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Palaeontological Society of Japan

June 30, 1986

The fossil on the cover is *Unuma* (*Spinunuma*) *echinatus* ICHIKAWA and YAO, a Middle Jurassic multisegmented radiolaria from Unuma, Gifu Prefecture, central Japan (photo by A. YAO, x 260).

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Trans. Proc. Palaeont. Soc. Japan, N.S., No. 142, pp. 341—353, pls. 65—68, June 30, 1986

811. *GINKGO TZAGAJANICA* SAMYLINA FROM THE PALAEOGENE NODA GROUP, NORTHEAST JAPAN, WITH SPECIAL REFERENCE TO ITS EXTERNAL MORPHOLOGY AND CUTICULAR FEATURES*

JUNJI HORIUCHI and TATSUAKI KIMURA

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Abstract. Many fossil *Ginkgo* leaves with well-preserved cuticles were obtained from the Lower Palaeogene Noda Group distributed in the Pacific side of Iwate Prefecture, Northeast Japan. Judging from the occurrence, external morphology and cuticular features, these fossil leaves belong to the same species and were derived from the same population. They are referable to *Ginkgo tzagajanica* originally described by Samylina from the lowermost Tertiary in the Bureja Basin.

In this paper, the detailed description of *Ginkgo tzagajanica* and its emended diagnosis were given. Variation of the external and cuticular features of these leaves were also discussed. Cuticular features of *Ginkgo tzagajanica* vary according to the portions of a lamina. This fact shows that careful observation of cuticular data is required when dealing with *Ginkgo* species by their cuticles. In addition, re-evaluation of some features, said to be diagnostic of *Ginkgo* leaves, were made based on our fossil and extant leaves.

Decrease in development of papillae on the subsidiary and ordinary cells, since the early Tertiary, is recognized among the Tertiary *Ginkgo* species hitherto known.

Introduction

Fossil *Ginkgo* leaves resembling those of the extant *G. biloba* in their external morphology have widely been known since the Middle Jurassic. Some early authors regarded them to be a single species and classified them as *Ginkgo adiantoides* (Unger) Heer (*e.g.*, Shaparenko, 1935) or *Ginkgoites adiantoides* (Unger) Seward (Seward, 1917).

Florin (1936) who studied the leaves of "*Ginkgo adiantoides*" from West Germany (Frankfurt am Main; Upper Pliocene) and Scotland (Isle of Mull; Eocene) showed that the German leaves were different from Scottish ones in cuticular features. So far as we know, at least nine species of fossil *Ginkgo* have been recognized since the early Tertiary by means of cuticular analyses (Table 1).

From the Lower Palaeogene Minato Formation of the Noda Group (Sasa, 1932), over sixty well preserved leaves and many leaf fragments of *Ginkgo* were collected and prepared for our studies. Cuticular features of our leaves vary within a leaf according to its portions. These features also vary from one leaf to another in some extent.

In the present work, variation and validity of some features formerly used for identifying *Ginkgo* species are discussed using the fossil

*Received January 29, 1985; revised manuscript received April 8, 1986; read October 3, 1981 at Hiroshima University.

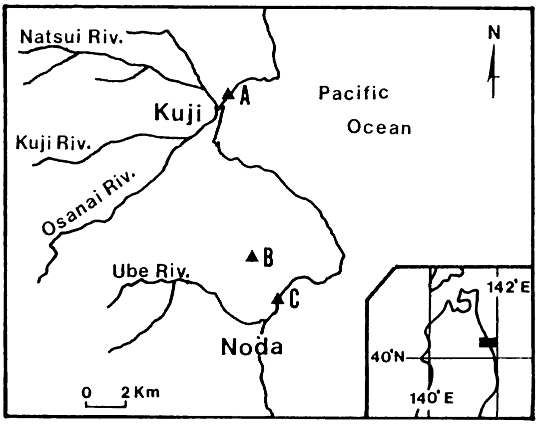
Table 1. List of Tertiary *Ginkgo* with described cuticles (*after Tralau, 1967).

G. biloba Linnaeus	Hikita, 1949 ; Pliocene, Japan
	Iwao, 1978 ; Pliocene, Japan
G. adiantoides (Unger) Heer	LaMotte, 1936 ; Miocene, U.S.A.
	Florin, 1936 ; Pliocene, West Germany
	Szafer, 1961 ; Miocene, Poland
	Jordanov et al., 1963 ; Pliocene, Burgaria*
	Lancucka-Srodoniova, 1966 ; Miocene, Poland*
	Givulescu, 1973 ; Pliocene, Romania
G. occidentalis Samylina	Samylina, 1967b ; Palaeogene, USSR
G. gardneri Florin	Florin, 1936 ; Eocene, Scotland
G. orientalis Samylina	Samylina, 1967b ; Palaeogene, USSR
	Medjulianov, 1969 ; Palaeogene, USSR
	Polyshchnuk, 1975 ; Late Eocene-Early Miocene, USSR
G. samylinae (Medjulianov) comb. nov.	Medjulianov, 1969 ; Palaeogene, USSR
G. spitsbergensis Manum	Manum, 1966 ; Palaeocene, Spitsbergen
G. wyomingensis Manum	Manum, 1966 ; Palaeocene, U.S.A.
G. tzagajanica Samylina	Samylina, 1967b ; Danian, USSR
	Krassilov, 1976 ; Danian, USSR
	This study, Lower Palaeogene, Japan

leaves from the Minato Formation and leaves of cultivated *G. biloba* from six locations of five places in Japan. Brief discussion is also made on the change in development of cuticular features of the genus *Ginkgo* and its trend since the early Tertiary.

Material

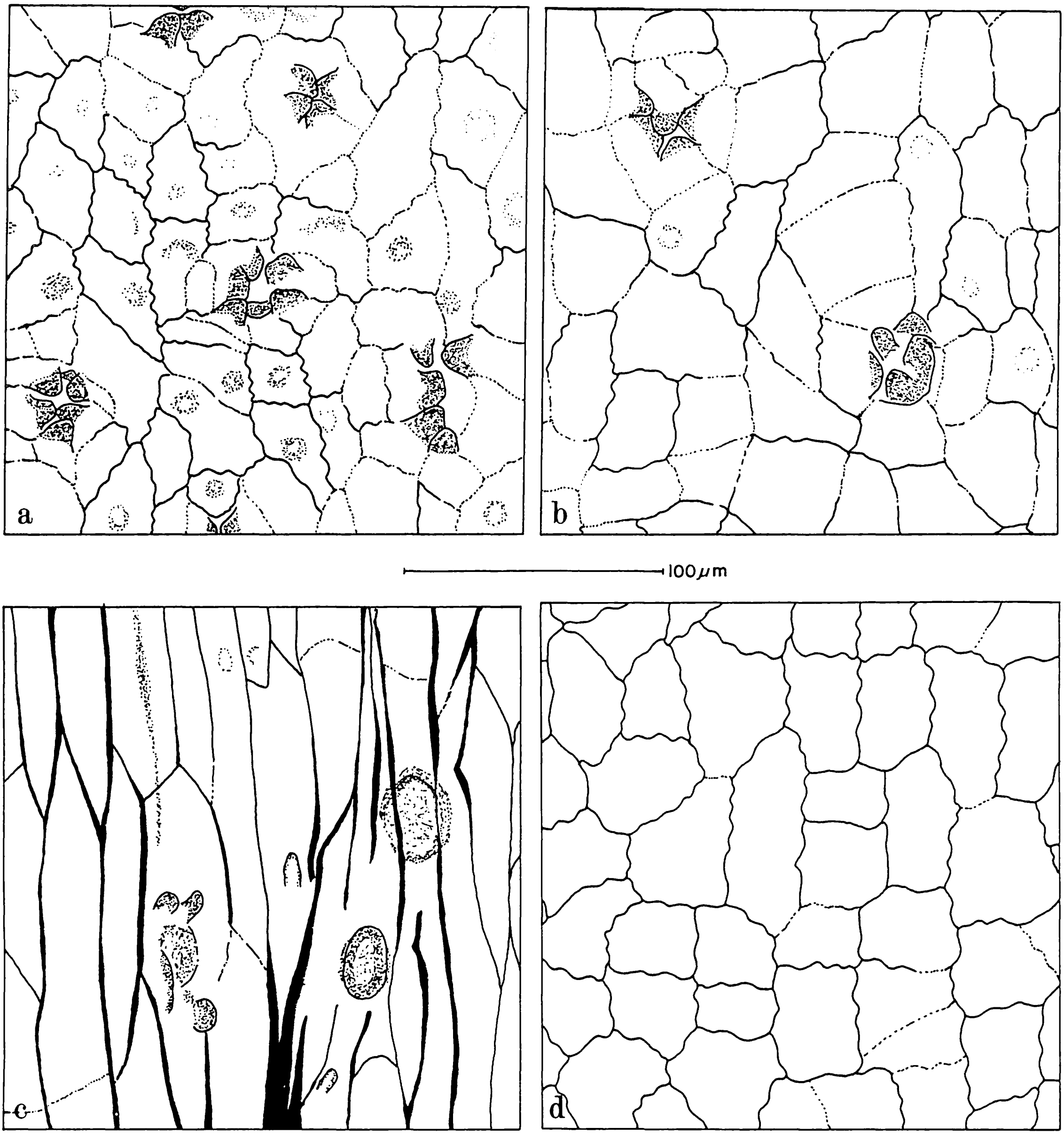
Fossil *Ginkgo* leaves from the Minato Formation were collected from three localities around Kuji City and Noda Village, Iwate Prefecture, Northeast Japan (Text-fig. 1). The Minato Formation is considered to range between Upper Palaeocene and Middle Eocene according to the palynological study by Horiuchi (MS). Materials from the localities A and B (Text-fig. 1) are excluded from this work because of their small number of specimens. From the locality C (Text-fig. 1), the *Ginkgo* leaves were collected from a



Text-fig. 1. Localities (▲ A—C) of *Ginkgo tzagajanica* Samylina in the Palaeogene Minato Formation, Kuji-area, Iwate Prefecture.

block of 3 m x 4 m and 0.2 m in thickness in a single bed. These leaves are considered to be derived from a single population. The *Ginkgo* leaves are most predominant in this bed in association with leaves and leafy twigs of such deciduous conifers as *Pseudolarix nipponica* (Kimura and Horiuchi, 1978) and *Metasequoia* sp., and dicotyledons.

Leaves of the extant *Ginkgo biloba* in Japan also treated in this study were collected from Asahikawa (Asahigawa), Hokkaido (ca. 43°50'N, 142°20'E), Kuji, Iwate Prefecture (ca. 40°10'N, 141°48'E), Tokyo (ca. 35°40'N, 138°50'E),



Text-fig. 2. Illustrations of cuticles from a single lamina (MI0735) of *Ginkgo tzagajanica* Samylina. a—b; lower cuticles of area *b* (Text-fig. 3) prepared from the distance of 1 mm, c; upper cuticle of area *c* (Text-fig. 3), d; ordinary cells of the upper cuticle, area *b* (Text-fig. 3).

Nagasaki, Nagasaki Prefecture (ca. 32°45′N, 129°50′E), and Ibusuki, Kagoshima Prefecture (ca. 31°10′N, 130°40′E) to check the differences influenced by climatic condition. In Tokyo, the extant leaves were collected from two locations in order to ascertain the variation in leaves grown under similar climatic condition. Their age and sex were not considered in this study.

All the specimens and slides described herein are kept in Department of Astronomy and Earth Sciences, Tokyo Gakugei University.

Methods

All the fossil leaves for cuticular study were picked off from tuffaceous sandstone and treated in Schulze's solution followed by KOH (ca. 10%), and mounted in glycerin jelly or canada balsam. Some of them were stained with safranin before mounting.

For the observation by scanning electron microscope (SEM), dried cuticles were coated with gold by the ion sputter. The ion sputter seems to be useful for the cuticular study because material can be coated from random directions. The coating was controlled to be about 150 Å to 250 Å in thickness. For SEM micrographs, HITACHI S-450 was used at 25 kv.

For the observation of resin bodies, compressed laminae were pealed off from the rocks using acetylcellulose film or collodion, then cleared in commercial bleach.

On the nomenclature in this study

Two generic names, *Ginkgo* and *Ginkgoites*, have often been used for fossil leaves. The fossil leaves resembling the extant *Ginkgo biloba* in their external morphology have been known since the Middle Jurassic. We adopt *Ginkgo* for these leaves following Harris and Millington (Harris *et al.*, 1974).

Many fossil *Ginkgo* leaves have been described from the various areas under the names of *Gingko adiantoides* (Unger) Heer or *Ginkgoites adiantoides* (Unger) Seward. Unfortunately, no cuticular information has been known on the original specimens of *Ginkgo adiantoides* (Unger) Heer. Florin (1936) considered the specimens from the Pliocene of Frankfurt am Main to be identical with the original *G. adiantoides* (= *Salisburia adiantoides*) described by Unger (1845, in Florin, 1936) and he described the cuticles of the leaves and emended the diagnosis of *G. adiantoides.*

Samylina (1967b) suggested to put 'ex gr.' in front of the specific name for fossil *Ginkgo* leaves when lacking cuticular informations. Concerning the fossil leaves resembling those of the extant *G. biloba* in their external morphology, we agree with Samylina's opinion because it is difficult to discuss the species of *Ginkgo* without their cuticular informations. She transferred *Ginkgo adiantoides* emended by Florin (1936) to her *Ginkgo florinii* (1967b) as nomen novum with citation of Florin's figures. However, since there is no precise distinction between Florin's and Unger's specimens, we prefer to retain Florin's *G. adiantoides* rather than to transfer it to *G. florinii.*

Medjulianov (1969) proposed a new species under the name of *Ginkgoites samylinae* consisting of two varieties, *G. samylinae* var. *samylinae* and *G. samylinae* var. *sachalinica.* He included *Ginkgo orientalis* Samylina, 1967b in his *Ginkgoites samylinae* var. *samylinae* as a synonym. *Ginkgoites samylinae* var. *samylinae* should now, in our opinion, be transferred to *Ginkgo orientalis*, and *Ginkgoites samylinae* var. *sachalinica* (Medjulianov, 1969, p. 147, pl. 19, figs. 4–11, pl. 20, figs. 1–13) to *Ginkgo samylinae* comb. nov. Accordingly, the diagnosis of *Ginkgo samylinae* should follow that of *Ginkgoites samylinae* var. *sachalinica* (Medjulianov, 1969, p. 147).

Description of species

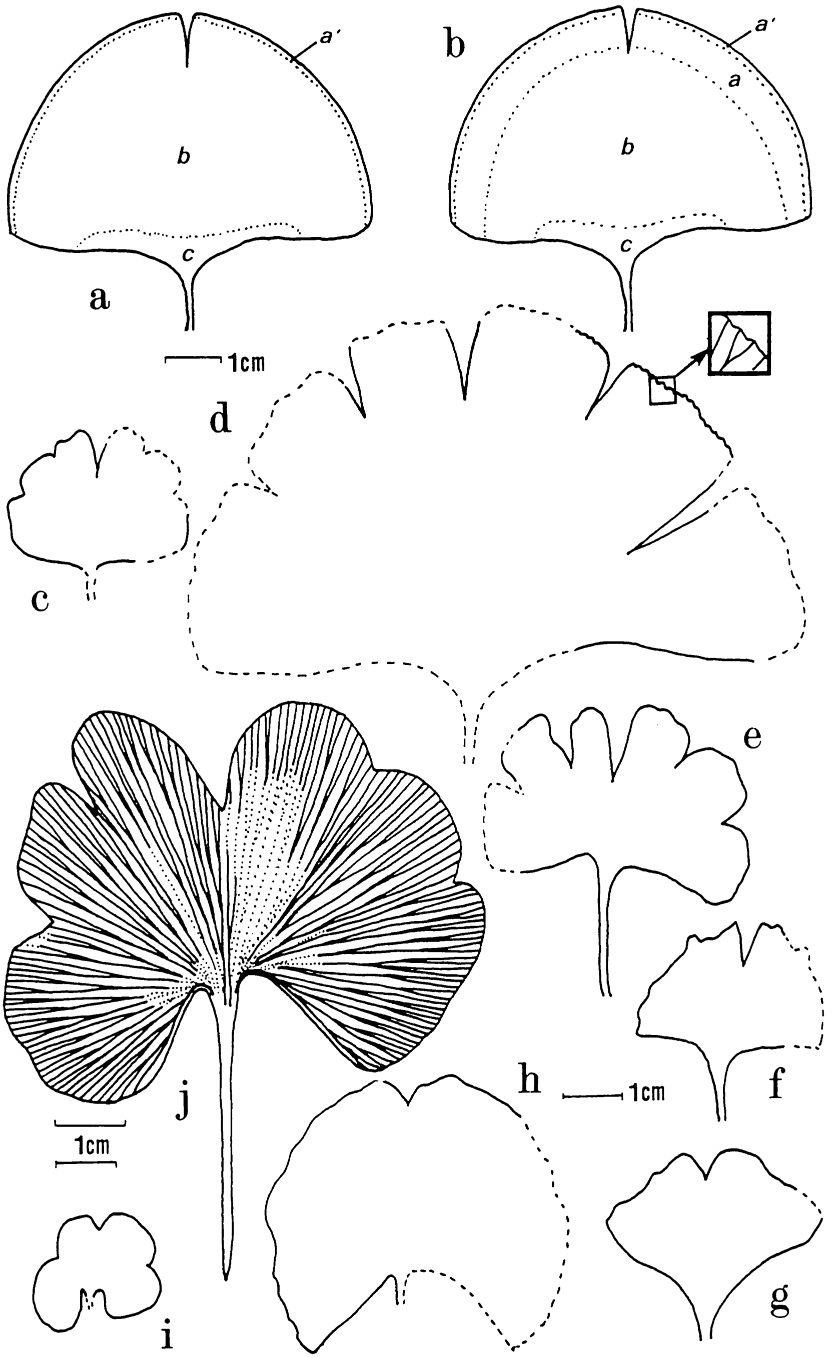
Order Ginkgoales

Family Ginkgoaceae

Genus *Ginkgo* Linnaeus

Ginkgo tzagajanica Samylina

Pl. 65; Pl. 66; Pl. 67, Figs. 1, 3–6; Pl. 68.



Text-figs. 3(a—b). Division of a lamina on the basis of cuticular features. a; upper surface, b; lower surface.

Text-figs. 3(c—j): Varied leaf outlines of *Ginkgo tzagajanica* Samylina from the Palaeogene Minato Formation. c (MI0729), d (MI0733), e (MI0786), f (MI0732), g (MI0750), h (MI0736), i (MI0724), j (MI0767).

Text-figs. 2a—d, 3c—j.

Ginkgo tzagajanica Samylina: Samylina, 1967b, p. 314, pl. 6, figs. 3—6 (Danian, Bureja Basin).
Ginkgoites cf. *adiantoides* (Unger): Oishi, 1938, p. 105, pl. 13, figs. 1—6, text-figs. A—C (from the locality C of Text-fig. 1 in this paper).
Ginkgo spitsbergensis Manum: Krassilov, 1976, p. 42, pl. 2, figs. 1—7 (Danian, Bureja Basin).

Emended diagnosis:—Leaves petiolate; cuneate to fan shaped, basal angle 70°—330°. Incisions shallow, one to seven in number; a median incision the deepest but never reaching halfway-down lamina. Apical margin of lamina either toothed or undulated. Resin bodies fusiform to oval, frequent only between veins. Veins bifurcating three to four times at all levels, persisting to tip of marginal tooth in lamina in case of toothed apical margin; density typically 17 per cm at halfway-down lamina. Upper surface of petiole longitudinally singly grooved.

Epidermis essentially hypostomatic, but with stomata on restricted portion of upper cuticle.

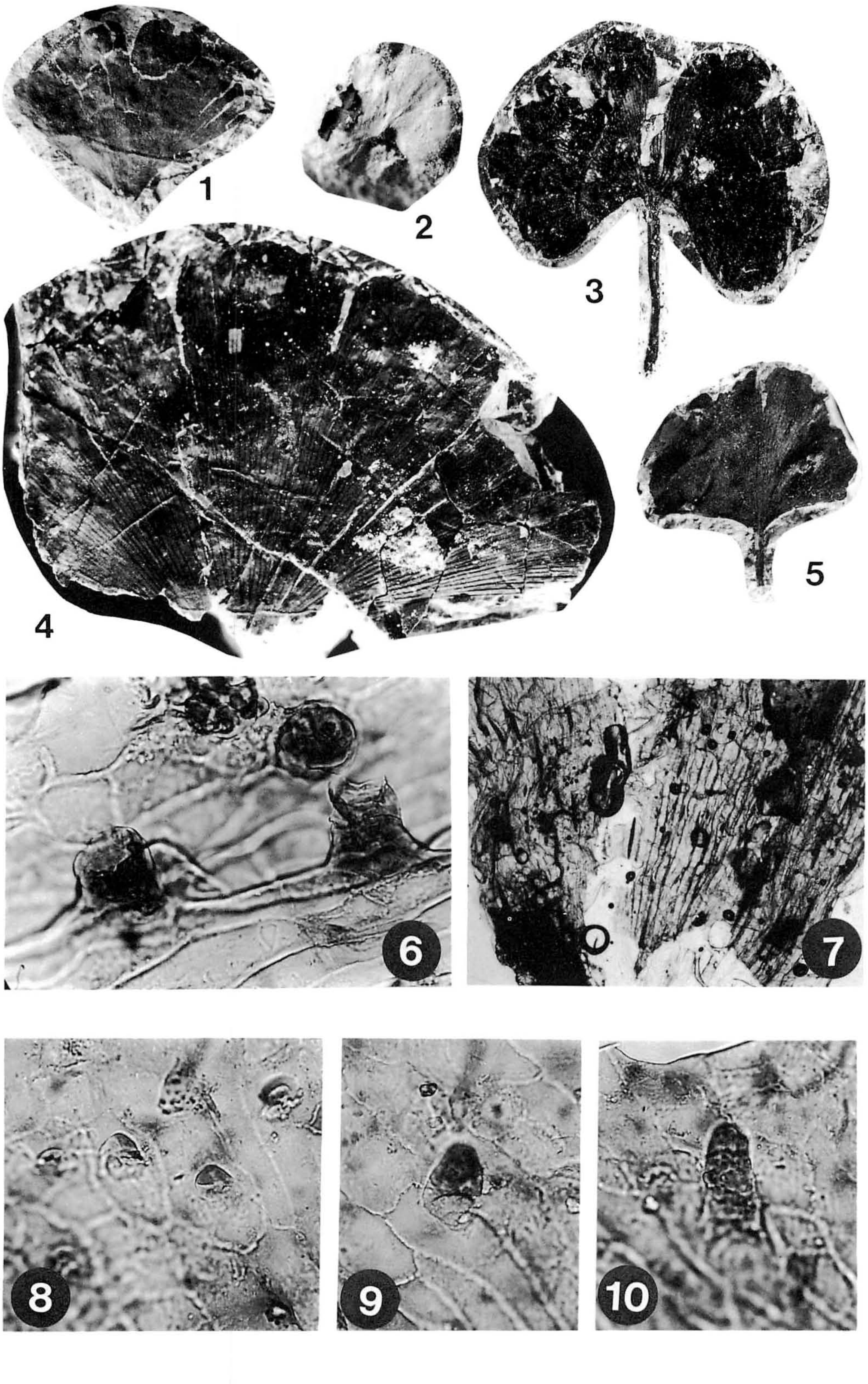
Upper cuticle 2 μm to 4 μm thick consisting mainly of ordinary cells with stomatal complexes, papillae and trichomes being present in restricted area. Ordinary cells elongated-rectangular or elongated-polygonal in shape, but isodiametric in apical portion of lamina; anticlinal walls sinuous, amplitude typically 2 μm to 3 μm, wave-length variable; periclinal walls smooth. Ordinary cells of over veins more elongated than those between veins. Stomata restricted in distribution to basal area of lamina, haplocheilic, dicyclic or incompletely dicyclic; guard cell walls along aperture thickly cutinised; aperture typically 15 μm long. Subsidiary cells four to seven in number. Trichomes unicellular, cylindrical and base peg-like.

Lower cuticle typically 2 μm thick consisting mainly of stomatal complexes, four- to six-sided polygonal cells with or without blunt papillae and trichomes. Cells over veins more elongated than cells between veins; anticlinal walls of cells between veins less marked; periclinal walls papillate or not, each having one papilla when papillate. Distribution of papillate ordinary cells uneven according to portions of lamina, or leaves; sometimes all cells being papillate, but sometimes sparsed or absent. Trichomes more frequent on cells over veins rather than on cells between veins. Stomata haplocheilic, usually dicyclic, restricted in distribution to intervenal areas. Guard cell walls along aperture thickly cutinised; dorsal walls also showing thickenings. Subsidiary cells mostly papillate. Aperture almost completely overarched by three to eight papillae projecting from both lateral and polar subsidiary cells. Trichomes unicellular, cylindrical and base peg-like. (Fructification not known.)

Supplementary description:—As mentioned later, cuticular features vary considerably according to portions of a lamina. They also vary from one leaf to another. There are some cuticular features varying between areas set close by. For example, Text-figs. 2a and 2b show the illustrations of cuticles prepared from the area *b* (Text-fig. 3b) of one lamina at distance of 1 mm. In Text-fig. 2a, periclinal walls of ordinary cells mostly have blunt papillae but in Text-fig. 2b, they are only occasional. Size of ordinary cells illustrated in Text-fig. 2a is much smaller than those in Text-fig. 2b. Furthermore, density of stomata is much smaller in Text-fig. 2a than in Text-fig. 2b. Density of stomata ranges from 66

Explanation of Plate 65

Figs. 1—10. *Ginkgo tzagajanica* Samylina
Figs. 1—5: Varied external morphology (all in natural size); 1 (MI0750), 2 (MI0724), 3 (MI0767), 4 (MI0733), 5 (MI0732).
Fig. 6: Trichomes on the vein course (slide no. MI0741-c), x 400.
Fig. 7: A part of cleared lamina showing the distribution of resin bodies (MI0791).
Figs. 8—10: Varied developmental stages of blunt papillae (slide no. MI0741-c), x 400.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to 106 per a square mm in cuticular preparations observed.

In upper cuticle, size of ordinary cells over veins is typically 16 μm wide, and their length, though very variable, is about 90 μm to 160 μm. Size of cells between veins is about 18 μm to 25 μm wide and 25 μm to 60 μm long in the area *b* (Text-fig. 3a).

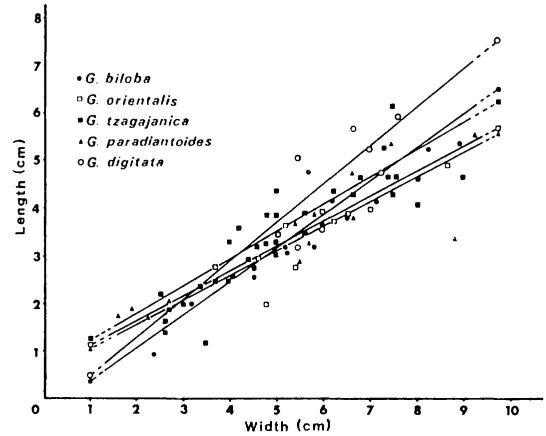
Figs. 1 and 3 of Pl. 67 show SEM micrographs of external and internal surfaces of lower cuticles, respectively. It is clear that papillae are caused by rise of whole cuticular layer of a small area. Oblique view of papillae from external surface (Pl. 68, Fig. 2) shows that papillae of subsidiary cells are much longer (ca. 15 μm) than those of ordinary cells (ca. 6 μm). Internal surface of guard cells is radially striated (Pl. 68, Figs. 3, 4). This structure seems to be comparable with micellae discussed by Heath (1975). Pl. 67, Fig. 5 shows the trichomes with thickened apex. Trichomes are easily distinguishable from slender papillae (Pl. 67, Fig. 6) by having such thickened apex.

Discussion on the diagnostic features of *Ginkgo* leaves

Many features for describing Cenozoic *Ginkgo* species have been discussed as diagnostic ones. However, while studying on the *Ginkgo* leaves from the Minato Formation, we have recognized that some of these features vary considerably as mentioned below.

1. External morphology

1-a) Size: Varied leaves are shown in Pl. 65, Figs. 1—5 and Text-figs. 3c—j. Maximum width and length (lamina base recognized as the first bifurcating point of veins from the petiole) of the lamina were measured. Length ranges from 1.6 cm to 7.0 cm [mode: 4.0 cm to 5.0 cm (32%)]. Maximum width ranges from 2.3 cm to 8.1 cm [mode: 4.0 cm to 5.0 cm (33%)]. It is interesting that the distinct relation between these two values is recognized (Text-fig. 4). Also plotted on the same graph is dimension of extant and some fossil *Ginkgo* species. The leaf indices (ratio of length to width) are almost the same

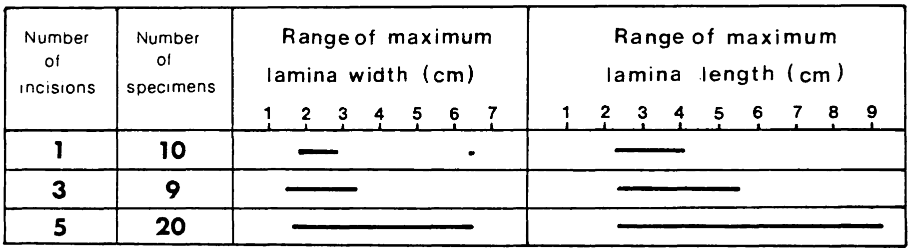


Text-fig. 4. Length-width relations of laminae of selected *Ginkgo* species [data after Samylina, 1967b and Medjulianov, 1969 for *G. orientalis*, partly after Samylina, 1967b for *G. tzagajanica*, after Samylina, 1967a for *G. paradiantoides* and after Harris and Millington (in Harris *et al.*, 1974) for *G. digitata.*]

value within the genus.

Sakisaka (1958) mentioned that lamina-size of the extant *Ginkgo biloba* was controlled by the balance of water absorption and transpiration, although no detailed datum was offered. According to him, more the water absorption exceeds transpiration, the larger in size is the lamina. He also mentioned that lamina-size varied within a single tree, because the amount of water supply was not unified throughout one tree.

1-b) Incision: In the extant *Ginkgo biloba*, incisions are 0, 1, 3, 5 and 7 in number. Thirty-nine leaves among those from the Minato Formation show well preserved lamina-margins. The incisions scarcely reach to the halfway-down lamina. Sakisaka (1958) further mentioned that the number of incisions was also controlled by the balance of water absorption and transpiration. According to him, more the water absorption exceeds transpiration, the larger is the number of incisions. From his two indications mentioned above, it can be expected that larger leaves possess well developed incisions. Text-fig. 5 shows the relationships between number of incision and their lamina-size in the *Ginkgo*



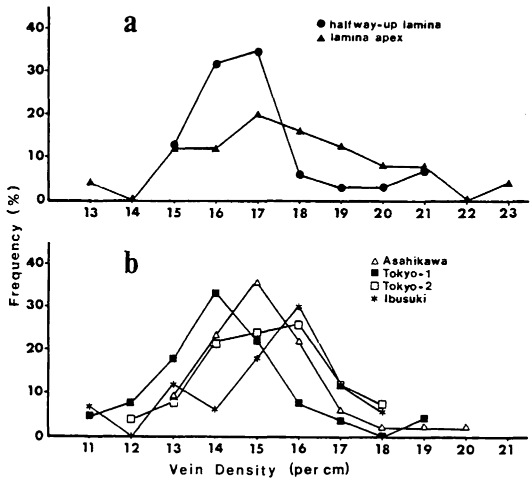
Text-fig. 5. Distribution of lamina size in relation to their incision numbers of *Ginkgo tzagajanica* from the Palaeogene Minato Formation.

leaves from the Minato Formation. It is clear that leaves with larger number of incisions (5 incisions) show wide range of lamina-size while leaves with smaller number of incisions (only one incision) do not attain to large size (with single exception of 64 mm in width). Leaves with intermediate number of incisions (3 incisions) show intermediate range in lamina-size. The bias of this distribution within the graph may indicate regional environmental conditions in some extent.

1-c) Vein-density: Vein-density was counted at apex and halfway-up lamina to note which part shows more stability (Text-fig. 6a). As is clear from the graph, countings should be made at halfway-up lamina. At this portion, about 35% of leaves showed vein-density of 17 per cm, and over 65% showed 16 to 17 per cm.

Text-fig. 6b shows vein-density of the extant species collected from four places in Japan. The peaks show high concentration but they range from 14 to 16 per cm without any direct relation to known climatic conditions.

In some previous studies of fossil *Ginkgo* leaves, vein-density is represented for every 5 mm instead of 1 cm (*e.g.*, Samylina, 1967b). It has been examined from our observation of many leaves that vein-density given for every 5 mm cannot be simply twiced to get the density for 1 cm. Such value usually turns out to be somewhat larger than the actual.



Text-fig. 6. Vein-density of *Ginkgo* species. a; *G. tzagajanica* Samylina from the Palaeogene Minato Formation, b; *G. biloba* L. from Japan.

Explanation of Plate 66

Figs. 1—10. *Ginkgo tzagajanica* Samylina

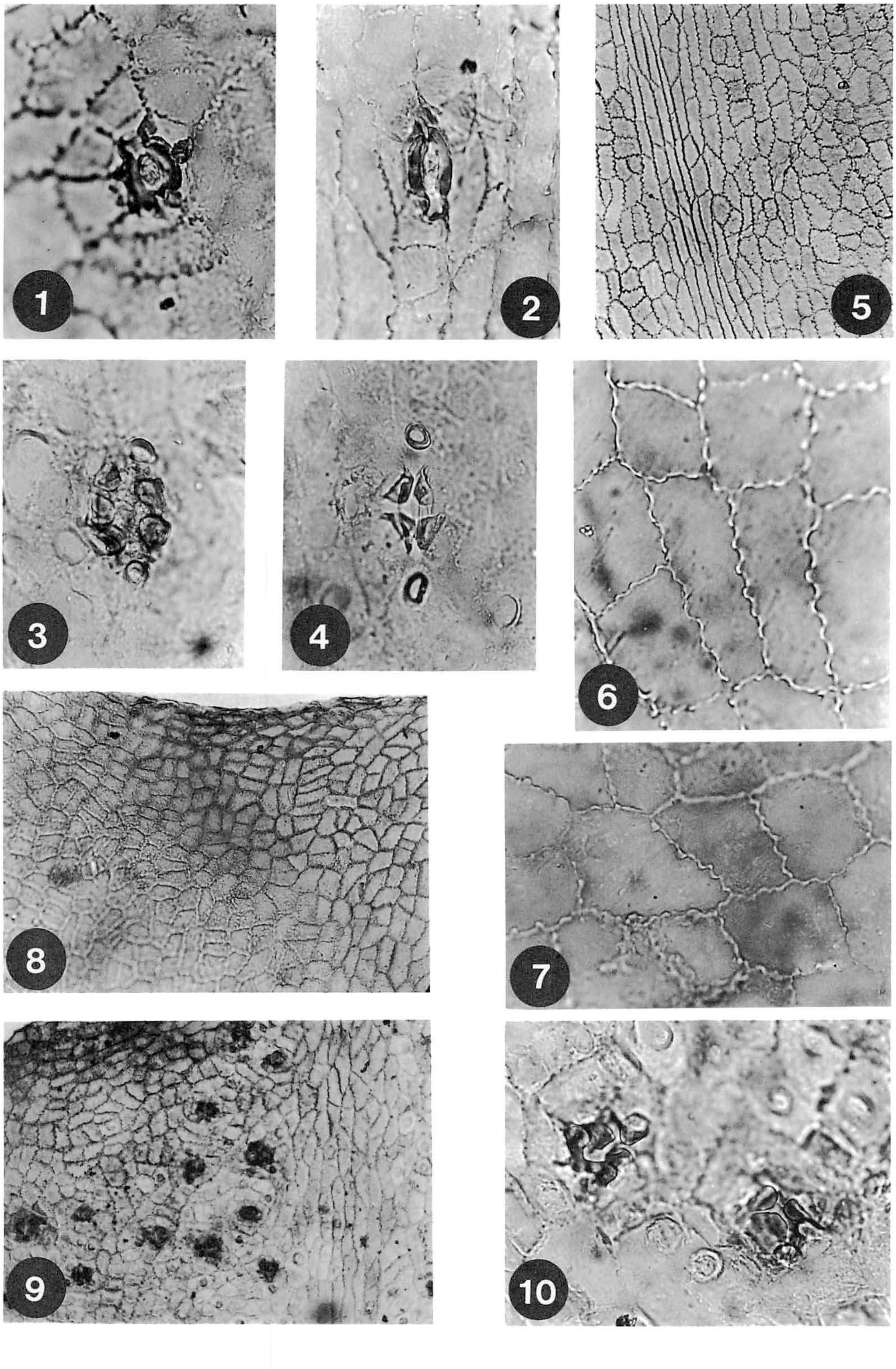
Figs. 1—2: Stomatal complexes of the upper cuticle (slide no. MI0752b-1), x 400.

Figs. 3—4, 10: Stomatal complexes of the lower cuticle, x 400. 3 (slide no. MI0733a-b-1), 4 (slide no. MI0727-1), 10 (slide no. MI0746b-1).

Figs. 5—7: Normal cells of the upper cuticle prepared from area *b*. 5 (slide no. MI0733a-b-1), x 100, 6 (slide no. MI0746b-1), x400, 7 (slide no. MI0772a-b-1), x 400.

Fig. 8: A cuticle prepared from area *a′* of the upper cuticle (Text-fig. 3a) (slide no. MI0746a-1), x 100.

Fig. 9: A cuticle showing areas *a* and *a′* of the lower cuticle (Text-fig. 3b) (slide no MI0746a-1), x 100.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2. Cuticular features

From our observation of cuticles prepared from various portions of a lamina, our fossil lamina is divided into the portions as shown in Text-figs. 3a and 3b.

2-a) *Upper cuticle*: Stomatal complexes are found only in the basal area lettered *c* in Text-fig. 3a. Also in the same area, papillae of varied developmental stages, blunt to slender, are found (Pl. 65, Figs. 8–10, Pl. 67, Fig. 6).

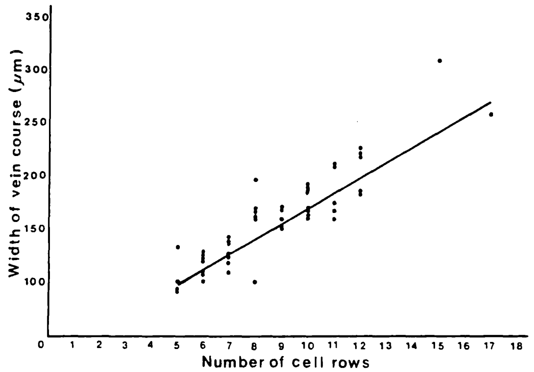
Ordinary cells are usually rectangular or polygonal in shape (Text-figs. 2a–c, Pl. 66, Figs. 5–7), but rather short in the area *c*, and isodiametric in the area *a* (Pl. 66, Fig. 8).

Medjulianov (1969) offered his data on the number of cell rows over veins and width of the vein-course, and indicated their systematic value. However, in our fossil leaves studied herein, the number of cell rows varied mainly from 5 to 12 (maximum, 17) and their width mainly from 86 μm to 220 μm (maximum, 300 μm). These evidences do not agree with Medjulianov's measurements. However, these two values show mutual relations indicating stable mean value of vein-course-cell-width (Text-fig. 7).

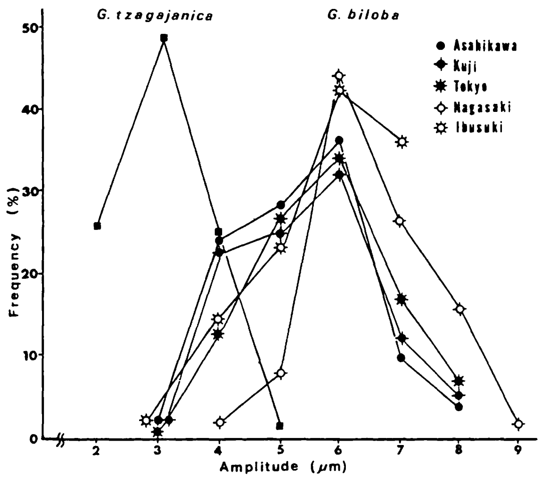
Sinuosity-amplitude of the ordinary-cell-walls is one of the diagnostic features commonly used in the previous works. It is necessary to be measured on the cell walls having somewhat regular wave-length for more than two waves (irrelevant to its actual length) to obtain the stable data. Fossil leaves studied herein show high concentration of amplitude value (Text-fig. 8). More than 45% of the measured cell walls show amplitude between 2 μm to 3 μm, and over 75% are placed between 2 μm to 4 μm.

For comparison, the leaves of the extant *Ginkgo biloba* from five places were examined. All populations show highest peak at 6 μm (Text-fig. 8). Medjulianov (1969) showed his data on the extant species collected from Vladivostok, USSR and Japan. Amplitude shown by him (15 μm) was not statistically represented, thus it could not be compared with our result.

2-b) *Lower cuticle*: At the basal portion of the area *c* (Text-fig. 3b), cell arrangements of over veins and intervenal areas are not well



Text-fig. 7. Relationship between number of vein course cells and width of vein courses of *Ginkgo tzagajanica* Samylina from the Palaeogene Minato Formation.



Text-fig. 8. Sinuosity-amplitude of anticlinal cell walls of *Ginkgo tzagajanica* Samylina from the Palaeogene Minato Formation and the extant *Ginkgo biloba* L. from Japan.

differentiated.

Dicyclic and incompletely dicyclic features of the stomatal complexes support the observation made by Kausik (1974) rather than that by Pant and Mehra (1964).

Trichomes are frequently well developed along vein-courses and sometimes between veins. However, some vein-course-cells of considerable length are provided with trichomes while some are not. Vein-course-cells prepared in extension over 1 mm were selected from several portions of laminae to count the number of veins provided with trichomes. More than 50% of the veins from the area *b* (Text-fig. 3b) were provided with trichomes, while only 20% of the veins from the area *a* were with them. In the area *c*, trichomes were very frequent, though as mentioned already this portion did not show clear differences in cell arrangements. It is necessary to be aware that in the area *a*, inspite of large sized cuticles obtained, they sometimes lack trichomes completely.

The area *a*, as in the upper cuticle, showed isodiametric rectangular or polygonal cells without any stoma, and cuticle was thicker.

Comparison

Our fossil leaves are characterized by the combination of the following three features; 1) well developed subsidiary-cell-papillae completely overarching the stomatal pit, 2) frequent occurrence of ordinary-cell-papillae on the lower cuticle and 3) smaller sinuosity-amplitude of ordinary-cell-walls with its mean value being approximately 3 μm.

Our fossil leaves are fundamentally identical with *Ginkgo tzagajanica* originally described by Samylina (1967b) from the Danian of the Bureja Basin in external and cuticular features. But the detailed observation of our fossil leaves led inevitably to give the emended diagnosis to *Ginkgo tzagajanica* as mentioned previously in this paper.

The following Tertiary *Ginkgo* species are comparable with *G. tzagajanica*: *G. gardneri*, *G. adiantoides*, *G. occidentalis* and *G. samylinae*. But they are distinguished from *Ginkgo tzagajanica* by the respects mentioned below.

Ginkgo gardneri from the Eocene of Isle of Mull, Scotland (Florin, 1936) has straight anticlinal cell walls, low vein-density (13 per cm), and has prominent papillae on almost all ordinary cells of the upper cuticle. *Ginkgo adiantoides* from the Miocene of Silesia (Szafer, 1961) and Pliocene of Frankfurt am Main (Florin, 1936) has high vein-density (29 per cm according to Florin, 1936), and its guard cells are not overarched by papillae. *Ginkgo occidentalis* from the Miocene of USSR (Samylina, 1967b) has also high vein-density (20 per cm), large amplitude of cell-sinuosity (measured from the original figures as 6 μm to 8 μm), and its guard cells are not overarched by papillae. *Ginkgo orientalis* from the Palaeogene of USSR (Samylina, 1967b; Medjulianov, 1969) has no subsidiary-cell-papillae and shows large amplitude of cell-sinuosity (9 μm to 11 μm). *Ginkgo samylinae* from the Palaeogene of USSR (Medjulianov, 1969) has very large vein-density (24 per cm), and lacks ordinary-cell-papillae of lower surface.

Ginkgo spitsbergensis from the Palaeocene of West Spitsbergen and *G. wyomingensis* from the Lower Palaeocene of Wyoming, U.S.A. (both described by Manum, 1966) show close resemblance with leaves from the Minato Formation. Taking the range of variation into consideration, *Ginkgo wyomingensis* is considered to have very close affinity with *G. spitsbergensis*. These two species are also difficult to distinguish from *Ginkgo tzagajanica*, but they are based on too small number of specimens to be compared readily with *G. tzagajanica*. Although Krassilov (1976) considered *Ginkgo tzagajanica* as a synonym of *G. spitsbergensis*, we are of the opinion

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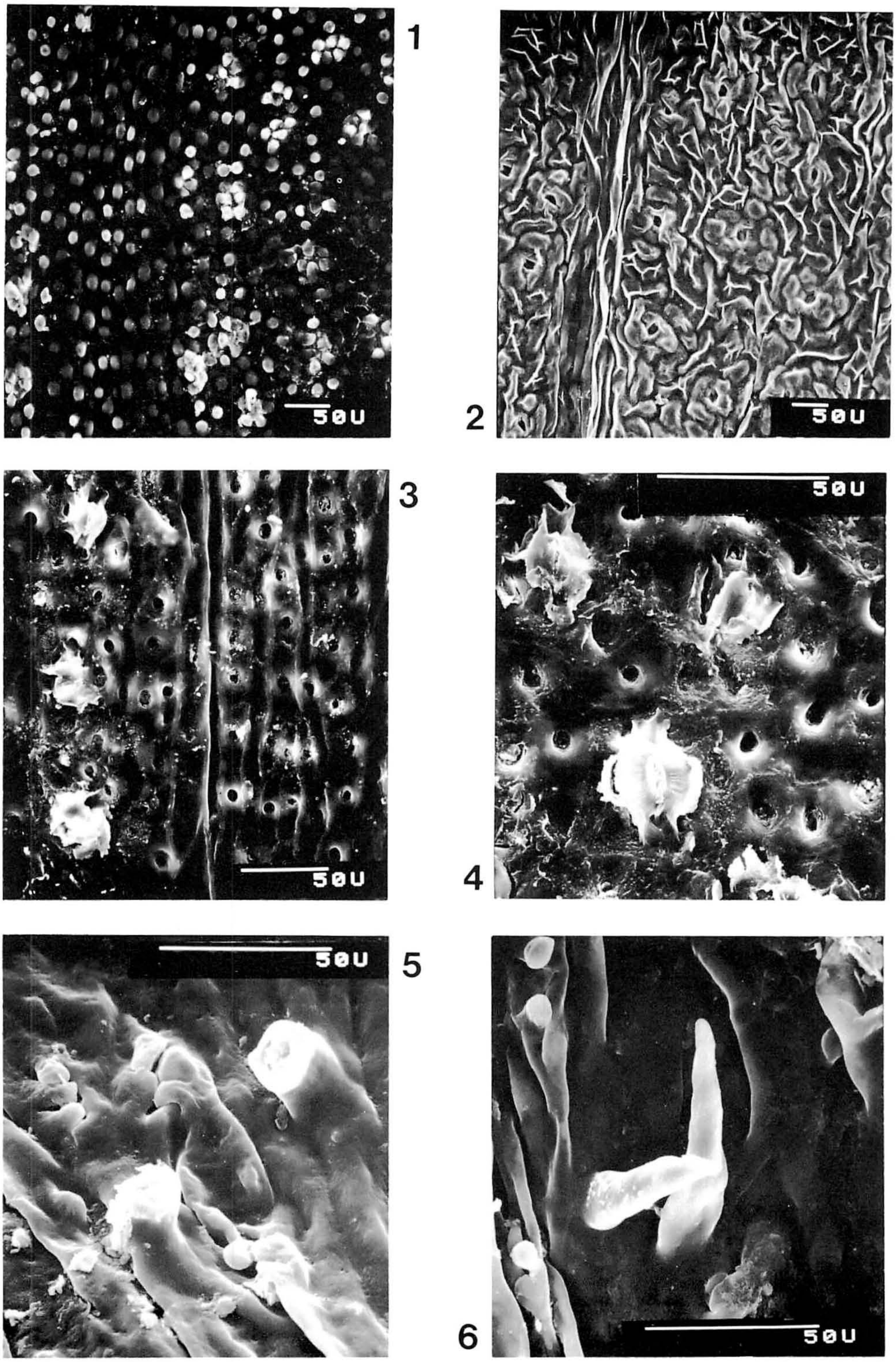
Explanation of Plate 67

Figs. 1, 3—6. SEM micrographs of *Ginkgo tzagajanica* Samylina (stage no. MISEM-1).
Fig. 2. A SEM micrograph of extant *Ginkgo biloba* L. (stage no. MISEM-2).
Figs. 1—2: External surface of the lower cuticle.
Fig. 3: Internal surface of the lower cuticle showing a vein course.
Fig. 4: Internal surface of the lower cuticle showing interveins.
Fig. 5: Trichomes with thickened apex.
Fig. 6: Slender papillae.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that these two species should be regarded as distinct until detailed informations are available on leaves from Spitsbergen.

The extant *Ginkgo biloba* has small vein-density (13 to 16 per cm), and large amplitude of cell-sinuosity (6 μm). Its periclinal walls of ordinary cells, though frequently swelled (Pl. 67, Fig. 2), do not show any blunt papillae.

Trend in development of cuticular features

Some cuticular features of Cretaceous, Tertiary and extant *Ginkgo* species are summarized in Table 2. In general, decrease in development of papillae on the ordinary and subsidiary cells can be recognized as follows. Three early Palaeogene species, *Ginkgo spitsbergensis*, *G. wyomingensis* and *G. tzagajanica*, are similar in cuticular features; each having the subsidiary-cell-papillae almost completely overarching the stomatal aperture, and ordinary-cell-papillae. Though these cuticular features are observed in many Cretaceous species, such species usually show prominent papillae and trichomes on the upper cuticle, not seen in early Palaeogene species. Among the Cretaceous species, *Ginkgo paradiantoides* described by Samylina (1967a) shows closest resemblance to the early Palaeogene species mentioned above.

Table 2. Cuticular features of *Ginkgo* species since the Cretaceous. NCP: Normal cell papillae, T: Trichomes, ACW: Anticlinal cell walls, SCP: Subsidiary-cell-papillae, x: Absent, solid circle: Present, triangle: Present in restricted area, wave (∽): Undulate, short line: straight, solid square: Present but not overarching the stomatal aperture, asteriks: Present and overarching the stomatal aperture.

	Upper cuticle			Lower cuticle		
	NCP	T	ACW	SCP	NCP	T
G. biloba	x	x	∽	x	x	x
G. adiantoides	x	x	∽	x	x	x
G. occidentalis	x	x	∽	■	●	x
G. gardneri	●	x	–	*	●	x
G. orientalis	x	x	∽	■	x	x
G. samylinae	x	x	∽	■	x	x
G. spitsbergensis	x	x	∽	*	●	x
G. wyomingensis	x	x	∽	*	●	x
G. tzagajanica	▲	▲	∽	*	●	●
G. pilifera	●	●	∽	*	●	●
G. paradiantoides	x	x	∽	*	●	●
G. pluripartita	●	●	–	*	●	●
G. coriacea	●	●	∽	*	●	●
G. polaris	●	x	∽	■	●	x

From the Palaeogene of Sakhalin and Primorye, *Ginkgo orientalis* and *G. samylinae* have been known. These two species show less developed cuticular features compared with the three early Palaeogene species discussed above. In these two species, ordinary-cell-papillae are absent, and subsidiary-cell-papillae, though present, do not overarch the stomatal aperture. Pliocene records of the genus in Asia are known from Japan (Hikita, 1949; Iwao, 1978). They are identical with the extant *Ginkgo biloba* lacking both the subsidiary- and ordinary-cell-papillae. Recently, Kamada *et al.* (1981) reported the occurrence of *Ginkgo biloba* from the Plio-Pleistocene of Kyushu, Japan, which is the youngest fossil record of the genus. Unfortunately, they did not describe the cuticles of their specimens.

In Europe, so far as we know, the oldest Tertiary record of the genus is *Ginkgo gardneri* from the Eocene of Isle of Mull. Although it is very different from other Tertiary or younger species in the features of the upper cuticle, the lower cuticular features of this species resemble other early Palaeogene species. *Ginkgo gardneri* is rather close to the Cretaceous *Ginkgo pluripartita* (Shimper) Heer. The cuticles of the latter species were described by Florin (1936) and Brown (1975). In our opinion, *Ginkgo gardneri* may represent phyletically different lineage from other Tertiary species though the informations of Palaeogene *Ginkgo* in Europe are still too scarce. *Ginkgo occidentalis* possesses the subsidiary- and ordinary-cell-papillae but the stomatal apertures are not overarched. Records of *Ginkgo* species without the subsidiary- and ordinary-cell-papillae in Europe are known from the Miocene of Silesia (Szafer, 1961) and Pliocene of Frankfurt am Main (Florin, 1936).

Concerning North American ginkgoes, the cuticular features of the Palaeocene *Ginkgo wyomingensis* have already been introduced earlier. Cuticular informations of the Eocene and Oligocene *Ginkgo* are absent in North America. A Miocene record given by LaMotte (1936) under the name of *Ginkgo adiantoides* (Unger) Heer does not show any papillae on the ordinary and subsidiary cells.

Acknowledgements

J. Horiuchi wishes to express his sincere thanks to Prof. Hisayoshi Igo of the University of Tsukuba for his helpful suggestions and giving him the opportunity to carry out this study as a part of his Master Thesis. His thanks are also extended to Profs. Naoaki Aoki and Hiroshi Noda of the University of Tsukuba for their kind suggestions.

This study was supported by the Grant-in-Aids for Scientific Researches from the Ministry of Education, Science and Culture of Japan (No. 59540499).

References

Brown, J. T. (1975): Upper Jurassic and Lower Cretaceous Ginkgophytes from Montana. *Jour. Paleont.*, vol. 49, no. 4, p. 724—730.

Florin, R. (1936): Die fossilen Ginkgophyten von Franz-Joseph-Land, nebst Erörterungen über vermeintlich Cordaitales mesozoischen Alters. II. Algemeiner Teil. *Palaeontogr.* B, Bd. 82, p. 1—68, pls. 1—6.

Givulescu, R. (1973): Die fossilen Koniferen des Fundortes Chiuzbaia F. *Geol. Inst. Mem.*, vol. 19, p. 31—34, pls. 11—15.

Harris, T. M., Millington, W. and Miller, J. (1974): The Yorkshire Jurassic Flora, IV. 1 Ginkgoales, 2 Czekanowskiales. viii + 150 pp., 8 pls., *Brit. Mus.* (*Nat. His.*), London.

Heath, O. V. S. (1975): Stomata. *Oxford Biology Readers*, no. 37, p. 1—31.

Hikita, S. (1949): On the new localities and habitat of *Ginkgo biloba* L. in Pliocene, Japan. *Kobutu to Chishitu*, vol. 12, p. 1—6.

Iwao, Y. (1978): Late Cenozoic *Ginkgo biloba* L. from the Hoshiwara Formation in Kumamoto Prefecture, Kyushu, Japan. *Rep. Fac. Sci. Engin., Saga Univ.*, no. 6, p. 45—50, pl. 1.

Jordanov, D. and Kitanov, B. (1963): Einige interessante fossilen Pflanzen aus dem Pliozän in der Umgebung der Stadt Goze Deltschev. *An. Univ. Sofia* (1961—62), vol. 51, no. 1 (not cited).

Kamada, Y., Iwao, Y., Miyaki, M. and Okazawa, A. (1981): On the Hiradoguchi plant bed discovered from Tabira-machi, Kitamatsuura-gun, Nagasaki Prefecture. *Nagasakikenchigakukaishi*, vols. 33/34, p. 11—28, pls. 1—5 (in Japanese).

Kausik, S. B. (1974): The stomata of *Ginkgo biloba* L., with comments on some noteworthy features. *Bot. J. Linn. Soc.*, vol. 69, p. 137—146.

Krassilov, V. A. (1976): Tsagajan Flora of the Amur Province. *Inst. Biol. Pedol., Far East. Sci. Centre, Acad. Sci. USSR*, p. 1—92, pls. 1—43 (in Russian).

Kimura, T. and Horiuchi, J. (1978): *Pseudolarix nipponica* sp. nov., from the Palaeogene Noda Group, Northeast Japan. *Proc. Japan Acad., Ser. B*, vol. 54, no. 8, p. 429—434.

LaMotte, R. S. (1936): The Upper Cedarville Flora of Northwestern Nevada and adjacent California. *In*, Middle Cenozoic Floras of Western North America. *Carnegie Inst. Washington, Pub.*, 455, p. 57—142, pls. 1—14.

Explanation of Plate 68

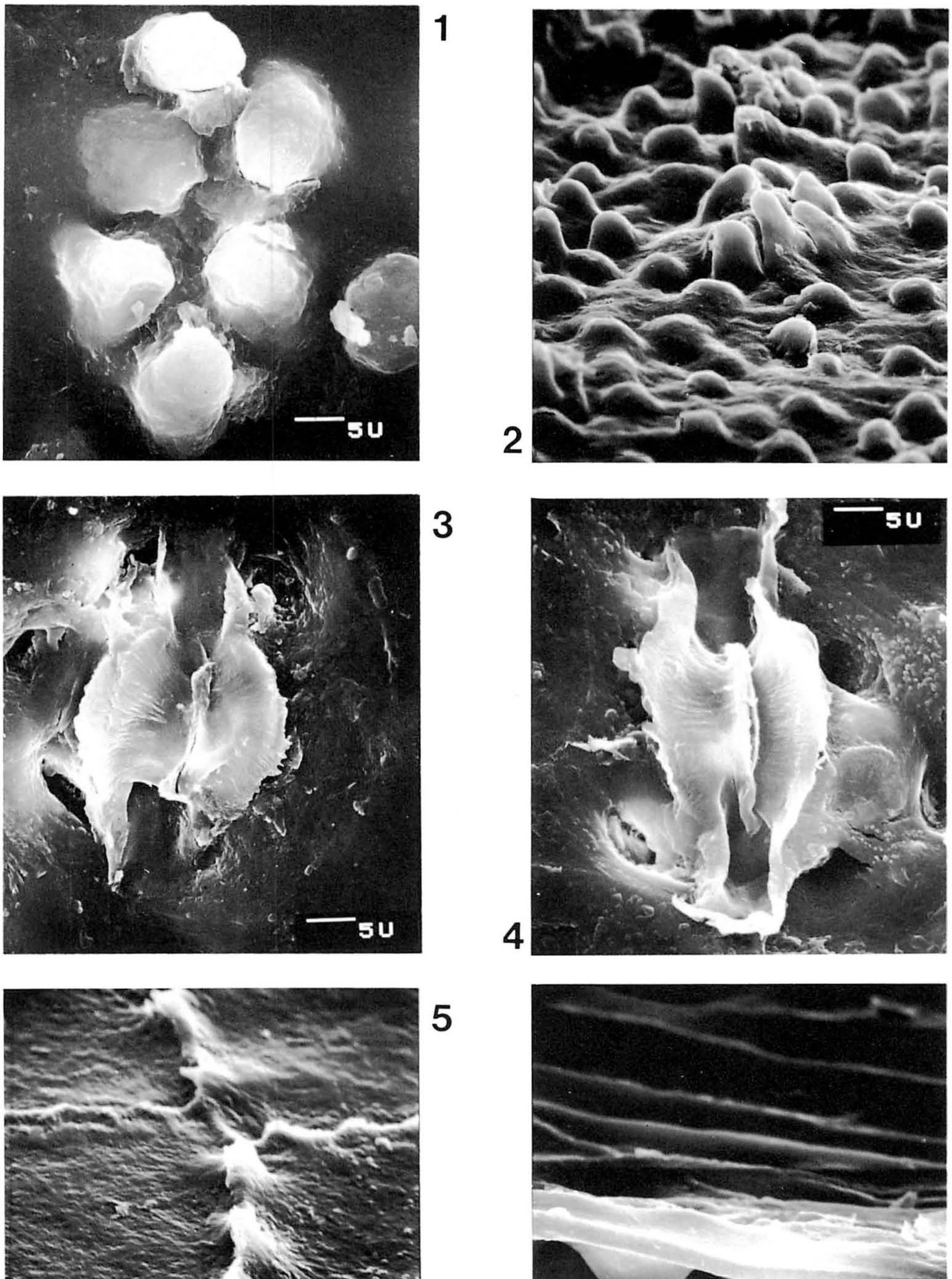
Figs. 1—6. SEM micrographs of *Ginkgo tzagajanica* Samylina (stage no. MISEM-1).

Fig. 1: External surface of a stoma of the lower cuticle. Note four lateral and two polar subsidiary-cell-papillae overarching the stomatal aperture.

Fig. 2. Oblique view of the external surface of the lower cuticle showing length difference between normal- and subsidiary-cell-papillae

Figs. 3—4: Internal surface of the boundary area of normal cells of the upper cuticle.

Fig. 6: A cross section of a lower cuticle.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Lancucka-Srodoniowa, M. (1966): Tortonian flora from the "Gdow Bay" in the South of Poland. *Acta Palaeobotanica*, vol. 7, no. 1, p. 3—135, pls. 1—7.

Manum, S. (1966): *Ginkgo spitsbergensis* n. sp. from the Paleocene of Spitzbergen and a discussion of certain Tertiary species of *Ginkgo* from Europe and North America. *Norsk Polarinst. Årbok* 1965, p. 49—58, pls. 1—2.

Medjulianov, V. A. (1969): *Ginkgoites* ex gr. *adiantoides* from the Lower Paleogene of South Sakhalin. *In*, Fossil Fauna and Flora of the Far East, I. *Far East Geol. Inst., Komarov Far East Filial, Sib. Br., Acad. Sci. USSR*, p. 139—152, pls. 18—20 (in Russian with English summary).

Oishi, S. (1938): On the cuticles of Tertiary *Ginkgoites* leaves from Kuji, Iwate Prefecture. *Jour. Fac. Sci., Hokkaido Imp. Univ., Ser. 4*, vol. 4, nos. 1—2, p. 103—106, pl. 13(1).

Pant, D. D. and Mehra, B. (1964): Development of stomata in leaves of three species of *Cycas* and *Ginkgo biloba* L. *J. Linn. Soc. (Bot.)*, vol. 58, no. 375, p. 491—497, pl. 1.

Polyshchnuk, L. V. (1975): Variation of epidermal characters of *Ginkgo* from the Palaeogene and Neogene of Primorye in respect to climatic changes. *In*, Krassilov, V. A. (*ed.*): Fossil floras of the Far East. *Inst. Bio. Ped., Far East. Sci. Centre, Acad. Sci. USSR Proc. N.S.*, vol. 27, p. 76—83, pl. 5 (in Russian with English abstract).

Sakisaka, M. (1958): Study of *Ginkgo*. 144 pp. Kazama-shobo, Tokyo (in Japanese).

Samylina, V. A. (1967a): The Mesozoic flora of the area to the west of the Kolyma River (the Zyrianka Coal-Basin) II. Ginkgoales, Coniferales, General Chapters. *Paleobotanika, Leningrad*, vol. 6, p. 133—175, pls. 1—14 (in Russian with English summary).

——(1967b): On the final stages of the history of the genus *Ginkgo* L. in Eurasia. *Jour. Bot. Acad. Sci. USSR, Leningrad*, vol. 52, no. 3, p. 303—316, pls. 1—6 (in Russian with English summary).

Sasa, Y. (1932): On the geology of Kuji District. *Jour. Geol. Soc. Tokyo*, vol. 39, no. 466, p. 401—431; no. 467, p. 481—501; no. 468, p. 552—579 (in Japanese).

Seward, A. C. (1919): Fossil plants. vol. 4, 16 + 543 pp. Cambridge.

Shaparenko, K. (1935): *Ginkgo adiantoides* (Unger) Heer; Contemporary and fossil forms. *Philip. Jour. Sci.*, vol. 57, no. 1, p. 1—29, pl. 1.

Szafer, W. (1961): Miocene floras from Stare Gliwice in Upper Silesia. *Inst. Geol., Prace*, vol. 33, p. 1—205, pls. 1—25.

Tralau, H. (1968): Evolutionary trends in the genus *Ginkgo*. *Lethaia*, vol. 1, no. 1, p. 63—101.

Unger, F. (1845): Synopsis Plantarum Fossilium. 211 pp., Lipsiae (not cited).

Asahikawa (Asahigawa) 旭川, Ibusuki 指宿, Kuji 久慈, Nagasaki 長崎, Noda 野田, Tokyo 東京.

東北地方に分布する古第三系野田層群港層産の *Ginkgo tzagajanica* Samylina—とくにその外形と表皮系の特徴：岩手県北部の太平洋沿岸地域に分布する野田層群港層（古第三系下部）から保存良好な *Ginkgo* 葉化石多数が得られた。これらは外形の変異幅は大きいが，産状および表皮構造に認められる特徴から，いずれも同一種の同一個体群に属し，Samylina (1967b) によって Bureja Basin の第三系最下部から記載された *Ginkgo tzagajanica* と同定される。この種ははじめ，ごくわずかの標本に拠ったものであるが，今般得られた多くの標本から，原記載に追加することのできる多くの情報が入手され，よって本種の識別標徴がより詳細なものとなった。

今般得られた *Ginkgo* 葉化石の表皮構造の研究から，一枚の葉の中でも部位によって相異が認められ，また個体群内においても連続的な変異幅のあることが明らかになった。さらに，*Ginkgo* 葉の外部形態および表皮構造に認められる各形質について，それらが分類形質としてどれだけ分類学的に有効性があるかについて論じ，化石葉および現生葉の検討から，第三紀以降，北半球より報告された *Ginkgo* 葉の表皮構造の時間的変化の傾向について論じた。

堀内順治・木村達明

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 142, pp. 354—365, pls. 69—73, June 30, 1986

812. A NEW SPECIES OF *INOCERAMUS* (*CORDICERAMUS*) (BIVALVIA) FROM THE UPPER CONIACIAN (CRETACEOUS) OF HOKKAIDO*

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Abstract. In this paper, a new species *Inoceramus* (*Cordiceramus*) *kawashitai* is established. The specimens were occurred from the Upper Coniacian of the Oyubari, Ikushumbets and Obira areas of Hokkaido. The variation of selected characters are examined quantitatively on the basis of measurements and statistics, in addition to traditional observation. The average relative growth of two relations (shell height *vs.* shell length and shell height *vs.* breadth) are also examined. On the ground of its considerably inflated equivalve shell, subquadrate or pentagonal marginal outline and development of three radial ridges, this species is certainly assigned to the subgenus *Cordiceramus.* But the ontogenetic change of the certain characters does not agree with that of any known species. I point out the significance of the occurrence of *Cordiceramus* from the Upper Coniacian of Japan, in that it represents the lower part of the range of the subgenus. The phylogenetic relationships with allied species are, however, put off, at present, as a further problem.

Introduction

In 1980, a large specimen of *Inoceramus* was unexpectedly obtained in a pebble of the Misojino-sawa, a tributary of the Ikushumbets River, by Mr. Yoshitaro Kawashita of Mikasa City. Its peculiar form has attracted my interest. But it has been very insufficient to establish a new species, because the stratigraphic position is unknown. Subsequently he collected a specimen with the same characters from a cliff of the right bank of Penkehorokayuparo-zawa, about 50 m upstream from the confluence with the Yubari River. In summer of 1981, Matsumoto, Kawashita and I investigated the stratigraphy along the Misojino-sawa and obtained a similar specimen with the former collection by Kawashita from a pebble in the sequence of the Zone of *Inoceramus mihoensis.* On the other hand, in 1982, Mr. Kenji Sanada of Sapporo City collected some similar specimens with Kawashita's collection from the pebbles of the Pombets-Gono-sawa. Next year, Matsumoto and I investigated the stratigraphy precisely with the help of others along the Gono-sawa, and obtained still more specimens from the middle part of the Upper Yezo Group. In this paper, these specimens are described under a new specific name which is dedicated to Mr. Yoshitaro Kawashita in appreciation of kindness for offering a number of specimens for this study.

Before going further, I express my sincere thanks to Emeritus Professor Tatsuro Matsumoto of Kyushu University for his cordial guidance in the field and laboratory, useful advice and critical reading of the typescript. I wish to thank Messrs. Yoshitaro Kawashita, Takemi Takahashi of Mikasa City, Kenji Sanada of Sap-

*Received February 2, 1985; revised manuscript received April 9, 1985; read February 3, 1985 at University of Tokyo.

poro City, Shigehiro Uchida and Toshio Shimanuki of Iwamizawa City for their help in the field work and for their kindness of offering some valuable specimens for this study. A part of the expense of this study was defrayed from the Shimonaka Commemorative Foundation (1984) and the Grant-in-Aid for Scientific Program (1984, No. 59916035), the Ministry of Education, Science and Culture.

Method

In addition to the traditional method, the statistic analyses for some biometric characters are examined, that is, the mean values of l/h, b/h and s/l and the angles α, β, γ and δ, their standard deviations, Pearson's coefficient of variation and the ontogenetic change of selected characters. The average relative growth of shell height to shell length, and shell height to breadth are also examined. The basic morphology and measurements are shown in Text-fig. 1.

For the measurements, the procedure of statistics and biometric analysis, see Hayami (1969), Hayami and Matsukuma (1971) and Noda (1975, 1983).

Palaeontological description

Family Inoceramidae Zittel, 1881

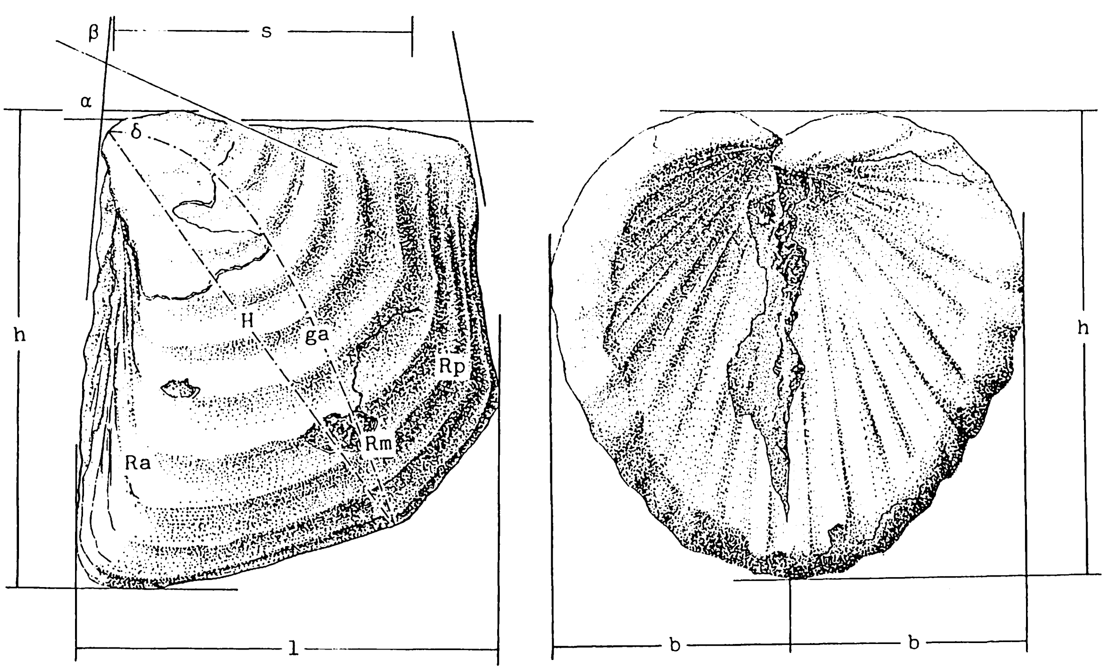
Genus *Inoceramus* Sowerby, 1814

Subgenus *Cordiceramus* Seitz, 1961

For subgenus *Cordiceramus*, see Seitz (1961, p. 110) and Noda (1979, p. 110, 114).

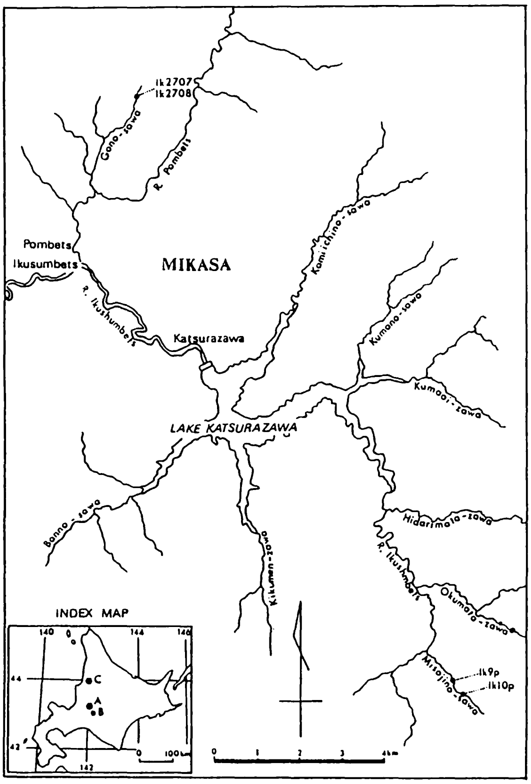
Inoceramus (*Cordiceramus*) *kawashitai*, sp. nov.

Pl. 69, Figs. 1a–1d; Pl. 70, Figs. 1a–2b;
Pl. 71, Figs. 1a–3; Pl. 72, Figs. 1a–2b;
Pl. 73, Figs. 1a–5.

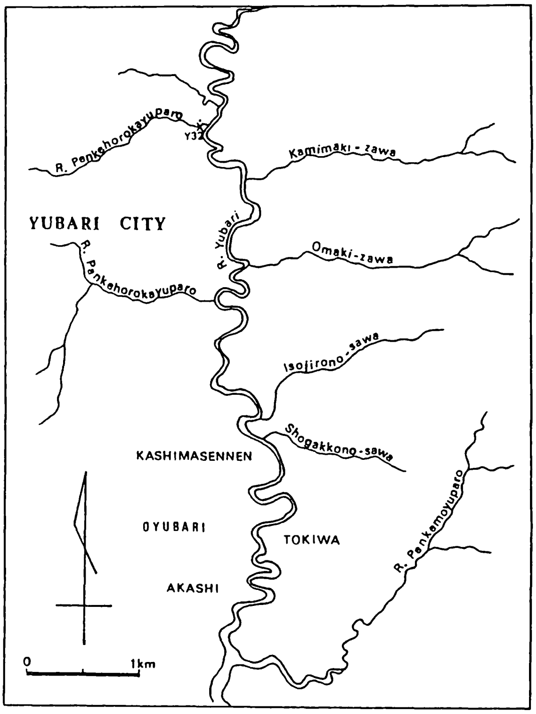


Text-fig. 1. Basic morphology for measurements.
h: shell height, l: shell length, H: maximum length from umbo to ventral extremity, ga: growth axis, b: breadth of right and left valves respectively, s: length of hinge-line, α: anterior hinge angle, β: angle of umbonal inflation, γ: posterior hinge angle, δ: obliquity, angle between the growth axis and hinge-line, Ra: anterior radial ridge, Rm: median radial ridge, Rp: posterior radial ridge.

Types.—The repositories of the type specimens are as follows: KW: Yoshitaro Kawashita Collection and JG: Jonan Geological Association, Oita. Holotype: KW2002, loc. Y32, a cliff of the right bank of Penkehorokayuparo-zawa, about 50 m upstream from the confluence with the Yubari River, Oyubari area, Hokkaido. Sandy siltstone bed, the middle part of the Upper Yezo Group. Upper Coniacian. Paratypes: KW2001, loc. Ik9p, Misojino-sawa, a tributary of the Ikushumbets River, Mikasa area, Hokkaido. Stratigraphic position uncertain. KW2003, lower reaches of Echinai-zawa, a tributary of the Shimokinenbets River, Obira area, Rumoi-gun, Hokkaido. JG.H2893, loc. Ik10p, Misojino-sawa, in the sequence of the Zone of *I. mihoensis*, stratigraphic position precisely unknown. JG.H2876–2892, locs. Ik2707, 2708, cliffs of the left bank of the upper reaches of Gono-sawa (=Takiyoshi-zawa or Takino-sawa), a tributary of the Pombets River, Mikasa area. Middle part of the Upper Yezo Group. The localities of the Oyubari and Mikasa areas are shown in Text-figs.



Text-fig. 2. Map showing localities of *Inoceramus* (*Cordiceramus*) *kawashitai*, n. sp. in the Ikushumbets area (Mikasa area), Hokkaido. A: Ikushumbets, B: Oyubari, C: Obira.

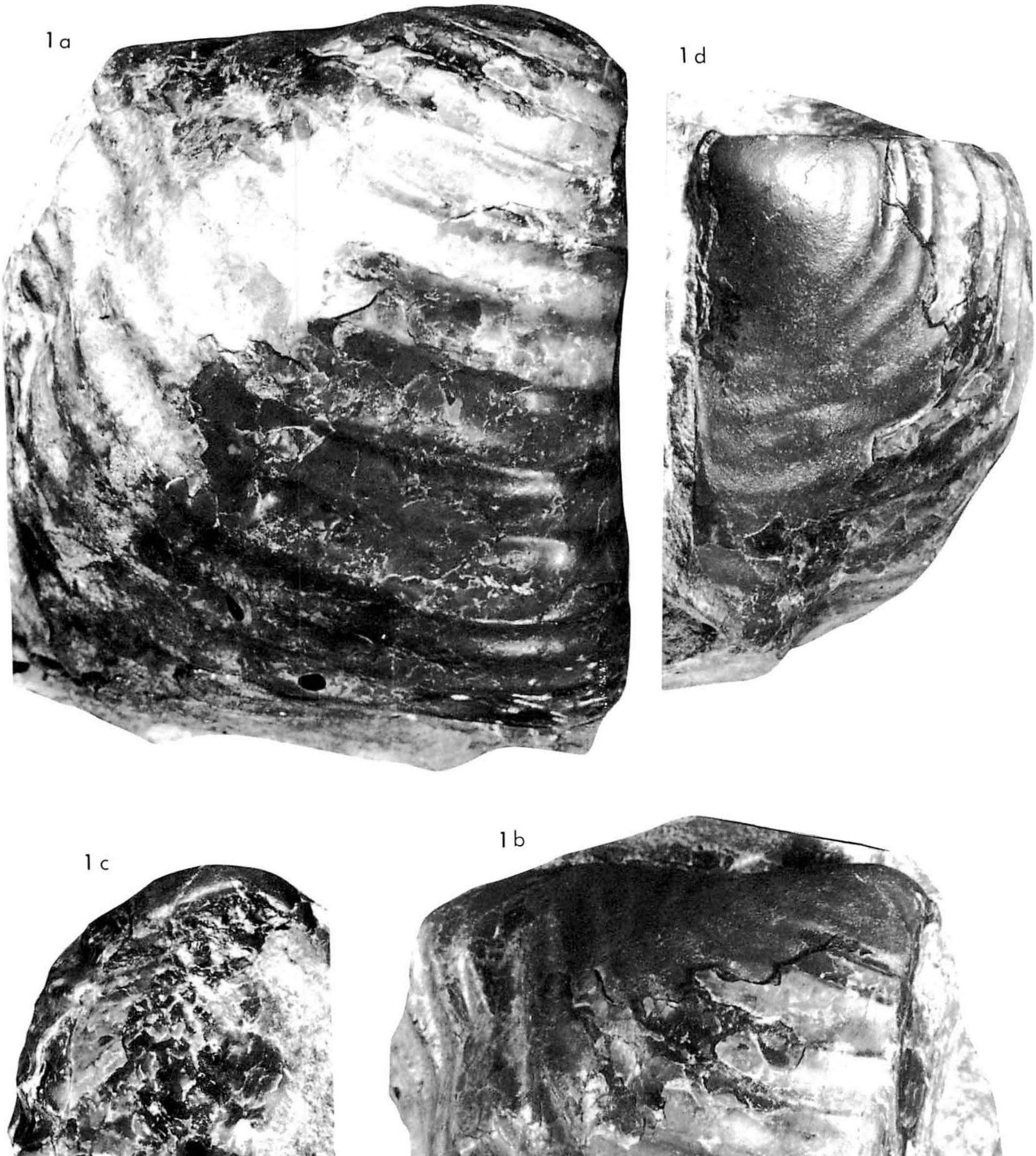


Text-fig. 3. The type locality of *Inoceramus* (*Cordiceramus*) *kawashitai*, n. sp. in the Oyubari area, Hokkaido.

Explanation of Plate 69

Figs. 1a–d. *Inoceramus* (*Cordiceramus*) *kawashitai*, sp. nov.

Paratype, KW2001, from loc. Ik9p, floated nodule of the Misojino-sawa, a tributary of the Ikushumbets River, Mikasa area, Hokkaido. Stratigraphic position uncertain (collected by Kawashita, 1980). a: lateral view, b: dorso-lateral view, c: anterior view and d: dorsal view, natural size.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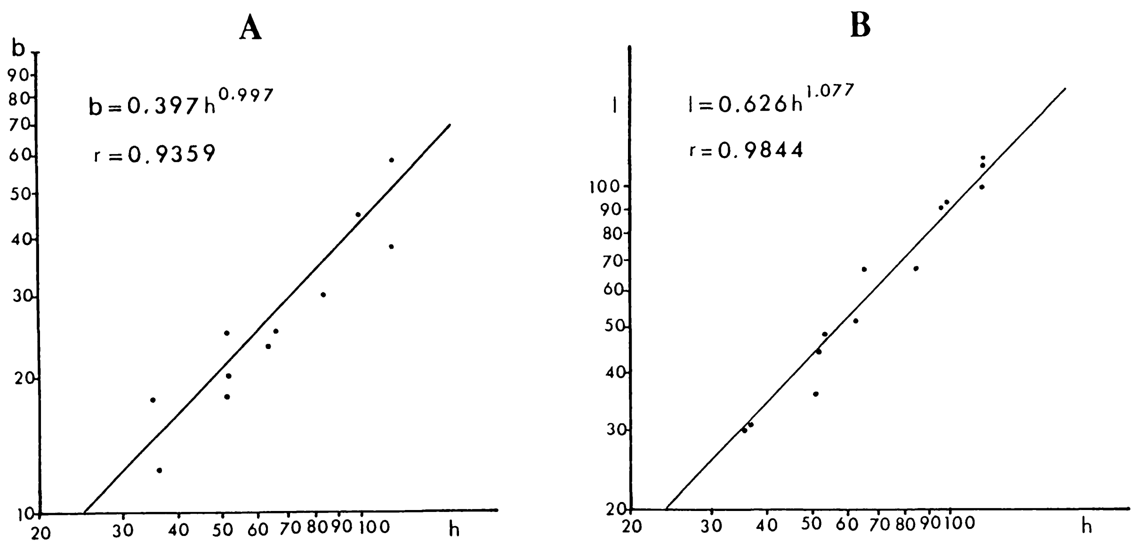
2 and 3.

Material.—Twenty-one specimens are concerned with the description, of which 14 are used for measurements and statistics.

Diagnosis.—Shell of medium size, equivalve or subequivalve and considerably inflated. Anterior part broad, abruptly bent from the flank and perpendicular to the valve plane. Marginal outline subpentagonal to subquadrate. Wing-like area developed with steep slope from the main part of the flank. Hinge-line long about two thirds of shell length.

Surface ornamented with concentric ribs of irregular intensity. Three ridges developed radially from the umbonal region. The anterior one most prominent and demarcates sharply the anterior part from the flank, the median ridge conspicuous along the growth axis in young stage and gradually weakened with growth, and the posterior one borders the posterior slope and the main part of flank.

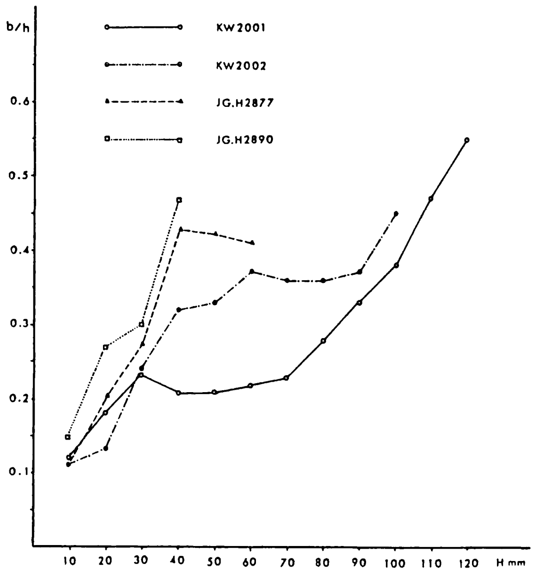
Description.—In general, either of two valves is displaced dorso-ventrally along the commissure plane, giving consequently a superficially inequivalve aspect. For example, in the specimens JG.H2876 (Pl. 71, Figs. 1a—d) and 2877 (Pl. 72, Figs. 1a—d), the right valve is slided toward the venter, and the left umbo is considerably projected above the hinge-line; to the contrary, in the specimens JG.H2883 (Pl. 71, Fig. 2) and 2884 (Pl. 72, Figs. 2a—b), the left valve is displaced toward the venter. The specimen JG.H2881 (Pl. 73, Fig. 5), which is not diplaced secondarily, shows clearly the equivalveness. As is demonstrated in Text-figs. 5 and 6, in some specimens (*i.e.*, JG.H2877 and 2890), shell is considerably inflated along the growth axis and antero-posteriorly in younger stages and gradually decreasing its convexity with growth, whereas in the full grown individuals, such as KW2001 and KW2002, the shell convexity changes abruptly at variable growth stages. Umbo is terminal, considerably curved inwards and forwards. Anterior part is truncated, broad, and bent angularly from the main part of the flank and concaved in itself, forming an obtuse angle with the valve plane. Postero-dorsal part inclined steeply, passing to the wing-like area. The boundary between postero-dorsal and wing-like areas is comparatively clear in the specimens KW2001 and 2002, but



Text-fig. 4A. Diagram showing the average relative growth of breadth to shell height in *I.* (*C.*) *kawashitai*, n. sp. 4B: Diagram showing the average relative growth of shell length to shell height in *I.* (*C.*) *kawashitai*, n. sp.

in the specimens from Gono-sawa, that is, JG.H2877, 2883, 2887, 2890, 2891, and 2892, the two parts gradually pass from each other without any sharp boundary.

Anterior margin is long and straight, forming nearly a right angle with the ventral margin. In younger individuals, such as JG.H2880, 2885, 2888 and 2890, the ventral margin is bent with an obtuse angle at about the center which corresponds to the end of the growth axis, and passed gradually into a broadly rounded postero-ventral margin. In the full grown individuals, such as KW2001, 2002, JG.H2891 and 2893, the ventral margin is nearly straight; postero-ventral margin



Text-fig. 5. Diagram showing the ontogenetic change of shell convexity in *I. (C.) kawashitai*, n. sp.

narrowly curved and posterior margin forms an angle of about 100°—117° with the hinge-line which is about two thirds of shell length on average.

Concentric ribs are low, acute-topped, separated by concave interspaces, and generally irregular in intensity. In the umbonal region they are fairly crowded but in some individuals much weakened and hardly discernible. In some specimens (*e.g.*, JG.H2877, 2891), minor concentric riblets are developed on the interspaces. Concentric ribs continue from the main part of flank to the postero-dorsal slope, being gradually weakened on the wing-like area and hardly visible at near the hinge. They are also comparable weakened on the anterior part. Three radial ridges run from about 20 mm behind the umbo to the ventral margin. The anterior one is most prominent and demarcates sharply the boundary between the flank and anterior region. The median one runs along the growth axis, which is much conspicuous in the young shell of about 40 — 60 mm in height, and it becomes weak gradually with growth and inclines somewhat posteriorly. The posterior one is less conspicuous, demarcating the postero-dorsal slope from the flank. Concentric ribs are bent at the intersections with the radial ridges. On some specimens (*e.g.*, JG.H2876, 2877), many granular substances are scattered irregularly on the inner surface of shell, which may be pearl-like substance.

Biometry.—The measurements and biometric characters are shown in Tables 1 and 2, respectively. The relative growth between two relation shows generally allometric. In general, it is more satisfactory that the allometric characters are

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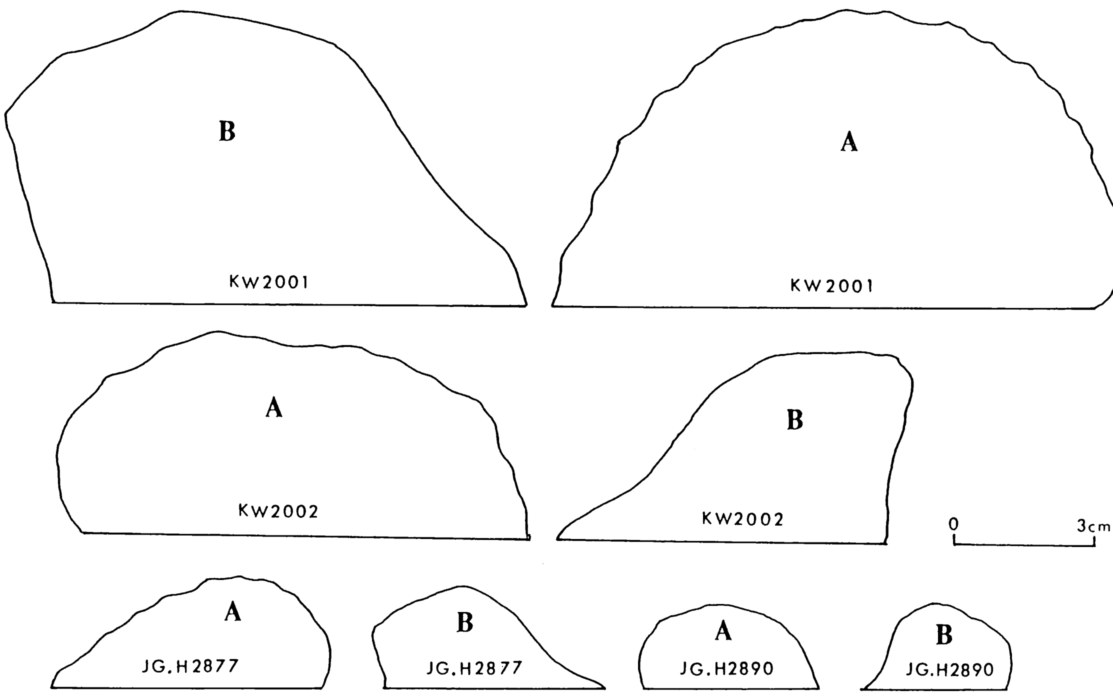
Explanation of Plate 70

Figs. 1a—2b. *Inoceramus (Cordiceramus) kawashitai*, sp. nov.

Figs. 1a—c. Holotype, KW2002, from loc. Y37, a cliff of the right bank of the Penkehorokayuparo-zawa about 50 m upstream from the confluence with the Yubari River, Oyubari area, Hokkaido. Stratigraphic position: middle part of the Upper Yezo Group (collected by Kawashita, 1981). a: lateral view, b: anterior view and c: dorsal view, natural size.

Figs. 2a—b. Paratype, KW2003, floated nodule of the Echinai-zawa, a tributary of the Shimokinenbets River, Obira area, Rumoi-gun, Hokkaido. Stratigraphic position uncertain (collected by Kawashita, 1981). a: lateral view, b: anterior view, natural size.


1b
1a
2a
2b
1c



Text-fig. 6. Cross section of *I.* (*C.*) *kawashitai*, n. sp.
A: vertical section along the growth axis.
B: transverse section from anterior to posterior.

compared at a certain growth stage. However, on the present species, even if the allometric characters are examined under such a condition, the numerical values calculated statistically would not be so significant, because the shell convexity and the marginal outline change abruptly at various stages of growth. This allows us to summarize totally the characters regardless of the difference in growth stage of the examined specimens.

The average relative growth is examined on the two relations, shell height (h) versus shell length (l), and shell height (h) versus breadth (b). (h) in abscissa and (l) and (b) in ordinate are plotted on logarithmic graph papers. The slope of the reduced major axes (α) and also Y intercepts (β) and the correlation coefficients (r) are calculated, respectively. These are shown in Table 3. Based on Table 3, the reduced major axes are demonstrated in Text-figs. 4a and 4b. The growth indices (α), the null hypothesis of isometry cannot be rejected considering the correlation coefficient and sample size (see Hayami and Matsukuma, 1971, p. 150—151).

The ontogenetic change of shell convexity in the selected specimens is shown in Text-fig. 5. The transverse section and vertical section along the growth axis of the same specimens are demonstrated in Text-fig. 6.

Remarks.—As is evident from Text-figs. 5 and 6, the ontogenetic change of shell convexity and the intensity of median ridge are closely related to the changes of transverse section, vertical section and marginal outline. These characters are variable among individuals and with growth stages.

To sum up, the present species shows a considerable extent of variation not only in the biometric characters but also in the characters hardly examined numerically. As is clarified from Table 2, the Pearson's coefficient of variation (v) of the angles α, β, γ and δ, and a simple ratio

Table 1. Measurements of *Inoceramus* (*Cordiceramus*) *kawashitai*, n. sp. linear dimension in mm.

specimen	v	h	l	b	s	α	β	γ	δ	l/h	s/l	b/h	remarks
KW2001	R	121.2	115.0	58.6	88.0	99°	82°	105°	68°	0.95	0.77	0.48	
KW2002	L	100.5	92.0	44.6	53.4	117°	75°	100°	65°	0.92	0.58	0.44	
KW2003	L	121.4	111.2	38.6	57.0	98°	75°	118°	68°	0.92	0.51	0.32	
JG.H2876	R	52.3	45.7	18.9	-	116°	80°	-	73°	0.87	-	0.36	
JG.H2876	L	52.5	45.7	25.0	-	117°	81°	-	74°	0.87	-	0.48	
JG.H2877	R	67.5+	67.7	25.4	41.0	97°	80°	100°	68°	(1.00-)	0.61	0.38	
JG.H2877	L	85.0	67.7	30.4	41.0	97°	80°	100°	76°	0.80	0.61	0.36	
JG.H2879	L	(119.3)	(99.7)	-	54.5	(96°)	(79°)	116°	(77°)	(0.84)	(0.56)	-	crushed
JG.H2883	L	63.6	51.4	23.0	39.7	98°	78°	107°	72°	0.81	0.77	0.36	
JG.H2885	R	51.4	36.3	18.0	25.0	115°	79°	98°	71°	0.71	0.69	0.35	
JG.H2887	R	54.3	48.6	-	33.4	98°	81°	113°	70°	0.90	0.69	-	
JG.H2888	R	37.4	31.6	12.5	23.0	109°	83°	105°	65°	0.84	0.73	0.33	
JG.H2890	L	36.6	30.8	18.0	20.3	118°	78°	117°	68°	0.84	0.66	0.49	
JG.H2893	R	(97.3)	(91.5)	(26.5)	48.5	(118°)	(87°)	109°	(74°)	(0.94)	(0.53)	(0.27)	crushed

v: valve, h: shell height, l: shell length, b: breadth, s: length of hinge-line, α: angle between anterior margin and hinge-line, β: angle of umbonal inflation, γ: angle between posterior margin and hinge-line, δ: obliquity, angle between growth axis and hinge-line, l/h: simple ratio of shell length to shell height, s/l: simple ratio of hinge-line to shell length, b/h: simple ratio of breadth to shell height, L: left valve, R: right valve.

l/h are all of small values, which indicate probably the stable characters for the species.

Every species assigned to *Cordiceramus* is characterized by peculiar marginal outline, convexity and surface ornamentations, which are, in general, hardly expressed biometrically, however these characters are rather important for the specific criteria. Furthermore, the ontogenetic change of these characters may be useful for the consideration of phylogenetic relationships with allied species.

Comparison.—The young specimens of the present new species is similar to *Inoceramus* (*Cordiceramus*) *cordiformis purus* Seitz, 1961,

Explanation of Plate 71

Figs. 1a—3. *Inoceramus* (*Cordiceramus*) *kawashitai*, sp. nov.

Paratypes, from loc. Ik2708, upper reaches of the Pombets Gono-sawa (=Takiyoshi-zawa or Takino-sawa), Mikasa area (Ikushumbets area), Hokkaido. Stratigraphic position: middle part of the Upper Yezo Group (collected by Matsumoto, Uchida, Takahashi and Noda, 1983), natural size.

Figs. 1a—d. JG.H2876, closed valves, right valve displaced towards the venter along the commissure plane. a: lateral view of right valve, b: lateral view of left valve, c: anterior view and d: dorsal view.

Fig. 2. JG.H2883, closed valves, left valve displaced towards the venter along the commissure plane. Lateral view of left valve.

Fig. 3. JG.H2887, right valve.

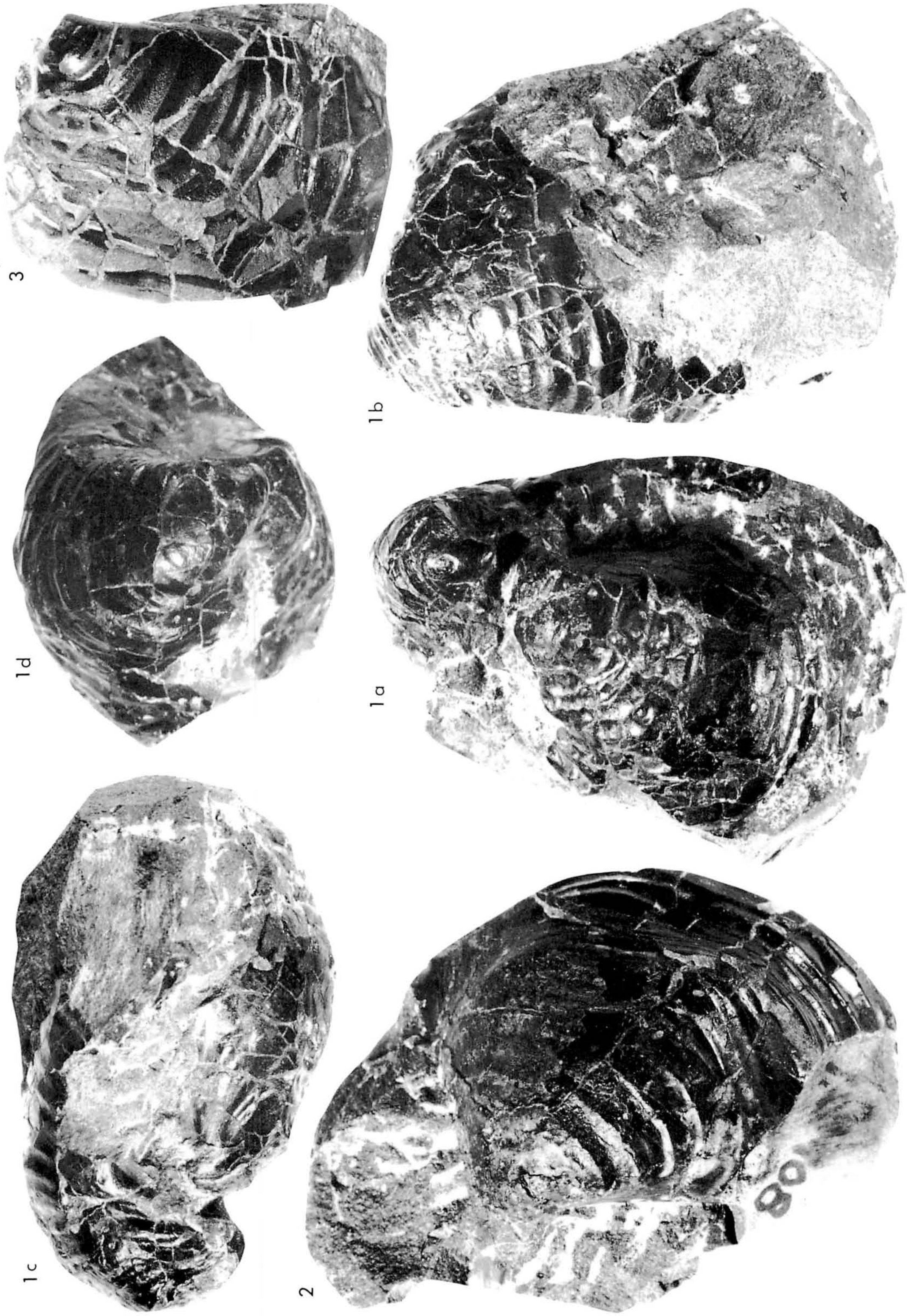

3
1b
1d
1a
1c
2

Table 2. Biometric characters of *Inoceramus* (*Cordiceramus*) *kawashitai*, n. sp.

	α	β	γ	δ	l/h	s/l	b/h
N	12	12	12	12	10	10	11
m	106.6°	79.3°	107.3°	69.8°	0.875	0.662	0.369
s	9.41°	3.78°	7.24°	3.46°	0.0678	0.0837	0.0640
v	8.83	4.77	6.98	4.96	7.91	12.64	16.16

N: sample size, m: mean value, s: standard deviation, u: Pearson's coefficient of variation.

Table 3. Data of the average relative growth of *Inoceramus* (*Cordiceramus*) *kawashitai*, n. sp.

	α	β	logβ	$\bar{h}'$	$\bar{l}'$	$\bar{b}'$	r	N
l and h	1.077	0.626	0.20344	1.84412	1.78268		0.9844	14
T and h	0.997	0.397	0.40200	1.81984		1.41165	0.9359	11

α: growth index (slope of the reduced major axis), β: Y intercept, $\bar{h}'$: mean of h' (h'=log h), $\bar{l}'$: mean of l' (l'=log l), $\bar{b}$: mean of b' (b'=log b), r: correlation coefficient, N: sample size.

from the Santonian of Henrichenburg, West Germany, in the pentagonal margin with three radial ridges, considerably inflated shell and weak concentric ornamentations but gradually differs from that subspecies with growth. For instance, in the present new species the concentric ribs become more conspicuous and the median radial ridge is weakened with growth. The full grown specimen of this new species is clearly distinguished from that subspecies in its subquadrate marginal outline and trapezoidal transverse section.

The present new species also resembles *I.* (*C.*) *cordiformis gravis* Seitz, 1967, from the Middle to Upper Santonian of Galdbeck and other areas in West Germany, in its much inflated shell, ontogenetic change of the shell convexity, three radial ridges, truncated anterior part and irregular surface ornamentation, but discriminated from the subspecies in that its umbo is terminal, anterior margin nearly straight or slightly concave, the median and posterior ridges not so strong as those of *L.* (*C.*) *cordiformis gravis* and the depression between the two radial ridges is inconspicuous.

The specimens from the lowest part of the Middle Santonian of the Niobrara Formation, Colorado were assigned to *I.* (*C.*) *cordiformis* and its affinity by Scott and Cobban (1964, pl. 7, figs. 1, 2; pl. 10, figs. 3, 5). Seitz (1965, p. 131) regarded these specimens as belonging to a group of *I.* (*C.*) *cordiformis* with some comments. A specimen USNM 131513 (Scott and Cobban, 1964, pl. 7, fig. 1) somewhat resembles the specimens of the present species, but the American specimen is clearly discriminated from those of the present species in the following characters, that is, the anterior ridge is more prominent, a radial groove runs somewhat posteriorly along the anterior ridge, and a shallow depression developes between the median and posterior ridges. Another specimen USNM 131514 also resembles the specimens of the present species but it differs from the latter in its small beak angle (β=ca. 65°) and clearly demarcated posterior wing.

A specimen JG.H2884 which is somewhat deformed secondarily, resembles the specimens of *Inoceramus ernsti* Heinz, 1928 (Woods, 1911, text-fig. 45; Heinz, 1933, p. 250, pl. 19, fig. 1;

I. deformis of Scott and Cobban, 1964, pl. 1, see Seitz, 1965, p. 130; Tröger, 1967, p. 128, pl. 14, figs. 1–6) from the Coniacian of Europe, North America and Madagascar in the weak radial ridges, small beak angle and truncate anterior region, but it differs from that species in its terminal umbo, and somewhat crowded and irregular concentric ornaments. Considering the secondary deformation, the specimen seems to be within the extent of variation of the present species.

The present new species somewhat resembles *Inoceramus selwyni* McLearn, 1926 (p. 122, pl. 21, figs. 8–9) from the *Scaphites venticosus* Zone of the Smoky River Formation, Alberta, Canada, in the anteriorly situated umbo, truncated anterior part, nearly straight or slightly concave anterior margin and high outline, but the Canadian species has a weak groove along the growth axis, coarser concentric ornaments, circular ventral margin and no radial ridge.

The specimens JG.H2877 and 2887, which are crushed diagonally towards the posterior part, resemble *I.* (*C.*) *brancoiformis* Seitz, 1961 from the Upper Santonian of Recklinghausen, West Germany, and also a specimen figured by Scott and Cobban (1964, pl. 10, fig. 5). But it would be superficial resemblance caused by secondary deformation.

Inoceramus iburiensis Nagao et Matsumoto, 1939 from the upper part of the Middle Turonian to the lower part of the Upper Turonian also closely resembles the present new species, in transverse section at a certain stage of growth (see Matsumoto, 1981, p. 18, fig. 1; p. 20, fig. 3) and higher marginal outline with nearly straight ventral margin, but *I. iburiensis* is inequivalve and belongs to *I.* (*Inoceramus*) and has much coarser concentric ribs and radial depression on the flank and no radial ridge on the umbonal region.

The young specimen of the present new species is similar to *Inoceramus yuasai* Noda, 1974 from the Campanian of Shikoku in the anteriorly placed umbo, pentagonal margin, abrupt change of shell convexity and the presence of radial ridges. *I.* (*C.*) *kawashitai* is distinct from the latter in its more inflated umbonal region which has weaker ornaments, small angle of α and γ, less obliquity and subquadrate outline in the adult stage.

Occurrence.—1. Loc. Y32, Penkehorokayuparo-zawa, Oyubari area, Hokkaido. Zone of *I. mihoensis*, Upper Coniacian, associated with small individuals of *Mytiloides*, *Gaudryceras* sp. and *Damesites* sp. Stratigraphic position: Middle part of the Upper Yezo Group (for stratigraphy, see Matsumoto, 1942, and Matsumoto and Haraguchi, 1978). 2. Locs. IK9p and IK10p, Misojino-sawa, Ikushumbets area, Hokkaido. In the sequence of the Zone of *I. mihoensis* of the Upper Coniacian (Matsumoto, 1977). Stratigraphic position: precisely unknown. 3. Loc. 3p. Okumatazawa, Ikushumbets area. Together with the pebbles containing *Inoceramus amakusensis* Nagao et Matsumoto which is a zonal index of the Lower Santonian of Japan (Matsumoto, 1977). Stratigraphic position: uncertain. 4. Locs.

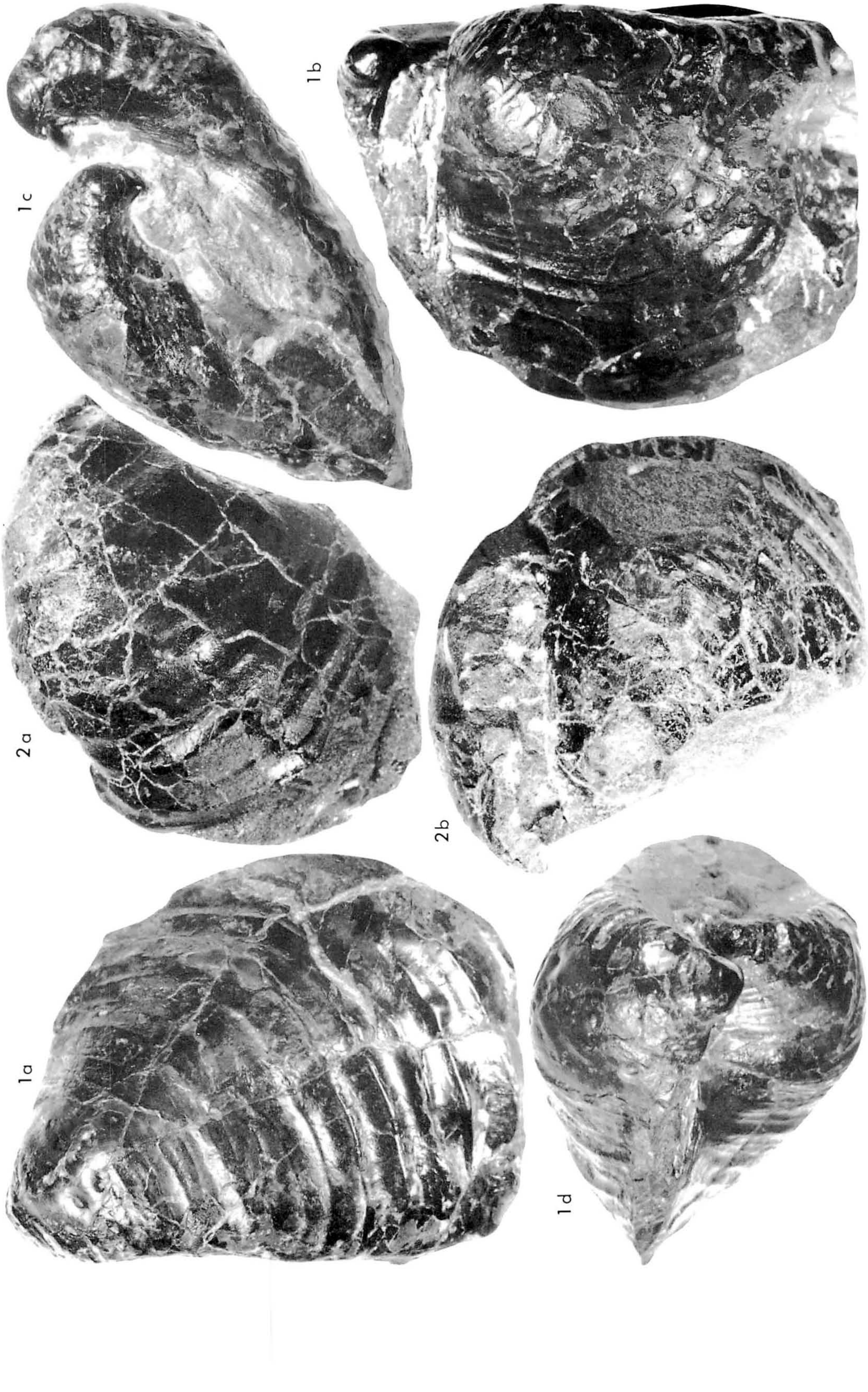
Explanation of Plate 72

Figs. 1a–2b. *Inoceramus* (*Cordiceramus*) *kawashitai*, sp. nov.

Paratypes, from locs. Ik2707, 2708, upper reaches of the Pombets Gono-sawa (=Takiyoshizawa or Takino-sawa), Mikasa area, Hokkaido. Stratigraphic position: middle part of the Upper Yezo Group, natural size.

Figs. 1a–d. JG.H2877 from loc. Ik2708, closed valves, right valve displaced towards the venter along the commissure plane. a: lateral view of left valve, b: lateral view of right valve, c: anterior view and d: dorsal view (collected by Sanada, 1982).

Figs. 2a–b. JG.H2884 from loc. Ik2707 somewhat higher than Ik2708, closed valves, left valve displaced towards the venter along the commissure plane. a: lateral view of right valve, b: lateral view of left valve (collected by Matsumoto, Uchida, Takahashi and Noda, 1983).


1c
1b
2a
2b
1a
1d

Ik2707 and 2708. Upper reaches of the Pombets-Gono-sawa (Takiyoshi-zawa or Takino-sawa), Ikushumbets area. Zone of *I. mihoensis*, Upper Coniacian, associated with *I. mihoensis* and *I.* (*P.*) *yubariensis*. Stratigraphic position: Middle part of the Upper Yezo Group (for stratigraphy, see Matsumoto, 1984, and Matsumoto and Noda, 1985). 5. Echinai-zawa, Obira area, Hokkaido. Stratigraphic position: uncertain.

Conclusion

To sum up, the present new species, *Inoceramus* (*Cordiceramus*) *kawashitai*, is not identical with any other allied species previously described so a new species is established in this paper and the specific name is dedicated to Mr. Yoshitaro Kawashita.

The occurrence of numerous specimens of the species from the Upper Coniacian is very significant not only as the zonal index of that stage but also to consider the phylogeny of the subgenus *Cordiceramus* because the present occurrence represents a lower part of the range of the subgenus as Kauffman (1977) pointed out.

Noda and Matsumoto (1976) have already shown the range of *I. cordiformis* from Japan without palaeontological description, but it is necessary to describe more clearly the taxonomy and succession of *I.* (*Cordiceramus*) species of Japan. This is beyond the scope of the present paper.

References

Hayami, I. (1969): Mensuration of fossils and statistics — An example of palaeontological exercise —. *Sci. Repts., Dept. Geol., Kyushu Univ.*, vol. 10, no. 2, p. 67—90 (in Japanese with English abstract).

—— and Matsukuma, A. (1971): Mensuration of fossils and statistics — Analysis of allometry and variation —. *Ibid.*, vol. 10, no. 3, p. 135-160 (in Japanese with English abstract).

Heinz, R. (1928): Das Inoceramen Profil der oberen Kreide Lüneburgs. Mitt Anführung der neuen Formen und deren Kennzeichnung. *Jber. Nieders. Geol. Ver.*, vol. 21, p. 63—81, pls. 1—2.

——(1933): Inoceramen von Madagaskar und ihre Bedeutung für die Kreidestratigraphie. *Z. deutsch. geol. Ges.*, Vol. 85, p. 241—259.

Kauffman, E. G. (1977): Systematic, biostratigraphic and biogeographic relationships between Middle Cretaceous Euramerican and North Pacific Inoceramidae. Mid-Cretaceous Event — Hokkaido Symposium, 1976 —. *Palaeont. Soc. Japan, Special Papers*, no. 21, p. 196—212.

Matsumoto, T. (1942): Fundamentals in the Cretaceous stratigraphy of Japan. Part 1. *Mem. Fac. Sci., Kyushu Imp. Univ., Ser. D*, vol. 1, no. 3, p. 129—280, pls. 5—20.

——(1977): Zonal correlation of the Upper Cretaceous in Japan. Mid-Cretaceous Events — Hokkaido Symposium, 1976 —. *Palaeont. Soc. Japan, Special Papers*, no. 21, p. 63—74.

——(1981): The specimens of *Inoceramus* (Bivalvia) donated to the Kitakyushu Museum of National History. *Bull. Kitakyushu Mus., Nat. Hist.*, no. 3, p. 15—26, pls. 2—5 (in Japanese with English abstract).

——(1984): The so-called Turonian-Coniacian boundary in Japan. *Bull. Geol. Soc. Denmark*, vol. 33, p. 171—181.

—— and Haraguchi, Y. (1978): A new texanitine ammonite from Hokkaido (Study of Cretaceous ammonites from Hokkaido and Saghalien 34). *Trans. Proc., Palaeont. Soc. Japan, N.S.*, no. 110, p. 306—318, pl. 42.

—— and Noda, M. (1985): A note on an inoceramid species (Bivalvia) from the Lower Coniacian (Cretaceous) of Hokkaido. *Ibid.*, no. 140, p. 263—273, pls. 41—44.

McLearn, F. H. (1926): New species from the Coloradoan of Lower Smoky and Lower Peace Rivers, Alberta. *Nat. Mus. Canada, Geol. Ser.*, no. 45, p. 117—126, pls. 20—23.

Nagao, T. and Matsumoto, T. (1939): A monograph of the Cretaceous *Inoceramus* of Japan. Part 1. *Jour. Fac. Sci., Hokkaido Imp. Univ., Ser. 4*, vol. 4, nos. 3—4, p. 241—299, pls. 23—34.

Noda, M. (1974): A new species of *Inoceramus* from the Shimantogawa Group of south Shikoku. *Trans. Proc. Palaeont. Soc. Japan, N.S.*, no. 93, p. 240—248, pl. 34.

——(1975): Succession of *Inoceramus* in the

Upper Cretaceous of Southwest Japan. *Mem. Fac. Sci., Kyushu Univ., Ser. D*, vol. 23, no. 2, p. 211—261, pls. 32—37.
——(1979): Nomenclatorial survey on *Inoceramus balticus* Böhm and related species. *Fossils*, no. 29, p. 107—121, pls. 1, 2 (in Japanese).
——(1983): Notes on so-called *Inoceramus japonicus* (Bivalvia) from the Upper Cretaceous of Japan. *Trans. Proc., Palaeont. Soc. Japan, N.S.*, no. 132, p. 191—219, pls. 41—46.
——and Matsumoto, T. (1976): *Atlas of Japanese Fossils*, 45, Mesozoic molluscan fossils of Japan 4 (Cretaceous *Inoceramus* 1—6). 24 pp. (in Japanese), Tsukiji-Shokan, Tokyo.
Scott, G. R. and Cobban, W. A. (1964): Stratigraphy of the Niobrara Formation at Pueblo, Colorado. *U.S. Geol. Surv. Prof. Paper*, 454-L, L1—L30, pls. 1—11.
Seitz, O. (1961): Die Inoceramen des Santon von Nordwestdeutschland. *Beih. Geol. Jb.*, vol. 46, p. 1—186, pls. 1—15.
——(1965): Die Inoceramen des Santon und Unter Campan von Nordwestdeutschland. Teil. II. *Ibid.*, vol. 69, p. 1—194, pls. 1—26.
——(1967): Die Inoceramen des Santon und Unter Campan von Nordwestdeutschland. Teil. III. *Ibid.*, vol. 75, p. 1—171, pls. 1—27.
Tröger, K. A. (1967): Zur Paläontologie, Biostratigraphie und faziellen Ausbildung der unteren Oberkreide (Cenoman bis Turon). Teil I. Paläontologie und Biostratigraphie der Inoceramen des Cenomans bis Turons Mitteleuropas. *Abh. Staatl. Mus. Mineral. Geol.*, vol. 12, p. 13—207, pls. 1—14.
Woods, H. (1910—1911): A monograph of the Cretaceous Lamellibranchia of England. *Palaeontgr. Soc. Mon., London*, vol. 2, part 7, *Inoceramus*. p. 261—284, pls. 44—50; part 8, *Inoceramus*. p. 285—340, pls. 51—54.

Echinai-zawa エチナイ沢, Gono-sawa 五の沢, Ikushumbets 幾春別, Iwamizawa 岩見沢, Kita-kyushu 北九州, Mikasa 三笠, Minami-Oita 南大分, Misojino-sawa 三十路の沢, Obira 小平, Obira-shibe 小平蘂, Oita 大分, Oyubari 大夕張, Penkehorokayuparo-zawa ペンケホロカユウパロ沢, Pombets 奔別, Rumoi-gun 留萌郡, Sapporo 札幌, Shimantogawa 四万十川, Shimokinenbets 下記念別, Takino-sawa 滝の沢, Takishita 滝下, Takiyoshi-zawa 滝吉沢, Yezo エゾ, Yubari 夕張.

Explanation of Plate 73

Figs. 1—5. *Inoceramus* (*Cordiceramus*) *kawashitai*, sp. nov.

Paratypes from locs. Ik2707, 2708, upper-reaches of the Pombets Gono-sawa (=Takiyoshi-zawa or Takino-sawa), Mikasa area, Hokkaido. Stratigraphic position: middle part of the Upper Yezo Group, natural size.

Fig. 1. JG.H2891 with weak radial ridges.

Fig. 2. JG.H2888.

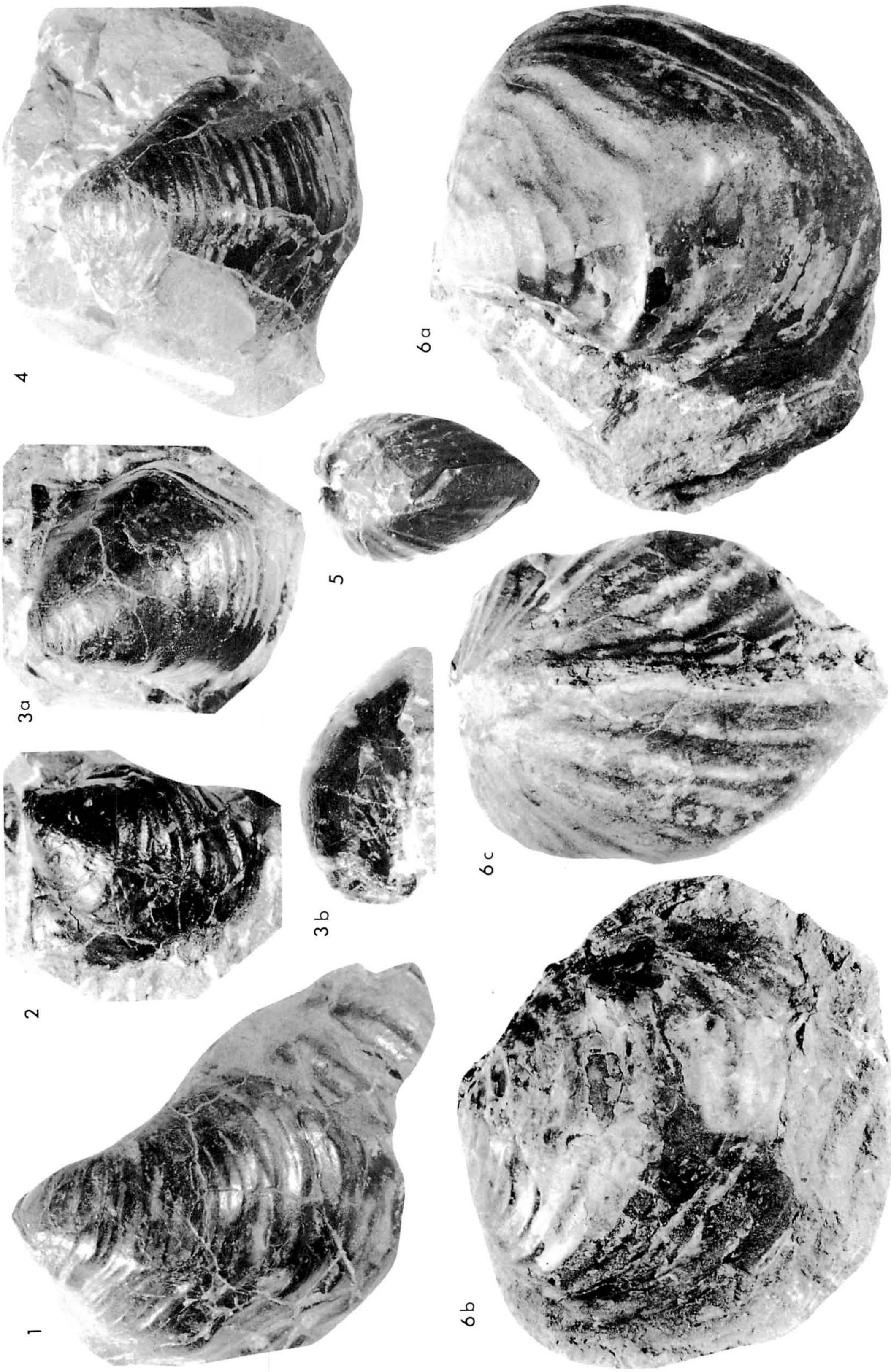
Figs. 3a—b. JG.H2890, a: lateral view, b: anterior view.

Fig. 4. JG.H2885 showing the regular, somewhat crowded concentric ribs.

Fig. 5. JG.H2881, closed valves, anterior view showing the equivalveness. Posterior half eroded out (collected by Matsumoto, Uchida, Takahashi and Noda, 1983).

Figs. 6a—c. *Inoceramus* (*Cordiceramus*) sp. cf. *I.* (*C.*) *kawashitai*, sp. nov.

JG.H2901, from floated nodule in the Obirashibe River, at Takishita, Obira area, Hokkaido. Stratigraphic position uncertain, ×0.8. a: left valve, b: right valve, c: posterior view showing the equivalveness (collected by Shimanuki, 1984).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6b
6c

北海道コニアシアン階上部から産出した *Inoceramus* (*Cordiceramus*) の新種について：北海道大夕張，幾春別，小平地域に露出するコニアシアン階上部の地層から産出した *Inoceramus* にはきわめて特徴ある形態を示すものがある。これについて，従来の研究方法に加えて，生物測定学的手法により，いくつかの形質の変異や平均相対成長の検討を試みた。その結果，等殻ないしは等殻に近く，大きな膨らみ，四辺形または五角形の輪かく，放射状に発達する3条の稜などは *Inoceramus* の亜属 *Cordiceramus* の模式種である *I.* (*C.*) *cordiformis* Sowerby の特徴に共通する点が多いが，類縁種と詳細に比較するとき，成長にともなう輪かくや装飾の変化など，これまでに知られた何れの種にも該当しないので，ここに新種として記載する。種名 *Inoceramus* (*Cordiceramus*) *kawashitai* は本研究に協力いただいた川下由太郎氏に献名したものである。本種は北海道各地のコニアシアン階上部から *Inoceramus mihoensis* Matsumoto や *I.* (*Platyceramus*) *yubariensis* Nagao et Matsumoto にともなって多産するので，将来，他の地域からも検証されるならば，有効な帯指示化石の1つとなることが期待される。また，本種は *Cordiceramus* としては産出層準が古く，その系統発生を考察する上に重要であるが，これについては本論では論及せず，その検討を今後に委ねた。　野田雅之

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 142, pp. 366—392, pls. 74—77, June 30, 1986

813. LOWER CRETACEOUS BIVALVES FROM THE SAKAWA AREA, SHIKOKU

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Abstract. This paper deals with the description of bivalve fossils from the Lower Cretaceous System of the Sakawa area, Shikoku. Thirty-three species of 24 genera, including four new species, *i.e.*, *Cosmetodon tomochiensis*, sp. nov., *Parvamussium tosaense*, sp. nov., *Parvamussium kattoi*, sp. nov. and *Protocardia* (*Protocardia*) *amanoi*, sp. nov., are described from various localities in this area. The bivalve fauna of the Bunjo Formation is nearly identical with that of the Aptian Hagino Formation of the Monobe area, Shikoku. Judging from the bivalve fauna and associated ammonites, the Yotsushiro Formation and the upper member of Tosakamo Formation are closely similar in their faunal compositon to each other and are probably correlated with the upper part of the Hibihara Formation (mainly Albian) of the Monobe area. The faunas of the lower member of Tosakamo Formation and Kurohara Formation closely resemble that of the lower part of the Hibihara Formation (mainly Aptian), having many common species among them. Although the geological age of the lower member of Tosakamo Formation, inclusive of the Kurohara Formation, is suggested at the Apitan and nearly the same as the presumable age of the Bunjo Formation, the bivalve fauna of the Bunjo Formation is quite different from that of the lower member of Tosakamo Formation except for the occurrence of several worldwide bivalve species and ammonites. The difference is probably due to ecological dissimilarity between them.

Introduction

Sakawa in Kochi Prefecture, central Shikoku is well known for the Mesozoic geological investigations. The Cretaceous System of the Sakawa area has hitherto been treated stratigraphically, tectonically and palaeontologically by many authors. The palaeontological study, however, has not been achieved sufficiently. Recently we have obtained many specimens of bivalves from various localities of the Lower Cretaceous strata in this area. In addition to them, numerous specimens have been supplied to us by Dr. J. Katto of Kochi. Through the study of these materials 33 species under 24 genera of bivalves are distinguished. After the systematic description, we give remarks on the biostratigraphical implications of the faunas.

Received February 18, 1985; revised manuscript received April 10, 1986; read January 24, 1982 at University of Tokyo.

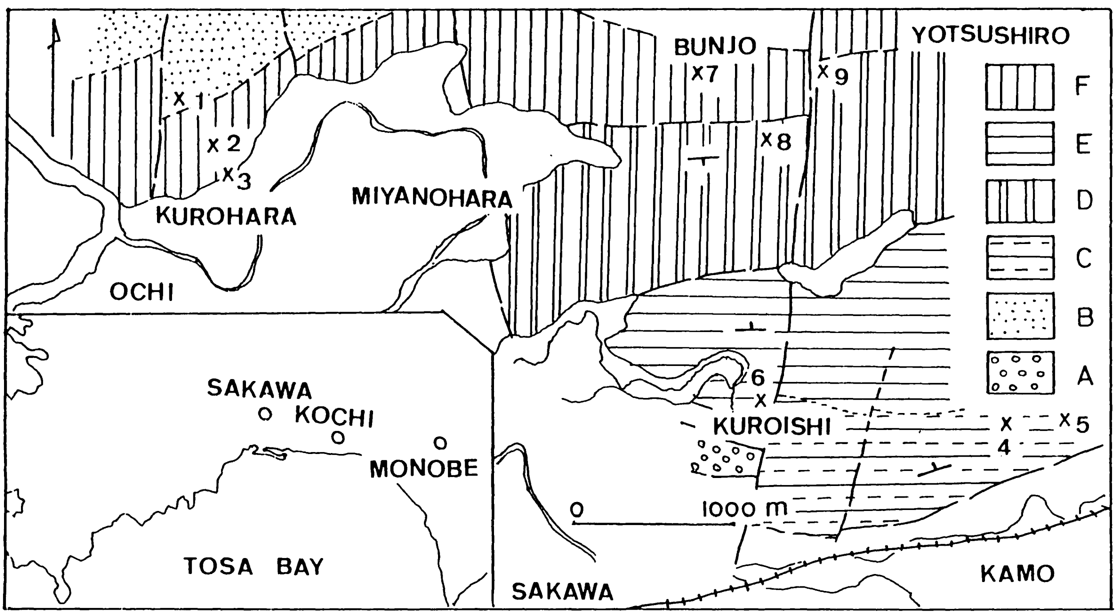
Before going further we wish to express our

sincere thanks to Prof. Emer. Tatsuro Matsumoto of Kyushu University for his reading the first draft of this paper, and giving valuable suggestions. We would like to express our hearty thanks to Prof. Emer. Jiro Katto of Kochi University for his supply of numerous specimens for our study and also to Mr. Masafumi Ito of Nara, for his kindness of several geological informations on this area for this study.

The specimens described in this paper are kept in the Department of Geology, Kochi University (KSG).

Geological setting

The Lower Cretaceous System of the Sakawa area consists of the Kaisekiyama (Aptian), Tosakamo (Aptian to Albian), Kurohara (Barremian to Aptian), Yotsushiro (mainly Albian), and Bunjo (Aptian) Formations (see Text-fig. 1; also see Tashiro, 1985). The lower member of Tosakamo Formation and Kurohara Formation are composed mainly of sandstone, and characterized by the occurrence of shallow marine bivalves. The former is distributed narrowly in the western part of the Sakawa basin, with the general trend of N 80°E. It is in fault contact with the Jurassic Torinosu Group (the belt of Kamo area) on the southern side and conformably overlain by the upper member of Tosakamo Formation. The latter is distributed in the northern part of the Sakawa basin, with the same trend as the Tosakamo Formation. It is in fault contact with the Paleozoic(?) strata on the northern side and is conformably covered by the Yotsushiro Formation on the southern side. Yotsushiro Formation is mainly composed of dark-gray siltstone and characterized by the occurrence of pure marine bivalves and ammonites. The upper member of Tosakamo Formation is also composed mainly of dark-gray siltstone, and several beds of conglomerate, about 50 m in each thickness, are intercalated in the lower part. Some pure marine bivalves and ammonites occur from



Text-fig. 1. Map showing the Cretaceous strata of the Sakawa Basin.
A: Kaisekiyama Formation, B: Kurohara Formation, C: lower member of Tosakamo Formation (= "Kaisekiyama Formation" by Katto and Tashiro, 1981), E: upper member of Tosakamo Formation (= "Yotsushiro Formation" by Katto and Tashiro, 1981; "Yunoki Formation" by Yamashita, 1961), F: Yotsushiro Formation, D: Bunjo Formation, X: fossil localities.

the siltstone.

The Bunjo Formation is characterized by the occurrence of many shallow marine bivalves from its fine- to medium-grained arenite sandstone, and intercalated narrowly between the Yotsushiro and Tosakamo Formations in the central part of the Lower Cretaceous area, bounded by faults on both northern and southern sides. The Kaisekiyama Formation is exposed very narrowly on and near the Kaisekiyama hills of Kamo in Sakawa, composed of coarse-grained sandstone and conglomerate, and contact with the "Paleozoic" strata on the northern side and with the Torinosu Group on the southern side. Several non-marine or brackish water species were reported from this formation by Kobayashi and Suzuki (1939) and Hirata (1974).

The Yamanokami Formation (not treated in this paper) is also very narrowly limited to the south of Torinosu, surrounded by the pre-Cretaceous rocks, bounded by the faults. Shallow marine bivalves, *e.g.*, *Pterotrigonia* (*Pterotrigonia*) *pocilliformis* (Yokoyama), *Nipponitrigonia convexa* Kobayashi, *N. sakamotoensis* (Yehara) and *Rutitrigonia yeharai* Kobayashi et Nakano, were described from the sandstone by Kobayashi (1957), and Kobayashi and Nakano (1957).

Systematic description

Class Bivalvia

Subclass Palaeotaxodonta

Order Nuculoida Dall

Superfamily Nuculacea Gray, 1824

Family Nuculidae Gray, 1824

Genus *Nuculopsis* Girty, 1911

Subgenus *Palaeonucula* Questedt, 1930

Nuculopsis (*Palaeonucula*) *ishidoensis* (Yabe et Nagao)

Pl. 74, Figs. 1–3.

1926. *Nucula ishidoensis* Yabe et Nagao, *in* Yabe, Nagao and Shimizu, *Sci. Rep., Tohoku Imp. Univ., Ser. 2*, vol. 9, no. 2, p. 41, pl. 13, figs. 46–47.
1965. *Nuculopsis* (*Palaeonucula*) *ishidoensis* (Yabe et Nagao); Hayami, *Mem. Fac. Sci., Kyushu Univ., Ser. D*, vol. 15, no. 2, p. 234.
1972. *Nuculopsis* (*Palaeonucula*) *ishidoensis* (Yabe et Nagao); Shikama and Suzuki, *Sci. Rept., Yokohama Nat. Univ., Ser. 2*, vol. 19, pl. 4, figs. 5–6.
1975. *Nuculopsis* (*Palaeonucula*) *ishidoensis* (Yabe et Nagao); Hayami, *Univ. Mus., Univ. Tokyo, Bull.*, no. 10, p. 20.
1980. *Nuculopsis* (*Palaeonucula*) *ishidoensis* (Yabe et Nagao); Hayami *in* Hayami and Oji, *Trans. Proc., Palaeont. Soc. Japan, N.S.*, no. 120, p. 423, pl. 51, figs. 1–6.

Materials:—KSG 3479—KSG 3480, external moulds, from Ujidani of Kamo, Sakawa; KSG 3481—KSG 3482, internal moulds from the same locality.

Measurements (in mm.):—

Specimens	Length	Height	Thickness
KSG 3479, l. ex. mol.	10.0	7.0	1.5
KSG 3480, ditto	10.1	7.2	2.0
KSG 3481, l. in mol.	11.3	8.4	—
KSG 3482, ditto	11.0	8.0	—

Remarks:—The specimens from the lower member of Tosakamo Formation are safely identified with *Nuculopsis* (*Palaeonucula*) *ishidoensis* (Yabe et Nagao) (Yabe, Nagao and Shimizu, 1926), from the Ishido Formation of Kwanto, judging from the smooth inner margin and numerous fine concentric striae on the disk. This species was also described from the Choshi Group of Kwanto (Hayami *in* Hayami and Oji, 1980).

Occurrence and geological age:—Common in medium grained sandstone of the lower member of Tosakamo Formation at Ujidani of Kamo, Sakawa area (Loc. 4); Aptian.

Superfamily Nuculanacea Adams et Adams

Family Nuculanidae Adams et Adams, 1858

Genus *Portlandia* Mörch, 1857

Portlandia sanchuensis (Yabe et Nagao)

Pl. 74, Figs. 4–7.

1926. *Nuculana sanchuensis* Yabe et Nagao, *in* Yabe, Nagao and Shimizu, *Sci. Rep., Tohoku Imp. Univ., Ser. 2,* vol. 9, no. 2, p. 42, pl. 12, figs. 21—23.
1965. *Nuculana* (s.l.) *sanchuensis* Yabe et Nagao; Hayami, *Mem. Fac. Sci., Kyushu Univ., Ser. D,* vol. 15, no. 2, p. 235.
1975. *Nuculana sanchuensis* Yabe et Nagao; Hayami, *Univ. Mus., Univ. Tokyo, Bull.,* no. 10, p. 24.
1980. *Portlandia* (s.l.) *sanchuensis* (Yabe et Nagao); Hayami, *in* Hayami and Oji, *Trans. Proc., Palaeont. Soc. Japan, N.S.,* no. 120, p. 425, pl. 51, figs. 7—10.

Materials:—KSG 3483 — KSG 3484, internal moulds from Ujidani of Kamo, Sakawa; KSG 3485 —KSG 3486, external moulds from the same locality.

Measurements (in mm.):—

Specimens	Length	Height	Thickness
KSG 3483, l. int. mol.	12.3	8.0	—
KSG 3484, r. int. mol.	13.2	9.0	—
KSG 3485, r. ext. mol.	13.9	8.9	3.3
KSG 3486, r. ext. mol.	18.5	9.8	3.9

Remarks:—The specimens in our hands are referable to *Portlandia* (s.l.) *sanchuensis* (Yabe et Nagao) which has been precisely redescribed by Hayami (*in* Hayami and Oji, 1980), from the Choshi Group of Kwanto. The typical species of this species is known from the Ishido Formation of Kwanto (Yabe, Nagao and Shimizu, 1926, pl. 12, fig. 21).

Occurrence and geological age:—Rare in the medium-grained sandstone of the lower member of Tosakamo Formation at Ujidani of Kamo, Sakawa area (Loc. 4); Aptian.

Subclass Pteriomorphia

Order Arcoida

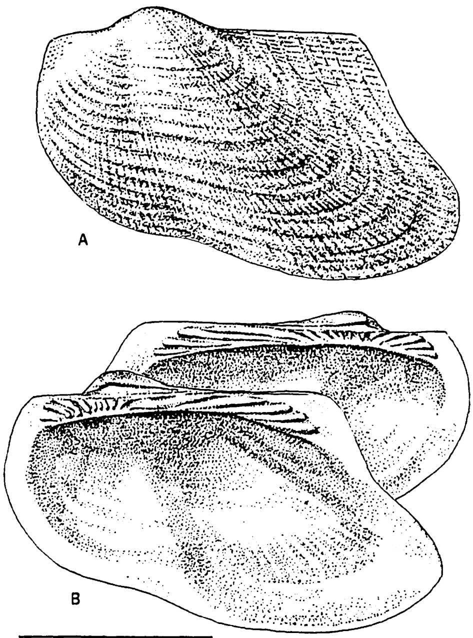
Superfamily Arcacea Lamarck, 1809

Family Parallelodontidae Dall, 1898

Subfamily Parallelodontinae Dall, 1898

Genus *Cosmetodon* Branson, 1942

Cosmetodon tomochiensis, sp. nov.



Text-fig. 2. The diagramatic sketches of *Cosmetodon tomochiensis* Tashiro et Matsuda, sp. nov., from the Tomochi Formation at Kashiwagawa of Tomochi, Kumamoto Pref. (scale 5 mm).

Pl. 74, Figs. 9—15, Pl. 76, Fig. 4, Text-fig. 2.

Materials:—Holotype, KSG 3487, internal mould of left valve, from Kashiwagawa of Tomochi, Kumamoto Prefecture, Kyushu; paratypes, KSG 3488 — KSG 3489, internal moulds, from the same locality of holotype; KSG 3490—KSG 3491, external moulds, from the same locality; paratypes, KSG 3492 — KSG 3493, internal moulds, from Kuroishi of Kamo, Sakawa.

Diagnosis:—Shell small, tapering to anterior, longer than high; umbo prosogyrate, located anteriorly; surface ornamented with numerous radial ribs and laminated concentric striae; radial sulcus weak; hinge plate elongated with typical parallelodontid hinge teeth.

Description:—Shell elongately subquadrate, expanded to posterior, tapering to anterior, moderately inflated; umbo prosogyrous, prominent but small, pointed at about one fourth from front of valve; dorsal margin nearly straight with about two thirds of valve length, shorter in its anterior segment than in posterior one with proportion of 1:3 in length; anterior margin slightly arched, subvertically truncated from dorsal margin; ventral margin weakly arched on posterior and anterior parts but weakly concave in central part; posterior margin nearly straight or weakly concave, obliquely truncated from dorsal margin; postero-ventral margin narrowly rounded; surface ornamented with numerous flat-topped radial ribs broader than their interspaces; numerous laminated concentric striae well developed on surface but weaker and more widely spaced than radial ribs; a weak radial sulcus extends from umbo to a point about one third from front of ventral margin; posterior carinal ridge weak but well elevated; dorsal carina indistinct; ligamental area very narrow with very asymmetrical triangular outline; hinge plate elongated with about 14 taxodont teeth of which about 6 teeth under umbonal part small, divergent; 3 on anterior segment of plate elongated, obliquely situated; about 5 on posterior segment very elongated, nearly horizontal; inner margin smooth; adductor scars very weakly impressed.

Measurements (in mm.):—

Specimens	Length	Height
KSG 3487, r. int. mol.	8.6	5.0
KSG 3488, l. int. mol.	9.8	5.3
KSG 3489, l. int. mol.	9.6	5.2
KSG 3492, r. int. mol.	7.8	5.2

Observation:—Although two specimens from the Tosakamo Formation are somewhat deformed, they are safely identified with the type specimens from the Tomochi Formation in Kumamoto Prefecture of central Kyushu, because of common features of hinge teeth and surface ornamentation. On the posterior carinal part of the disk, the radial ribs and concentric striae of the Tosakamo specimens are generally stronger than those of the other part of the disk. Fine and numerous radial striae sometimes appear on the inner surface over the pallial line. The ligament grooves are indistinct.

Comparison:—This species resembles *Parallelodon (Torinosucatella) kobayashii* (Tamura, 1959) (Hayami, 1975) from the Jurassic of southern Kyushu, in the surface ornamentation and the outline which is tapering to anterior, but differs from the latter clearly in its weaker radial sulcus and concentric striae. *Cosmetodon nipponica* (Nagao), from the Miyako Group of northeast Japan (Hayami, 1975), is easily discriminated from this species in its obsolete or disappeared radial ribs on the surface, and horizontal anterior teeth.

Occurrence and geological age:—Rare in the dark-gray siltstone of the upper member of the Tosakamo Formation at Kuroishi of Kamo, Sakawa area (Loc. 6); Albian: Rare in the dark-gray shale of the Tomochi Formation at Kashiwagawa of Tomochi, Kumamoto Prefecture, Kyushu; Upper Aptian or ?Lower Albian.

Genus *Nemodon* Conrad, 1869

Nemodon sp.

Pl. 74, Fig. 8.

1957b. *Nemodon* (?) sp.; Amano, *Kumamoto Jour. Sci., Ser. B*, vol. 2, no. 2, p. 84, pl. 1, fig. 8.

Materials:—KSG 3494, internal mould of left valve and several fragmental external moulds, from Bunjo of Ochi, Sakawa.

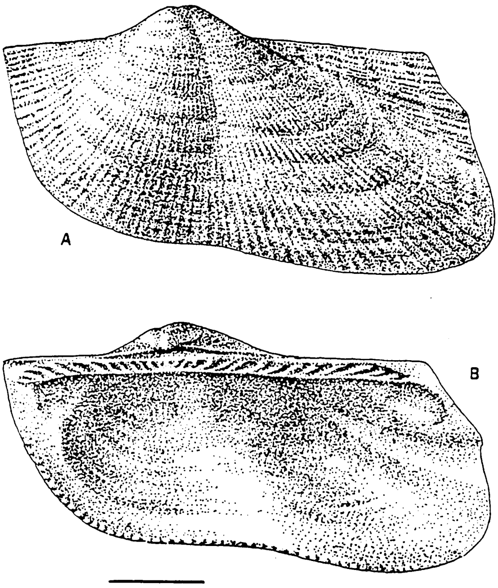
Remarks:—KSG 3494 is 15.0 mm length and 8.0 mm high. This species is characterized by the elongated and subhorizontal hinge teeth on the anterior and posterior segments of the hinge plate and the diverging small teeth in central part of the plate. The radial ribs on the surface are weak but distinct. This species is identical with *Nemodon* (?) sp. from the Hagino Formation in the Monobe area (Amano, 1957b).

Occurrence and geological age:—Very rare in the medium-grained sandstone of the Bunjo Formation at Bunjo of Ochi, Sakawa area (Loc. 8); Aptian.

Family Arcidae Lamarck, 1809

Subfamily Arcinae Lamarck, 1809

Genus *Arca* Linné, 1758



Text-fig. 3. The diagramatic sketches of *Arca* (*Eonavicula*) *prolata* Amano, KSG 3495 (B) and KSG 3496 (A), both from the Bunjo Formation at Bunjo of Ochi, Sakawa. (scale 5 mm).

Subgenus *Eonavicula* Arkell, 1929

Arca (*Eonavicula*) *prolata* Amano

Pl. 74, Figs. 19, 20; Text-fig. 3.

1957b. *Arca prolata* Amano, *Kumamoto Jour. Sci., Ser. B*, vol. 2, p. 80, pl. 1, figs. 1—3.
1965. *Eonavicula prolata* (Amano); Hayami, *Mem. Fac. Sci., Kyushu Univ., Ser. D*, vol. 15, no. 2, p. 49.
1975. *Arca* (*Eonavicula*) *prolata* Amano; Hayami, *Univ. Mus., Univ. Tokyo, Bull.*, no. 10, p. 32.

Materials:—KSG 3495, internal mould of right valve; KSG 3496, external mould of left valve; both from Bunjo of Ochi, Sakawa.

Description:—Shell small, elongately subquadrate or trapezoidal in outline, moderately inflated; umbo strongly prominent, nearly orthogyrous, located at about a fourth from front of valve; dorsal margin very long, nearly straight, shorter in anterior segment than in posterior one with about a half length of posterior; anterior margin slightly convex, subvertically or obliquely truncated from dorsal margin; ventral margin long, nearly horizontal, straight in general but sometimes sinuated in central part; posterior margin obliquely truncated, a little convex; posterior carinal ridge indistinct but moderately swollen; a shallow radial sulcus extends vertically from umbo to ventral margin; surface ornamented by fine numerous radial ribs and laminated concentric striae; radial ribs narrower than their interspaces, stronger than concentric striae on main part of surface except for reticulated umbonal region; hinge plate very long with numerous small subvertical or diverging taxodont teeth; ligament area very narrow with a few chevrons; inner margin finely crenulated; both adductor scars weakly impressed; a strong inner radial ridge extends from inner beak to about center of inner posterior margin.

Measurements (in mm.):—

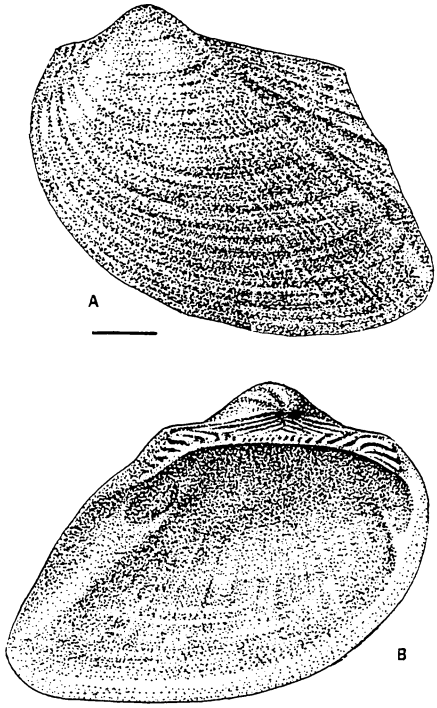
Specimens	Length	Height	Thickness
KSG 3495, r. in. mol.	23.0	10.2	—
KSG 3496, l. ex. mol.	18.4	9.8	3.0

Remarks:—This is undoubtedly conspecific with *Arca* (*Eonavicula*) *prolata* Amano from the Hagino Formation of the Monobe area (Amano, 1957b), in its strong inner radial ridge and crenulated inner ventral margin. It is discriminated from *Arca* (*Eonavicula*) sp. from the Fukigoshi Formation (Cenomanian) of the Monobe area, in its crenulated inner ventral margin. *Arca* (*Eonavicula*) *shinanoensis* Yabe et Nagao (Yabe, Nagao and Shimizu, 1926) from the Ishido Formation (Barremian) of Kwanto, is characterized by more inflated valve, less angulated antero-dorsal corner and smooth inner margin.

Occurrence and geological age:—Common in the medium-grained sandstone of the Bunjo Formation at Bunjo of Ochi, Sakawa area (Loc. 8); Aptian.

Family Cucullaeidae Stewart, 1930

Genus *Cucullaea* Lamarck, 1801



Text-fig. 4. The diagramatic sketches of *Cucullaea obliquata* (Amano), KSG 3497 (B) and KSG 3498 (A), both from the Bunjo Formation at Bunjo of Ochi, Sakawa. (scale 5 mm).

Cucullaea obliquata (Amano)

Pl. 74, Figs. 16—18; Text-fig. 4.

1957b. *Trigonoarca* (?) *obliquata* Amano, *Kumamoto Jour. Sci., Ser. B*, vol. 2, no. 2, p. 82, pl. 1, figs. 6—8.

1965. *Trigonoarca* sp. cf. *T. obliquata* Amano; Hayami, *Mem. Fac. Sci., Kyushu Univ., Ser. D*, vol. 15, no. 2, p. 248, pl. 28, fig. 17.

1979. *Trigonoarca*? *obliquata* Amano; Matsukuma, *Venus* (*Japan. Jour. Malac.*), vol. 38, no. 2, p. 112.

Materials:—KSG 3497, internal mould of left valve; KSG 3498, external mould of left valve; both specimens from Bunjo of Ochi, Sakawa.

Description:—Shell medium to small in size, warped elliptical in outline, strongly tapering to anterior, longer than high, well inflated; umbo orthogyrous, prominent but rather small, located at about two fifths from front of valve; dorsal margin straight with about a half length of valve, somewhat longer in posterior than in anterior; anterior margin moderately convex, gradually changing into very weakly arched ventral margin; antero-dorsal corner bluntly angulated with about 120°; posterior margin nearly straight or weakly concave, obliquely trancated; postero-ventral corner narrowly rounded, expanded to posterior; posteior carinal ridge distinctly angulated for *Cucullaea*; posterior dorsal carina narrow but distinct; posterior half of disk and posterior area (slope) ornamented by very fine numerous radial ribs; growth lines on surface weak; ligament area very narrow with a few chevron shaped grooves; hinge plate narrow but elongated; 3 or so teeth on anterior segment of plate elongated, nearly subhorizontal, parallel with one another; 6 or more on posterior segment elongated but not so long as anterior ones, nearly subhorizontal, parallel with one another; about 16 teeth on central part of plate very small, nearly vertical but somewhat oblique on anterior side; inner margin smooth; posterior adductor scar strongly impressed but anterior one very weak; inner posterior ridge remarkably developed; fine numerous radial striae observable over shallow pallial line.

Measurements (in mm.):—

Specimens	Length	Height	Thickness
KSG 3497, l. in. mol.	36.4+	33.0	—
KSG 3498, l. ex. mol.	24.0+	19.0+	10.0

Remarks:—KSG 3497 is a well preserved internal mould. Another specimen, KSG 3498, is imperfect external mould, but shows distinctly the characteristics of the surface ornamentation.

This species was referred to *Trigonoarca* Conrad (1862) by Amano (1957b), Hayami (1965, 1975) and Matsukuma (1979) with some doubts. It is, however, undoubtedly assigned to genus *Cucullaea*, because of its fine radial striae on the surface and horizontally elongated teeth on anterior and posterior segments of the hinge plate.

Occurrence and geological age:—Rare in the medium-grained sandstone of the Bunjo Formation at Bunjo of Ochi, Sakawa area (Loc. 8); Aptian. The holotype designated by Amano (1957b) is known from the Hagino Formation (Aptian) in the Monobe area, Kochi.

Order Mytiloida Ferussac

Superfamily Mytilacea Rafinesque, 1815

Family Mytilidae Rafinesque, 1815

Subfamily Modiolinae Keen, 1958

Genus *Modiolus* Lamarck, 1799

Modiolus falcatus Amano

Pl. 75, Figs. 6, 12.

1957b. *Modiolus falcatus* Amano, *Kumamoto Jour. Sci., Ser. B*, vol. 2, no. 2, p. 91, pl. 2, figs. 3—8.
1965. *Modiolus falcatus* Amano; Hayami, *Mem. Fac. Sci., Kyushu Univ., Ser. D*, vol. 15, no. 2, p. 255, pl. 30, figs. 1—2.
1975. *Modiolus falcatus* Amano; Hayami, *Univ. Mus., Univ. Tokyo, Bull.*, no. 10, p. 38.

Materials:—KSG 3499 and KSG 3501, external moulds of right valve; KSG 3500, internal mould of left valve; all from Bunjo of Ochi, Sakawa.

Measurements (in mm.):—

Specimens	Length	Height	Thick-ness
KSG 3499, r. ex. mol.	22.2	15.0	3.7
KSG 3500, l. in. mol.	13.5	8.5	—

Remarks:—This species was originally established by Amano (1957b) on the material from the Hagino Formation of the Monobe area. Its outline is variable from trigonal ovate to elongated elliptical.

Occurrence and geological age:—Common in medium-grained sandstone of the Bunjo Formation at Bunjo of Ochi, Sakawa area (Loc. 8); Aptian.

Superfamily Pinnacea Leach, 1818

Family Pinnidae Leach, 1819

Genus *Pinna* Linné, 1758

Subgenus *Pinna* Linné, 1758

Pinna (*Pinna*) sp. cf. *P.* (*P.*) *robinaldina* d'Orbigny

Pl. 75, Fig. 9.

1975b. *Pinna* sp.; Amano, *Kumamoto Jour. Sci., Ser. B*, vol. 2, no. 2, p. 85, pl. 1, figs. 10—13.
1965. *Pinna* sp. cf. *P. robinaldina* d'Orbigny; Hayami, *Mem. Fac. Sci., Kyushu Univ., Ser. D*, vol. 15, no. 2, p. 281, pl. 39, figs. 2—3.
1975. *Pinna* (*Pinna*) sp. cf. *P.* (*P.*) *robinaldina* d'Orbigny; Hayami, *Univ. Mus., Univ. Tokyo, Bull.*, no. 10, p. 40.

Compare with:—

1899. *Pinna robinaldina* d'Orbigny; Woods, *Monogr. Cretaceous Lamell. England*, vol. 1, p. 96, pl. 12, figs. 11—15, pl. 13, fig. 1.

Remarks:—Although numerous specimens of this species are in our hands, they are all imperfect or fragmentary. This is undoubtedly conspecific with *Pinna* sp. which was described from the Hagino Formation in the Monobe area by Amano (1957b). It is also known from the Ishido Formation in Kwanto (Hayami, 1965) and the lower part of the Hibihara Formation in the Monobe area (Tashiro *et al.*, 1980).

Occurrence and geological age:—Abundant in the medium-grained sandstone of the Bunjo Formation at Bunjo of Ochi, Sakawa area (Loc. 8); Aptian.

Order Pterioida Newell

Suborder Pteriina Newell

Superfamily Pteriacea Gray, 1847

Family Bakevelliidae King, 1850

Genus *Gervillaria* Cox, 1954

Gervillaria haradae (Yokoyama)

Pl. 75, Figs. 1—5, 13.

1890. *Avicula haradae* Yokoyama, *Palaeontographica*, vol. 36, p. 199, pl. 25, fig. 12.
1926. *Gervillia haradae* (Yokoyama); Yabe,

Nagao and Shimizu, *Sci. Rep., Tohoku Imp. Univ., Ser. 2,* vol. 9, no. 2, p. 58, pl. 13, figs. 1—3, 7, pl. 14, fig. 2.

1934. *Gervillia* cf. *haradae* (Yokoyama); Nagao, *Jour. Fac. Sci., Hokkaido Imp. Univ., Ser. 4,* vol. 2, no. 3, p. 199, pl. 31, fig. 13.

1957a. *Bakevellia* sp.; Amano, *Kumamoto Jour. Sci., Ser. B,* vol. 2, no. 2, p. 86, pl. 1, figs. 14—15.

1963. *Gervillaria haradae* (Yokoyama); Matsumoto, Hayami and Asano, *Palaeont. Soc. Japan, 25th Anniv. Vol.,* p. 32, pl. 51, fig. 12.

1965. *Gervillaria haradae* (Yokoyama); Hayami, *Mem. Fac. Sci., Kyushu Univ., Ser. D, Geol.,* pt. 1, vol. 15, no. 2, p. 269, pl. 35, figs. 3—6, pl. 36, fig. 1, pl. 37, fig. 2.

1975. *Gervillaria haradae* (Yokoyama); Hayami, *Univ. Mus., Univ. Tokyo, Bull.,* no. 10, p. 46.

Materials:—KSG 3504 — KSG 3506, internal moulds of left valve, from Bunjo of Ochi, Sakawa; KSG 3507, external mould of left valve, from the same locality; KSG 3508, internal mould of left valve, from Ujidani of Kamo, Sakawa.

Measurements (in mm.):—

Specimens	Length	Height	Thickness
KSG 3504, l. in. mol.	70.8	61.5	—
KSG 3505, ditto	23.0+	25.8	—
KSG 3506, ditto	36.5	37.0	—
KSG 3507, l. ex. mol.	72.8	65.0	10.5

Remarks:—This species is one of the well known Early Cretaceous bivalves from Japan. It is usually found from the Monobe and Hibihara Formations in the Monobe area. Many specimens from the Bunjo and Hagino Formations are in our hands.

Occurrence and geological age:—Abundant in the medium-grained sandstone of the Bunjo Formation at Bunjo of Ochi, Sakawa area (Loc. 8); Aptian. Rare in the medium-grained sandstone of the lower member of Tosakamo Formation (="Kaisekiyama" Formation by Katto and Tashiro, 1981, non Kaisekiyama Formation by Kurata, 1940, and Yamashita, 1961), at Ujidani of Kamo, Sakawa area (Loc. 4); Aptian.

Genus *Gervillia* Defrance, 1820

Subgenus *Gervillia* Defrance, 1820

Gervillia (*Gervillia*) sp. cf. *G.* (*G.*) *forbesiana* d'Orbigny

Pl. 75, Fig. 8.

1926. *Gervillia forbesiana* d'Orbigny; Yabe, Nagao and Shimizu, *Sci. Rep., Tohoku Imp. Univ., Ser. 2,* vol. 9, no. 2, p. 57, pl. 12, figs. 36—37.

1927. *Gervillia forbesiana* d'Orbigny; Yabe, *Sci. Rep., Tohoku Imp. Univ., Ser. 2,* vol. 11, no. 1, pl. 5, fig. 5.

1934. *Gervillia forbesiana* d'Orbigny; Nagao, *Jour. Fac. Sci., Hokkaido Imp. Univ., Ser. 4,* vol. 2, no. 3, p. 197, pl. 24, fig. 8, pl. 25, figs. 8—10.

1951. *Gervilliopsis forbesiana* (d'Orbigny); Shinohara, *Illustrated handbook for fossils in Shikoku,* p. 26, pl. 11, fig. 2.

1965. *Gervillia* (*Gervillia*) *forbesiana* d'Orbigny; Hayami, *Mem. Fac. Sci., Kyushu Univ., Ser. D, Geol.,* vol. 15, no. 2, p. 276, pl. 37, figs. 7—8, pl. 38, figs. 1—5.

1972. *Gervillia* (*Gervillia*) *forbesiana* d'Orbigny; Shikama and Suzuki, *Sci., Rept. Yokohama Nat. Univ., Ser. 2,* vol. 19, pl. 4, fig. 13.

1978. *Gervillia* (*Gervillia*) *forbesiana* d'Orbigny; Katto and Tashiro, *Res. Rept., Kochi Univ.,* vol. 27, p. 145, pl. 1, fig. 3.

1980. *Gervillia* (*Gervillia*) *forbesiana* d'Orbigny; Tashiro, Kozai, Okamura and Katto, *Geol. Paleont. Shimanto Belt,* Taira and Tashiro eds., *Kochi,* pl. 10, fig. 1.

Materials:—KSG 3508 — KSG 3509, external moulds; KSG 3510 — KSG 3511, internal moulds; all from Bunjo and Yotsushiro of Ochi, Sakawa.

Remarks:—The specimens from the Bunjo Formation are more or less imperfect, but the specific features of *Gervillia* (*Gervillia*) *forbesiana* d'Orbigny (see Hayami, 1965) are well shown in some of them.

Occurrence and geological age:—Common in fine to medium-grained-arenite sandstone of the Bunjo Formation at Bunjo and Yotsushiro of Ochi, Sakawa area; Aptian. Rare in medium-grained sandstone of the lower member of Tosakamo Formation at Ujidani of Kamo, Sakawa area (Loc. 4); Aptian.

Family Isognomonidae Woodring, 1925

Genus *Isognomon* Lightfoot, 1786

Isognomon sp.

Pl. 75, Fig. 7.

Material:—KSG 3512, internal mould of left valve, from Bunjo of Ochi, Sakawa.

Description:—Shell small, roundly ovate, slightly longer than high, nearly flat; ligament area very narrow, short with about a fifth of valve length, nearly straight with about 5 small ligament pits; anterior margin well rounded; ventral margin long, broadly arched; posterior dorsal margin very weakly arched; posterior margin broadly convex; postero-ventral corner somewhat angulated; beak located at about a third from front of valve; adductor scar weakly impressed.

Remarks:—KSG 3512, 34.1 mm long and 23.0 mm high, is a single available specimen. This is similar to *Isognomon (Melina) ichikawai* Hayami (1965) from the Ishido Formation of Sanchu in its narrow ligament area, but differs from the latter in its elongated posterior dorsal margin.

Occurrence and geological age:—Very rare in fine graind sandstone of Bunjo Formation at Bunjo of Ochi, Sakawa area (Loc. 8); Aptian.

Family Inoceramidae Giebel, 1852

Genus *Inoceramus* Sowerby, 1814

Inoceramus anglicus Woods

Pl. 76, Figs. 15—16, 19, 21—23.

1913. *Inoceramus anglicus* Woods, *Monogr. Cretaceous Lamell. England*, vol. 2, p. 264, pl. 45, figs. 8—10, text-fig. 29.
1964. *Inoceramus anglicus* Woods; Matsumoto and Harada, *Mem. Fac. Sci., Kyushu Univ., Ser. D*, vol. 15, no. 1, p. 94, pl. 9, figs. 1—2.
1980. *Inoceramus anglicus* Woods; Tashiro, Kozai, Okamura and Katto, *Geol. Paleont. Shimanto Belt*, Taira and Tashiro *eds. Kochi*, pl. 10, fig. 5.
1985. *Inoceramus anglicus* Woods; Tashiro, Matsuda and Tanaka, *Mem. Fac. Sci., Kochi Univ., Ser. E, Geol.*, vols. 5—6, p. 7, pl. 2, figs. 1—2.

Materials:—KSG 3513 — KSG 3514, internal and external moulds of right valve from Kurohara of Ochi, Sakawa; KSG 3516 and KSG 3515, conjoined valves from the same locality.

Measurements (in mm.):—

Specimens	Length	Height	Thick-ness
KSG 3513, r. valve	21.1	18.0	2.0
KSG 3514, ditto	9.0	12.0	0.9
KSG 3515, conj. valve	—	26.5	—
KSG 3516, ditto	12.5	14.5	1.3

Remarks:—The specimens from this area are certainly identical with *Inoceramus anglicus* Woods, 1913 from the Albian of England in all the external and internal characters which were described by Woods (1913). Specimen of KSG 3513 resembles more especially a specimen of *I. anglicus* by Woods (pl. 45, fig. 9) in its features of outline and arrangement of ribbing.

Occurrence and geological age:—Rare in dark-gray siltstone of the Yotsushiro Formation at Kurohara of Ochi, Sakawa area (Loc. 3); Upper Albian?.

Inoceramus sp. aff. *I. crippsi* Mantell

Pl. 76, Figs. 17—18.

Compare with:—

1913. *Inoceramus crippsi* Mantell; Woods, *Monogr. Cretaceous Lamell. England*, vol. 2, p. 273, pl. 48, figs. 2—3.

Materials:—KSG 3517, internal and external moulds of right valve, from Kurohara of Ochi, Sakawa.

Description:—Shell small, roundly ovate, higher than long; umbo slightly prominent, located at about one eighth from front of valve; hinge line straight with about a half length of valve; anterior margin nearly straight for about a half of height; ventral margin broadly arched in anterior part but well rounded in posterior half; posterior margin nearly straight obliquely truncated; surface ornamented with irregularly spaced concentric wrinkles; umbonal angle about 100°.

Remarks:—KSG 3517 is measured 17.2 mm in length, 19.7 mm in height and 1.7 mm in thickness. The concentric wrinkles of the surface are 10 or more in number, distinct near the anterior marginal and on the anterior ventral parts but nearly obsolete on the posterior marginal part. The described specimen resembles the immature form of *Inoceramus crippsi* Mantell by Woods (1913, see p. 277, text-fig. 35) from the Albian of England, in its features of hinge line and postero-ventral expansion of the valve.

Occurrence and geological age:—Rare in dark-gray siltstone of the Yotsushiro Formation at Kurohara of Ochi, Sakawa area (Loc. 3); Albian.

Inoceramus sp.

Pl. 76, Figs. 20, 24.

Materials:—KSG 3518 and KSG 3519, imperfect right valves, from Kurohara of Ochi, Sakawa.

Remarks:—Two fragmental specimens are characterized by numerous concentric ribs and rings. Although the outline of the species is imperfectly shown, this is probably referable to *Inoceramus*, judging from its concentric ornamentation.

Occurrence and geological age:—Very rare in dark-gray siltstone of the Yotsushiro Formation at Kurohara of Ochi, Sakawa (Loc. 3); Albian.

Superfamily Pectinacea Rafinesque, 1815

Family Pectinidae Rafinesque, 1815

Subfamily Pectininae Rafinesque, 1815

Genus *Neithea* Drouet, 1825

Subgenus *Neithea* Drouet, 1825

Neithea (*Neithea*) *syriaca amanoi* Hayami

Pl. 74, Figs. 21—22.

1957b. *Pecten* (*Neithea*) cf. *morrisi* (Pictet et Renevier); Amano, *Kumamoto Jour. Sci., Ser. B*, vol. 2, no. 2, p. 88, pl. 1, figs. 17—18, 20—25, 27—29.

1965. *Neithea* (*Neithea*) *amanoi* Hayami, *Mem. Fac. Sci., Kyushu Univ., Ser. D, Geol.*, vol. 15, no. 2, p. 229, text-fig. 4, pl. 41, figs. 8—10, pl. 42, figs. 1—4.

1973. *Neithea* (*Neithea*) *syriaca* (Conrad); Dhondt, *Mem. Inst. Roy. Sci. Nat. Belgique*, no. 176, p. 37.

1975. *Neithea* (*Neithea*) *syriaca* (Conrad); Hayami, *Univ. Mus., Univ. Tokyo, Bull.*, no. 10, p. 75.

1977. *Neithea* (*Neithea*) *syriaca amanoi* Hayami; Hayami and Noda, *Trans. Proc., Palaeont. Soc. Japan, N.S.*, no. 105, p. 49.

Materials:—KSG 3520 — KSG 3521, external and internal moulds, from Bunjo of Ochi, Sakawa; KSG 3522 — KSG 3523, internal and external moulds, from Yotsushiro of Ochi, Sakawa.

Measurements (in mm.):—

Specimens	Length	Height	Thickness
KSG 3520, r. ex. mol.	17.1	22.6	6.3
KSG 3521, l. in. mol.	19.0	24.9	—
KSG 3522, r. ex. mol.	11.8	15.3	3.8

Remarks:—Numerous specimens are obtained from the Sakawa area. They are safely referable to *Neithea* (*Neithea*) *syriaca amanoi* Hayami (1965) from the Hagino Formation in the Monobe area, Shikoku, by their characteristic features of the valve.

Occurrence and geological age:—Abundant in fine-grained sandstone of the Bunjo Formation at Bunjo and Yotsushiro, both of Ochi, Sakawa area (Locs. 8, 9); Aptian.

Family Propeamussiidae Abbott, 1954

Genus *Parvamussium* Sacco, 1897

Parvamussium hinagense Tamura

Pl. 76, Figs. 7—9, 13.

1973. *Parvamussium hinagense* Tamura, *Geol. Pal. Southeast Asia*, vol. 11, p. 122, pl. 17, figs. 1—4.

1975. *Parvamussium hinagense* Tamura; Hayami, *Univ. Mus., Univ. Tokyo, Bull.*, no. 10, p. 83.

Materials:—KSG 3523, internal mould of right valve, from Kuroishi, north of Kamo, Sakawa; KSG 3524 and KSG 3525, external moulds of right and left valves from Kuroishi.

Measurements (in mm.):—

Specimens	Length	Height
KSG 3523, r. in. mol.	12.8	16.0
KSG 3524, r. ex. mol.	8.4	8.5+
KSG 3525, l. ex. mol.	18.2	—

Remarks:—The species based on three specimens from Sakawa area, is undoubtedly conspecific with *Parvamussium hinagense* Tamura (1973) from the Hinagu Formation of Yatsushiro in central Kyushu, in its strong radial ridges of the inner surface and the fine radial riblets which cross the distinct concentric ribs on the right external surface.

Occurrence:—Rare in dark-gray siltstone of the upper member of Tosakamo Formation at Kuroishi, about 700 m north of Kamo, Sakawa area (Loc. 6); Albian.

Parvamussium tosaense, sp. nov.

Pl. 76, Figs. 3, 5–6, 11–12.

1980. *Parvamussium* sp.; Tashiro, Kozai, Okamura and Katto, *Geol. Paleont. Shimanto Belt*, Taira and Tashiro *eds.*, *Kochi*, pl. 10, fig. 3.

Materials:—KSG 3526 and KSG 3528, internal moulds of right and left valves; KSG 3529, external mould of left valve; these three form Yotsushiro of Ochi, Sakawa; KSG 3527, internal mould of right valve, from Kurohara of Ochi, Sakawa; KSG 3530, external mould of right valve, from Kuroishi of Kamo, Sakawa.

Diagnosis:—Shell roundly ovate, strongly inequivalve; inner radial ridges about 10 in number; surface of left valve with numerous primary and secondary ribs; right valve with abundant concentric riblets.

Description:—Shell medium to small in size, roundly ovate, slightly taller than length in general, slightly inflated; umbo less prominent, located at center of valve; umbonal angle about 90°; both ears moderate in size, with anterior one somewhat larger than posterior; surface of right valve ornamented with numerous fine concentric ribs narrower than interspaces; surface of left valve with fine radial ribs composed of about 30 primary and about 30 secondary ones in alternation; inner surface with about 10 weak inner radial ridges several of which do not reach the umbonal axis; the inner ridges of left valve not reach the periphery of ventral margin; resilifer very small under beak; a pair of cardinal crurae developed on both sides of resilifer.

Measurements (in mm.):—

Specimens	Length	Height
KSG 3526, holotype, l. in. mol.	8.0	7.9
KSG 3527, paratype, ditto	8.9	9.8
KSG 3528, ditto, l. in. mol.	6.2	6.4
KSG 3529, ditto, l. ex. mol.	12.3	—
KSG 3530, ditto, r. ex. mol.	8.4	8.3

Remarks:—This is clearly discriminated from *Parvamussium kimurai* (Hayami, 1965), from the Barremian of southwest Japan, in its weaker radial ribs of the left valve. It is similar to *Parvamussium yubarense* (Yabe et Nagao) from the Upper Cretaceous strata (Cenomanian to Lower Campanian) of Japan (Tashiro, 1976; 1985), in its outline and radial ribs of the left valve, but is distinguishable from the latter in its more numerous concentric ribs of the right valve and imperfect inner radial ridges. *Parvamussium* sp. by Tashiro *et al.* (1980) from the upper member of the Hibihara Formation in the Monobe area, is safely referable to this species, judging from same diagnostic features. Several specimens collected from the Tomochi Formation in central Kyushu are also probably conspecific with this species.

Occurrence and geological age:—Common in dark-gray siltstone of the upper member of Tosakamo Formation at Kuroishi, about 700 m north of Kamo, Sakawa area (Loc. 6); Albian?. Common in dark-gray siltstone of the Yotsushiro Formation at Yotsushiro of Ochi, Sakawa area (Loc. 7); Albian.

Parvamussium kattoi, sp. nov.

Pl. 76, Figs. 1–2, 10.

1985. *Parvamussium* sp.; Tashiro, Matsuda and Tanaka, *Mem. Fac. Sci., Kochi Univ., Ser. E, Geol.*, vols. 5–6, p. 8, pl. 1, figs. 26, 27.

Materials:—KSG 3531, holotype, external mould of left valve; KSG 3532, paratype, internal mould of right valve; KSG 3533, paratype, external mould of left valve; all from Kurohara of Ochi, Sakawa.

Description:—Shell small, roundly ovate, vertically elongated, with moderately inflated in left and slightly swollen in right valves; umbo nearly central; apical angle about 85°; surface of left valve ornamented with numerous fine concentric ribs; surface of left valve with primary and secondary radial ribs; primary ones number about 20, round-topped; secondary ones very weak, about 20 in number; inner radial ridges distinct, number 8 or 9; both ears moderate in size.

Measurements (in mm.):—

Specimens	Length	Height	Thick-ness
KSG 3531, holotype, l. ex. mol.	6.9	10.1	0.5
KSG 3532, paratype, r. in. mol.	6.3	9.8	—
KSG 3533, ditto, r. ex. mol.	5.3	7.3	1.3

Observation:—This species is specially characterized by the inflated left valve and oblong outline for *Parvamussium*. Narrow and short secondary radial ribs of left valve generally appear on the ventral part. The concentric ribs of right valve are narrower than their interspaces.

Comparison:—This species is undoubtedly conspecific with *Parvamussium* sp. which had been described in detail based on the specimens from the Albian stratum in Oita, Kyushu by Tashiro and Matsuda (*in* Tashiro, Matsuda and Tanaka, 1985), judging from the same diagnostic features.

This species is discriminated from *Parvamussium tosaense* from the same formation by its inflated valve and distinct radial ribs. The hitherto described species of *Parvamussium* from the Cretaceous of Japan, *i.e.*, *Parvamussium kimurai* (Hayami), *P. yubarense* (Yabe et Nagao) and *P. hinagense* Tamura, are easily discriminated from this species in their less inflated left valve and more rounded valve.

Occurrence and geological age:—Very rare in dark-gray siltstone of the Yotsushiro Formation at Kurohara of Ochi, Sakawa area (Loc. 2); Albian.

Family Plicatulidae Watson, 1930

Genus *Plicatula* Lamarck, 1801

Plicatula sp.

Pl. 76, Fig. 14.

Material:—KSG 3534, internal mould of left valve, from Bunjo of Ochi, Sakawa.

Remarks:—A single specimen, KSG 3534, 11.2 mm long and 13.9 mm high, shows clearly the inner features of left valve but indistinctly other features. The shell is subtriangular in outline, higher than long. The umbo is located nearly central. Seven inner radial ridges corresponding to the external radial ribs are observable distinctly. The ligament area is narrowly triangular.

This species is probably conspecific with the specimens from the middle member of the Doganaro Formation of the Shimanto Belt in Shikoku (Tashiro *et al.*, 1981, not described but listed), in the same features of the inner surface.

Occurrence and geological age:—Rare in fine-grained sandstone of the Bunjo Formation at Bunjo of Ochi, Sakawa area (Loc. 8); Aptian.

Subclass Palaeoheterodonta Newell

Order Trigonioida Dall

Superfamily Trigoniacea Lamarck, 1819

Family Trigoniidae Lamarck, 1819

Subfamily Trigoniinae Lamarck, 1819

Genus *Nipponitrigonia* Cox, 1952

Nipponitrigonia kikuchiana (Yokoyama)

1891. *Trigonia kikuchiana* Yokoyama, *Jour.*

Coll. Sci., Imp. Univ. Tokyo, Sec. 2, vol. 4, art. 2, p. 363, pl. 40, figs. 4—6.

1957. *Nipponitrigonia convexa* Kobayashi, *Trans. Proc., Palaeont. Soc. Japan, N.S.*, no. 26, p. 55, pl. 10, fig. 14, pl. 11, figs. 4—7.

1975. *Nipponitrigonia convexa* Kobayashi; Hayami, *Univ. Mus., Univ. Tokyo, Bull.*, no. 10, p. 106.

1980. *Nipponitrigonia convexa* Kobayashi; Tashiro, Kozai, Okamura and Katto, *Geol. Paleont. Shimanto Belt*, Taira and Tashiro *eds., Kochi*, pl. 10, fig. 13.

Material:—KSG 3435, moulds included in a boulder of sandstone, from Kurohara of Ochi, Sakawa.

Remarks:—This species is characterized by well inflated valve, more or less small in size and strong 4 or more concentric costae near the umbo. The outline of the valve is very variable: subtrigonal, elongated ovate, subquadrate or elliptical. It is discriminated from "*Nipponitrigonia kikuchiana* (Yokoyama)", from the Miyako Group in northeast Japan (Yehara, 1915, 1923) and from the Goshonoura Group in central Kyushu (Yehara, 1923), in its strong concentric costae near the umbo and inflated valve. It should be noted that the specimens in our collection from the Hanoura Formation in Katsuura, Tokushima Prefecture, the probable type locality of *Trigonia kikuchiana* Yokoyama, 1891, also show well inflated valves, subtrigonal outline and strong concentric costae near the umbo, and are probably conspecific with the present species. Therefore, a taxonomic new name is necessary for the specimens from the Miyako and Goshonoura Groups by Yehara (1915, 1923). This species is also known from the lower part of Hoji Formation in Tokushima, the lower part of Hibihara Formation in Kochi, the Aptian strata of Osaka in Oita, and the lower part of Hinagu Formation in Kumamoto (Tashiro, 1985).

Occurrence and geological age:—Abundant in medium-grained sandstone of the Kurohara Formation at Kurohara (Sendatsuno by Kobayashi, 1957) of Ochi, Sakawa area (Loc. 1); Aptian.

Subfamily Pterotrigoniinae van Hoepen, 1929

Genus *Pterotrigonia* van Hoepen, 1929

Subgenus *Pterotrigonia* van Hoepen, 1929

Pterotrigonia (Pterotrigonia) pocilliformis (Yokoyama)

Pl. 74, Figs. 24—27.

Synonymy:—(See Tashiro and Matsuda, 1983, p. 18).

Materials:—KSG 3436, external mould of left valve, from Kurohara of Ochi, Sakawa; KSG 3437 — KSG 3438, external moulds of right valve; KSG 3439, internal mould of right valve, latter three from Ujidani of Kamo, Sakawa.

Measurements (in mm.):—

Specimens	Length	Height	Thickness
KSG 3436, l. ex. mol.	—	21.0	8.0
KSG 3437, r. ex. mol.	36.9+	32.0	9.8
KSG 3438, r. ex. mol.	16.0	9.8	3.0
KSG 3439, r. in. mol.	33.7	22.0	—

Remarks:—The specimens from the Kurohara Formation are certainly referable to *Pterotrigonia (Pterotrigonia) pocilliformis* (Yokoyama), as already redescribed by Yehara (1923), and Kobayashi and Nakano (1957). The specimens from the Tosakamo Formation are also undoubtedly conspecific with *P. (P.) pocilliformis* in its elongated outline, arrangements of the ribs on area, disk and escutcheon. Recently, Tashiro and Matsuda (1983) classified *P. (P.) pocilliformis* into two forms, *i.e.*, A Form (with parallel costae) and B Form (with radial costae) by the minor difference in the arrangements of the costae on the disk. The present specimens from the Sakawa area are identical with B Form of *P. (P.) pocilliformis.*

Occurrence and geological age:—Abundant in medium-grained sandstone of the Kurohara Formation at Kurohara (Sendatsuno) of Ochi, Sakawa area (Loc. 1); Aptian. Common in fine- to medium-grained sandstone of the lower member of Tosakamo Formation at Ujidani of Kamo, Sakawa area (Loc. 4); Aptian.

Subgenus *Scabrotrigonia* Dietrich, 1933

Pterotrigonia (?*Scabrotrigonia*) *moriana* (Yehara)

Pl. 74, Fig. 23.

Synonymy, material, description and measurements:—See Tashiro and Matsuda, 1983, p. 23.

Remarks:—Numerous specimens in internal and external moulds are in our hands. They are safely referable to *Pterotrigonia* (?*Scabrotrigonia*) *moriana* (Yehara) from the Hagino Formation of the Monobe area (Yehara, 1927) judging from the diagnostic features of costae and costellae on the surface.

Occurrence and geological age:—Abundant in fine- to medium-grained sandstone of the Bunjo Formation at Bunjo and Yotsushiro of Ochi, Sakawa area (Locs. 8, 9); Aptian.

Pterotrigonia (?*Scabrotrigonia*) sp.

Material, description and remarks:—See Tashiro and Matsuda, 1983.

Occurrence and geological age:—Abundant in fine-grained sandstone of the Bunjo Formation at Bunjo of Ochi, Sakawa area (Loc. 8); Aptian.

Subclass Heterodonta Neumayr

Order Veneroida Adams et Adams

Superfamily Lucinacea Fleming, 1828

Family Lucinidae Fleming, 1828

Subfamily Myrteinae Chavan, 1969

Genus *Lucinoma* Dall, 1901

Lucinoma? sp.

Pl. 77, Figs. 15—16.

Materials:—KSG 3440 and KSG 3441, external moulds of left valves, from Ujidani of Kamo, Sakawa.

Description:—Shell small, subovate, slightly longer than high, weakly inflated; umbo small, prosogyrous, a little prominent, located at about a third from front of valve; anterior dorsal margin short, weakly concave; anterior margin slightly arched, subtruncated from anterior dorsal margin; ventral margin subcircular; posterior margin moderately convex, subtruncated from long and weakly arched posterior dorsal margin; surface ornamented with numerous concentric ribs which are narrower than the interspaces; umbonal angle about 120°; lunule very narrow; escutcheon indistinct.

Measurements (in mm.):—

Specimens	Length	Height	Thickness
KSG 3440, l. ex. mol.	13.0	11.8	2.0
KSG 3441, ditto	7.0	6.1	1.2

Observation:—The inner features and hinge structure are unknown. The concentric ribs are crowded near the umbonal part but widely spaced later. The number of ribs is about 20 in KSG 3440.

Comparison:—This species is similar to *Lucinoma*? *kotoi* (Nagao) from the Miyako Group in northeast Japan (Hayami, 1965) in its rounded outline, but differs in its smaller size and has more numerous ribs. Since the hinge structure of this species is not observable, its generic position is uncertain.

Occurrence and geological age:—Rare in fine- to medium-grained sandstone of the lower member of Tosakamo Formation at Ujidani of Kamo, Sakawa area (Loc. 4); Aptian.

Superfamily Carditacea Fleming, 1828

Family Carditidae Fleming, 1828

Genus *Xenocardita* Vokes, 1946

Xenocardita amanoi (Hayami)

Pl. 75, Figs. 10—11.

1957b. *Cardita* (?) sp.; Amano, *Kumamoto Jour. Sci., Ser. B*, vol. 2, no. 2, p. 38, pl. 2, figs. 27—29, text-fig. 2.

1965. *Pseudocardia amanoi* Hayami, *Mem. Fac. Sci., Kyushu Univ., Ser. D*, vol. 17, no. 2, p. 79, pl. 7, figs. 4—7.

1975. *Xenocardita amanoi* (Hayami); Hayami, *Univ. Mus., Univ. Tokyo, Bull.*, no. 10, p. 124.

Materials:—KSG 3442 — KSG 3445, external moulds of left and right valves, from Bunjo of Ochi, Sakawa; KSG 3446, external mould of left valve, from Yotsushiro of Ochi, Sakawa.

Measurements (in mm.):—

Specimens	Length	Height	Thick-ness
KSG 3442, l. ex. mol.	6.2	6.5	2.1
KSG 3446, l. ex. mol.	5.5	7.0	1.8

Remarks:—The specimens from the Sakawa area are safely identical with *Xenocardita amanoi* (Hayami) from the Hagino Formation in the Monobe area, in the diagnostic features which were described clearly by Hayami (1965).

Occurrence and geological age:—Common in fine- to medium-grained sandstone of the Bunjo Formation at Bunjo and Yotsushiro of Ochi, Sakawa area (Locs. 8, 9); Aptian.

Superfamily Crassatellacea Ferussac, 1822

Family Astartidae d'Orbigny, 1844

Subfamily Astartinae d'Orbigny, 1844

Genus *Astarte* Sowerby, 1816

Subgenus *Astarte* Sowerby, 1816

Astarte (*Astarte*) *subsenecta* Yabe et Nagao

Pl. 75, Fig. 14; Pl. 77, Figs. 17—19, 25—26.

1926. *Astarte subsenecta* Yabe et Nagao, *in* Yabe, Nagao and Shimizu, *Sci. Rep., Tohoku Imp. Univ., Ser. 2*, vol. 9, no. 2, p. 47, pl. 13, figs. 14—16, pl. 14, fig. 11.
1965. *Astarte* (*Astarte*) *subsenecta* Yabe et Nagao; Hayami, *Mem. Fac. Sci., Kyushu Univ., Ser. D, Geol.*, vol. 17, no. 2, p. 81, pl. 7, figs. 10—18, pl. 14, figs. 1—5.
1972. *Astarte* (*Astarte*) *subsenecta* Yabe et Nagao; Shikama and Suzuki, *Sci. Rept., Yokohama Nat. Univ., Ser. 2*, vol. 19, pl. 6, fig. 4.
1975. *Astarte* (*Astarte*) *subsenecta* Yabe et Nagao; Hayami, *Univ. Mus., Univ. Tokyo, Bull.*, no. 10, p. 125.
1980. *Astarte* (*Astarte*) *subsenecta* Yabe et Nagao; Hayami, *in* Hayami and Oji, *Trans. Proc., Palaeont. Soc. Japan, N.S.*, no. 105, p. 431, pl. 53, figs. 1—6.
1980. *Astarte* (*Astarte*) *subsenecta* Yabe et Nagao; Tashiro, Kozai, Okamura and Katto, *Geol. Paleont. Shimanto Belt*, Taira and Tashiro *eds.*, *Kochi*, p. 75.
1985. *Astarte* (*Astarte*) *subsenecta* Yabe et Nagao; Tashiro and Matsuda *in* Tashiro, Matsuda and Tanaka, *Mem. Fac. Sci., Kochi Univ., Ser. E*, vols. 5—6, p. 10, pl. 2, fig. 16, pl. 3, figs. 1—3.

Materials:—KSG 3476, internal mould of right valve; KSG 3475, external mould of left valve; both from north of Hirooka, Kamo, Sakawa; KSG 3472 and KSG 3473, internal moulds of right valve, from Ujidani of Kamo, Sakawa; KSG 3477 and KSG 3474, external moulds of right valve, from Ujidani of Kamo, Sakawa.

Measurements (in mm.):—

Specimens	Length	Height	Thick-ness
KSG 3472, r. in. mol.	19.8	18.9	—
KSG 3473, ditto	14.2	15.0	—
KSG 3476, ditto	18.5	20.0	—
KSG 3474, r. ex. mol.	14.9	13.9	2.0

Remarks:—Although the present specimens from this area are not well preserved, they are undoubtedly conspecific with *Astarte* (*Astarte*) *subsenecta* Yabe et Nagao, a well known species from the Lower Cretaceous in Japan, in their features of valve, hinge structure and surface ornamentation.

Occurrence and geological age:—Rare in fine-grained sandstone of the lower member of Tosakamo Formation at about 900 m north of Hirooka of Kamo, Sakawa area (Loc. 5); Aptian. Rare in fine- to medium-grained sandstone of the same formation at Ujidani of Kamo, Sakawa area (Loc. 4); Aptian.

Subgenus *Trautscholdia* Cox et Arkell, 1948

Astarte sp. cf. *Astarte* (*Trautscholdia*) *minor* Nagao

Pl. 77, Figs. 20—24.

Compare with:—

1934. *Astarte minor* Nagao, *Jour. Fac. Sci., Hokkaido Imp. Univ., Ser. 4*, vol. 2, no. 3, p. 220, pl. 28, figs. 5—10.
1965. *Astarte* (*Nicaniella*) *minor* Nagao; Hayami, *Mem. Fac. Sci., Kyushu Univ., Ser. D, Geol.*, vol. 17, no. 2, p. 91, pl. 8, figs. 19—22.

1975. *Astarte (Trautscholdia) minor* Nagao; Hayami, *Univ. Mus., Univ. Tokyo, Bull.*, no. 10, p. 126.

Materials:—KSG 3466 and KSG 3468, internal moulds of left and right valves, from Ujidani of Kamo, Sakawa; KSG 3469 – KSG 3471, external moulds of left and right valves, from the same locality.

Measurements (in mm.):—

Specimens	Length	Height	Thick-ness
KSG 3469, r. ex. mol.	8.3	6.1	0.7
KSG 3471, l. ex. mol.	9.0	7.1	0.8
KSG 3466, l. in. mol.	8.6	5.8	—
KSG 3467, r. in. mol.	7.7	6.9	—
KSG 3468, l. in. mol.	7.9	6.4	—

Remarks:—This species is closely similar to *Astarte (Trautscholdia) minor* Nagao from the Miyako Group of northeast Japan (Nagao, 1934; Hayami, 1965), in its small valve, distinct concentric costae on the surface and chestnut-like outline of the valve, but slightly differs in its more numerous concentric costae.

Occurrence and geological age:—Common in fine- to medium-grained sandstone of the lower member of Tosakamo Formation at Ujidani of Kamo, Sakawa area (Loc. 4); Aptian.

Superfamily Solenacea Lamarck, 1809

Family Cultellidae Davies, 1935

Genus *Leptosolen* Conrad, 1865

Leptosolen sp.

Material:—KSG 3447, internal mould of right valve, from Ujidani of Kamo, Sakawa.

Remarks:—KSG 3447 is an imperfect specimen, measured about 20 mm in length and 6 mm in height. A vertical inner buttress is distinctly observable under the beak which is located at about a fourth from front of valve. Several other fragmental specimens are still more imperfectly preserved.

Occurrence and geological age:—Very rare in fine-grained sandstone of the lower member of Tosakamo Formation at Ujidani of Kamo, Sakawa area (Loc. 4); Aptian.

Superfamily Cardiacea Lamarck, 1809

Family Cardiidae Lamarck, 1809

Subfamily Protocardiinae Keen, 1951

Genus *Protocardia* von Beyrich, 1845

Subgenus *Protocardia* von Beyrich, 1845

Protocardia (Protocardia) amanoi, sp. nov.

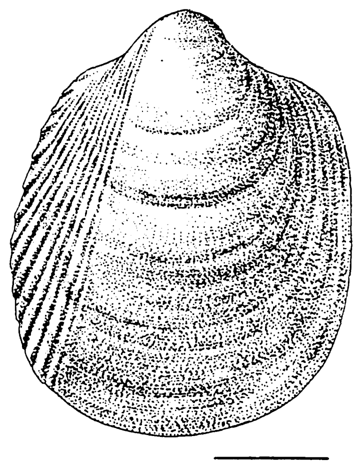
Pl. 77, Figs. 10–14; Text-fig. 5.

1957b. *Protocardium* sp.; Amano, *Kumamoto Jour. Sci., Ser. B*, vol. 2, no. 2, p. 100, pl. 2, figs. 31–34.

Materials:—The holotype, KSG 3448, external mould of right valve, from Bunjo of Ochi, Sakawa; paratypes, KSG 3449 – KSG 3451, external moulds of left and right valves from the same locality as the holotype.

Diagnosis:—Shell roundly subquadrate in outline; umbo prominent but small; disk smooth; posterior area with several distinct radial ribs; inner margin not crenulated.

Description:—Shell small, roundly subquadrate, nearly equivalve, somewhat inequilateral, higher than long in general, moderately inflated; umbo orthogyrous, weakly prominent for *Proto-*



Text-fig. 5. The diagramatic sketch of *Protocardia (Protocardia) amanoi* Tashiro et Matsuda, sp. nov., holotype from the Bunjo Formation at Bunjo of Ochi, Sakawa. (scale 5 mm).

cardia, pointed, nearly central or slightly anteriorly placed; anterior dorsal margin short, weakly concave; posterior dorsal margin nearly straight, somewhat shouldered; anterior margin subvertically truncated, nearly straight or weakly convex; ventral margin moderately arched; posterior margin obliquely truncated, nearly straight; postero-ventral margin narrowly rounded; posterior carinal ridge indistinct but observable as a boundary line between smooth disk and ribbed posterior slope; radial ribs on posterior slope (area) round-topped, about 10, broader than their interspaces; hinge plate narrow but elongated with small cardinal teeth and long but narrow lateral teeth; inner margin smooth; growth lines on surface indistinct.

Measurements (in mm.):—

Specimens	Length	Height	Thickness
KSG 3448, holotype, r. ex. mol.	19.0+	20.0	4.9
KSG 3449, paratype, l. ex. mol.	11.0	11.2	2.8
KSG 3450, ditto, ditto	12.5	11.5+	2.5

Observation:—This species is variable in the outline as already mentioned by Amano (1957b). The radial ribs on the posterior slope are constantly 10 in number. The specimens from this area are more or less incomplete, but they show well the diagnostic characters.

Comparison:—This species is easily discriminated from *Portocardia hiraigensis* Hayami (1965) from the Miyako Group of northeast Japan, in its distinct radial ribs on the posterior slope. It is characterized by smaller size and more distinct and less numerous radial ribs on the posterior slope than *Protocardia koshikijimensis* Amano (1957a) (Tashiro, 1976) from the Himenoura Group in Kyushu. It resembles *Protocardia beiha* Vokes (1946) from the Aptian of Lebanon in the arrangements of the radial ribs, but differs in its more numerous radial ribs and subquadrate outline.

Occurrence and geological age:—Rare in fine- to medium-grained sandstone of the Bunjo Formation at Bunjo and Yotsushiro of Ochi, Sakawa area (Locs. 8, 9); Aptian.

Subfamily Laevicardiinae Keen, 1936

Genus *Laevicardium* Swainson, 1840

Laevicardium? *ishidoense* (Yabe et Nagao)

Pl. 77, Figs. 8—9.

1926. *Cardium ishidoensis* Yabe et Nagao, *in* Yabe, Nagao and Shimizu, *Sci. Rep., Tohoku Imp. Univ., Ser. 2,* vol. 9, no. 3, p. 48, pl. 12, figs. 9, 16, 18.
1965. *Laevicardium* (?) *ishidoensis* (Yabe et Nagao); Hayami, *Mem. Fac. Sci., Kyushu Univ., Ser. D,* vol. 17, no. 2, p. 123, pl. 17, figs. 8—10.
1975. *Laevicardium*? *ishidoensis* (Yabe et Nagao); Hayami, *Univ. Mus., Univ. Tokyo, Bull.*, no. 10, p. 134.
1978. *Laevicardium*? *ishidoensis* (Yabe et Nagao); Katto and Tashiro, *Res. Rep., Kochi Univ.*, vol. 27, p. 146, pl. 1, figs. 12—15.
1980. *Laevicardium* (?) sp. aff. *L.* (?) *ishidoense*; Hayami *in* Hayami and Oji, *Trans. Proc., Palaeont. Soc. Japan, N.S.*, no. 120, p. 434, pl. 53, fig. 7.

Materials:—KSG 3452 and KSG 3453, external moulds of left valve, from the northeast of Ujidani, Kamo, Sakawa.

Remarks:—KSG 3452, 32.8 mm high and 8.0 mm thick, is weathered on the posterior marginal part. Another specimen, KSG 3453, is a fragmentary left valve. Although they are imperfect, the characteristic surface ornamentation and outline of the valve are well preserved. They are undoubtedly conspecific with *Laevicardium*? *ishidoense* (Yabe et Nagao), from the Ishido Formation in Sanchu (Yabe, Nagao and Shimizu, 1926; Hayami, 1965), in its vertically elongated outline and very fine delicate radial ribs.

Occurrence and geological age:—Very rare in medium-grained sandstone of the lower member of Tosakamo Formation at about 800 m north of Hirooka (northeast of Kamo), Kamo Sakawa area (Loc. 5); Aptian.

Laevicardium? *corpulentum* (Amano)

Pl. 77, Figs. 1—7.

1957b. *Cardium corpulentum* Amano, *Kumamoto Jour. Sci., Ser. B*, vol. 2, no. 2, p. 99, pl. 2, fig. 30.

1965. *Laevicardium* (?) *corpulentum* (Amano); Hayami, *Mem. Fac. Sci. Kyushu Univ., Ser. D*, vol. 17, no. 2, p. 125, pl. 15, fig. 11.

1975. *Laevicardium*? *corpulentum* (Amano); Hayami, *Univ. Mus., Univ. Tokyo, Bull.*, no. 10, p. 135.

Materials:—KSG 3454, external mould of left valve; KSG 3455 and KSG 3456, internal moulds of left and right valves; KSG 3457, external mould of left? valve; all from Bunjo of Ochi, Sakawa.

Measurements (in mm.):—

Specimens	Length	Height	Thickness
KSG 3454, l. ex. mol.	21.6	26.9	11.5
KSG 3455, r. in. mol.	20.3	25.0	—
KSG 3456, l. in. mol.	24.2	28.1	—

Remarks:—The specimens from the Bunjo Formation are in favorable preservation more than the specimens from the Hagino Formation in Monobe area, type locality by Amano (1957b). This species clearly differs from *Laevicardium*? *ishidoense* (Yabe et Nagao) in its more prominent umbo, more vertically elongated outline and far more delicate radial ribs on the surface than those of the latter.

Occurrence and geological age:—Common in fine- to medium-grained arenite sandstone of the Bunjo Formation at Bunjo of Ochi, Sakawa area (Loc. 8); Aptian.

Superfamily Myacea Lamarck, 1809

Family Corbulidae Lamarck, 1818

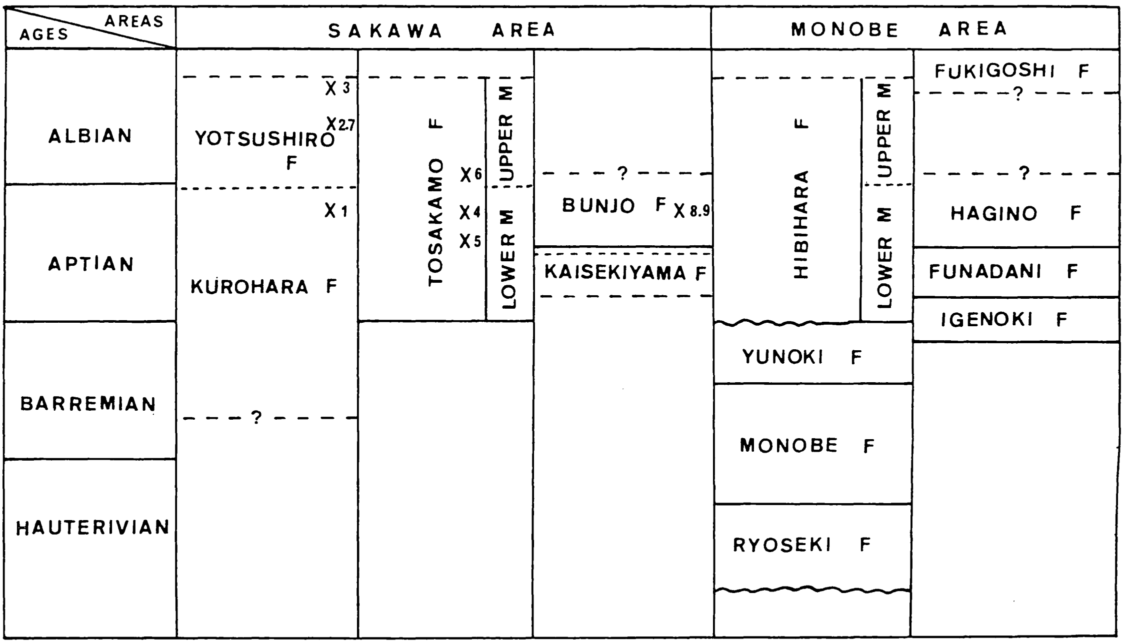
Subfamily Caestocorbulinae Vokes, 1945

Genus *Caestocurbula* Vincent, 1910

Caestocorbula minima Hayami

Pl. 77, Figs. 27—30.

1980. *Caestocorbula minima* Hayami, *in* Hayami and Oji, *Trans. Proc., Palaeont. Soc. Japan, N.S.*, no. 120, p. 437, pl. 53, figs. 15, 16.



Text-fig. 6. The correlational diagram of the Lower Cretaceous strata of the Sakawa and Monobe areas in Kochi. X: fossil localities.

Materials:—KSG 3458 — KSG 3460, internal moulds of right valve; KSG 3461 — KSG 3463, internal moulds of left valve; all from Ujidani of Kamo, Sakawa.

Measurements (in mm.):—

Spcimens	Length	Height
KSG 3458, r. in. mol.	7.5	5.3
KSG 3459, ditto	9,0	7.5
KSG 3461, l. in. mol.	7.5	5.0
KSG 3463, ditto	8.3	6.2

Remarks:—Numerous specimens are in our hands. They are undoubtedly conspecific with *Caestocorbula minima* Hayami (Hayami and Oji, 1980) from the Aptian Choshi Group in central Japan on account of its diagnostic features which were well defined by Hayami (*in* Hayami and Oji, 1980). This species also occurs abundantly from the Aptian Hibihara (=Kaminiro) Formation in the Monobe area, Shikoku, as reported by Tashiro *et al.* (1980).

Occurrence and geological age:—Abundant in fine- to medium-grained sandstone of the lower member of Tosakamo Formation at Ujidani of Kamo, Sakawa area (Loc. 4); Aptian.

Caestocorbula sp. cf. *C. shikamai* Hayami

Pl. 77, Fig. 31.

Comapre with:—

1980. *Caestocorbula shikamai* Hayami, *in* Hayami and Oji, *Trans. Proc., Palaeont. Soc. Japan, N.S.*, no. 120, p. 436, pl. 53, figs. 8—12.

Materials:—KSG 3464 and KSG 3465, right valves, from Ujidani of Kamo, Sakawa.

Measurements (in mm.):—

Specimens	Length	Height	Thick-ness
KSG 3464, r. valve	16.3	9.8	4.0
KSG 3465, ditto	13.5	9.6	3.6

Remarks:—These specimens are probably referable to *Caestocorbula shikamai* Hayami (1980) from the Choshi Group in central Japan judging from its concentric riblets on the disk, broadly prominent umbo and less rostrated posterior area.

Occurrence and geological age:—Rare in fine-grained sandstone of the lower member of Tosakamo Formation at Ujidani of Kamo, Sakawa area (Loc. 4); Aptian.

Concluding remarks

Taxonomic results:—Bivalve species from the Lower Cretaceous System in the Sakawa basin, which were described in this part, are listed in Table 1. Most of the species are already known from the other Cretaceous System in southwest Japan (Amano, 1957b; Hayami, 1965—66; Tashiro *et al.*, 1980, 1981, 1985; Tashiro and Kozai, 1984).

Correlation:—The Kurohara Formation (= Lower Monobegawa Group by Fukuji, 1941 and Hirata, 1974) closely resembles and is correlated with the lower part of the Hibihara Formation (=Kaminiro Formation by Hujita, 1943, Aptian) in the Monobe area, Shikoku, in having the bivalve fauna characterized by *Pterotrigonia* (s.s.) *pocilliformis*, *Nipponitrigonia kikuchiana* and *N. sakamotoensis*. The lower member (=Kaisekiyama Formation by Kurata, 1941; Ryoseki Formation by Hirata, 1974; "Kaisekiyama Formation" by Katto and Tashiro, 1981) of the Tosakamo Formation is also correlated with the lower part of the Hibihara Formation by the occurrence of common bivalve species, *e.g.*, *Nuculopsis* (*Palaeonucula*) *ishidoensis*, *Portlandia sanchuensis*, *Pterotrigonia* (s.s.) *pocilliformis*, *Astarte* (s.s.) *subsenecta*, *A.* (*Trautscholdia*) *minor*, *Caestocorbula minima* and *C. shikamai*. The bivalve fauna from the lower member of the Tosakamo Formation somewhat differs from that of the Kurohara Formation by the occurrence of very shallow marine or subtidal bivalves, *i.e.*, *Nipponitrigonia* spp., which have not been know from the former.

The Yotsushiro Formation (=Upper Monobegawa Group by Fukuji, 1941; Hirata, 1974) is undoubtedly correlated with the upper member (="Yunoki Formation" by Yamashita, 1961; "Yotsushiro Formation" by Katto and Tashiro, 1981; Upper Monobegawa Group by Fukuji, 1941; Hirata, 1974) of the Tosakamo Formation because of the similarity in characteristics of facies and the presence of common bivalves and ammonites. The Yotsushiro Formation and the upper member of the Tosakamo Formation are also safely correlated with the upper part of the Hibihara Formation (Upper Aptian to Albian) on account of the common occurrence of *Inoceramus anglicus*, *Parvamussium tosaense* and several ammonites (Dr. T. Matsumoto's information). The upper member of Tosakamo Formation very resembles and is correlated with the Tomochi Formation and the upper part of Hinagu Formation in central Kyushu in having similar muddy facies and occurrence of common bivalves, e.g., *Parvamussium hinagense*, *P. tosaense* and *Cosmetodon tomochiensis*.

The bivalve fauna from the Bunjo Formation (=eastern part of the Miyanohara Formation by Yamashita, 1961; Hirata, 1974) is nearly identical to that of the Hagino Formation (Amano, 1957b; Aptian) in the Monobe area, Shikoku, because nearly all of the species of bivalves and ammonites are common between them. Although the Bunjo and Kurohara (including the lower member of the Tosakamo Formation) Formations are determinable to the Aptian in age by

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Explanation of Plate 74

Figs. 1—3. *Nuculopsis* (*Palaeonucula*) *ishidoensis* (Yabe et Nagao) . . . . Page 368
× 2, Loc. Ujidani of Kamo, Sakawa (4), Fig. 1, KSG 3479, gum cast of external mould, Fig. 2, KSG 3481, Fig. 3, KSG 3480, gum cast of external mould.

Figs. 4—7. *Portlandia sanchuensis* (Yabe et Nagao) . . . . Page 368
× 2, Loc. Ujidani of Kamo, Sakawa (4), Fig. 4, KSG 3486, gum cast of external mould, Fig. 5, KSG 3484, internal mould, Fig. 6, KSG 3483, internal mould, Fig. 7, KSG 3485, gum cast of external mould.

Fig. 8. *Nemodon* sp. . . . . Page 370
× 2, Loc. Bunjo of Ochi, Sakawa (8), KSG 3494, gum cast of external mould.

Figs. 9—15. *Cosmetodon tomochiensis*, sp. nov. . . . . Page 369
Fig. 9, Paratype, KSG 3492, × 2, Loc. Kuroishi of Kamo, Sakawa (6), Figs. 10—11, Holotype, KSG 3487, Loc. Kashiwagawa of Tomochi, Kumamoto Prefecture, Fig. 10, × 2, internal mould, Fig. 11, × 2.5, gum cast, Figs. 12—15, Paratypes, × 2.5 excluding Fig. 12 (× 2), Loc. same with above, Figs. 12 (KSG 3488) — 13 (KSG 3489), internal moulds, Figs. 14 (KSG 3490) — 15 (KSG 3491), gum casts of external moulds.

Figs. 16—18. *Cucullaea obliquata* (Amano) . . . . Page 372
Figs. 16—17, × 1, KSG 3497, gum casts of internal moulds, Fig. 18, × 2, KSG 3498, gum cast of external mould, Loc. Bunjo of Ochi, Sakawa (8).

Figs. 19—20. *Arca* (*Eonavicula*) *prolata* Amano . . . . Page 371
× 1, Fig. 19, KSG 3496, gum cast of external mould, Fig. 20, KSG 3495, internal mould, Loc. Bunjo of Ochi, Sakawa (8).

Figs. 21—22. *Neithea* (*Neithea*) *syriaca amanoi* Hayami . . . . Page 376
Fig. 21, × 1, KSG 3520, gum cast of external mould, Fig. 22, × 1.2, KSG 3521, external mould, Loc. Bunjo of Ochi, Sakawa (8).

Fig. 23. *Pterotrigonia* (?*Scabrotrigonia*) *moriana* (Yehara) . . . . Page 380
× 1.2, external mould, Loc. Bunjo of Ochi, Sakawa (8).

Figs. 24—27. *Pterotrigonia* (*Pterotrigonia*) *pocilliformis* (Yokoyama) . . . . Page 379
Fig. 24 (KSG 3439), × 2, internal mould, Fig. 25 (KSG 3438), × 2.5, gum cast of external mould, Fig. 27 (KSG 3437), × 1, gum cast of external mould, Loc. Ujidani of Kamo, Sakawa (4), Fig. 26, KSG 3436, × 1.5, gum ast of external mould, Loc. Kurohara (Sendatsuno) of Ochi, Sakawa (1).

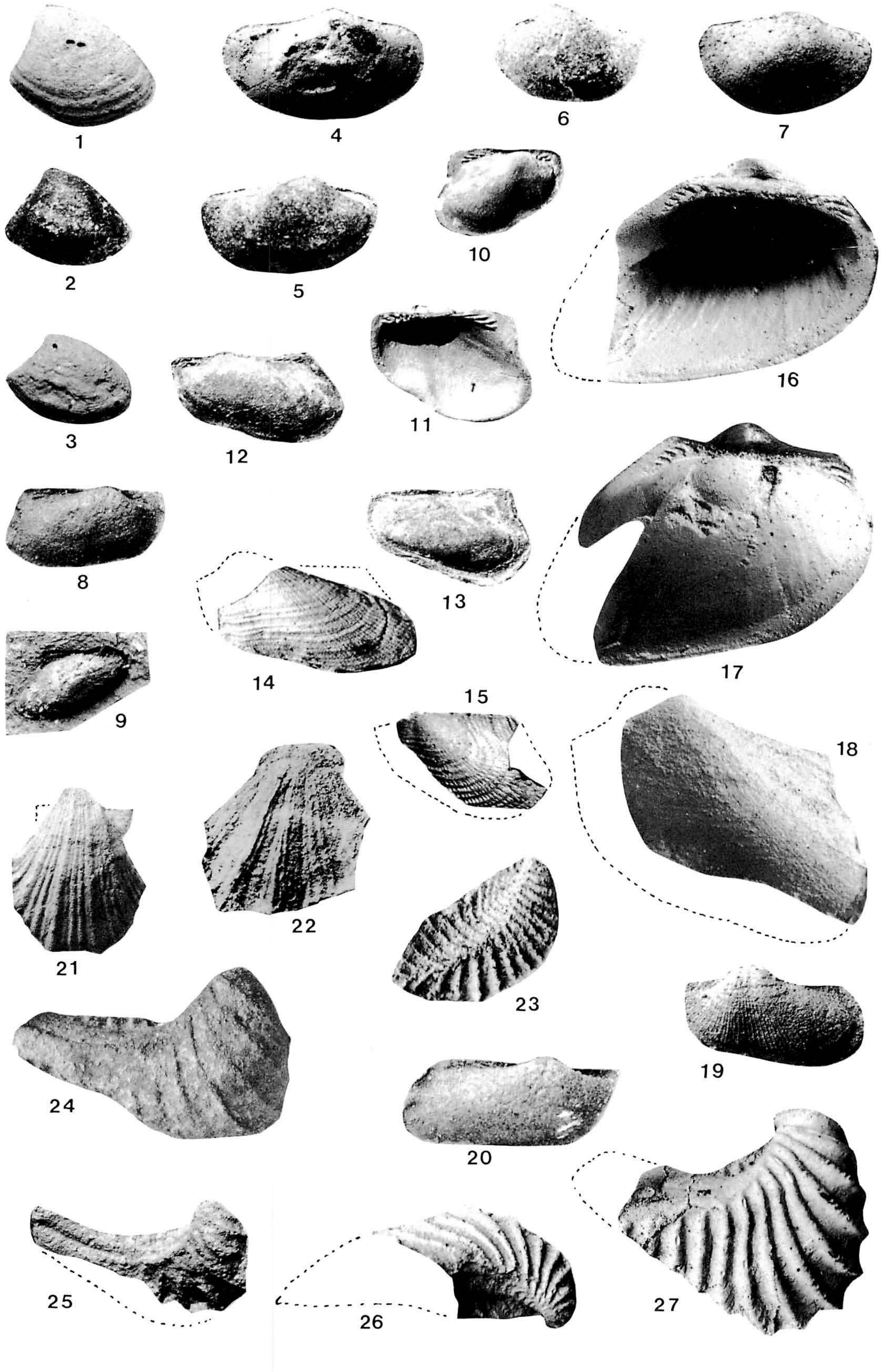
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Table 1. List of bivalve species from Sakawa.

	Sakawa					Monobe	
Species	K	Y	TL	TU	B	HI	HA
Nuculopsis (Palaeonucula) ishidoensis			◉			○	
Portlandia sanchuensis			○			○	
Cosmetodon tomochiensis				×			
Nemodon sp.					×		×
Arca (Eonavicula) prolata					○		○
Cucullaea obliquata					×		×
Modiolus falcatus					○		○
Pinna (P.) sp. cf. *P. (P.) robinaldina*					◉	○	◉
Gervillaria haradae	○		○		○	○	○
Gervillia (Gervillia) sp. cf. *(G.) forbesiana*	◉		○		○	◉	○
Isognomon sp.					×		×
Inoceramus anglicus		○				○	
I. sp. aff. *I. crippsi*		×					
I. sp.		×					
Neithea (Neithea) syriaca amanoi					◉		◉
Parvamussium hinagense				○			
P. tosaense		◉		○		◉	
P. kattoi		○					
Plicatula sp.					○		○
Nipponitrigonia kikuchiana	◉					◉	
Pterotrigonia (Pterotrigonia) pocilliformis	◉		○			◉	
P. (?Scabrotrigonia) moriana					◉		◉
P. (?S.) sp.					○		○?
Lucinoma (?) sp.			○			○	
Xenocardita amanoi					◉		◉
Astarte (Astarte) subsenecta			○			○	
A. sp. cf. *A. (Trautscholdia) minor*			◉			◉	
Leptosolen sp.			×			○	
Protocardia (Protocardia) amanoi					○		○
Laevicardium? ishidoense			○			○?	
L.? corpulentum					◉		◉
Caestocorbula minima	○		◉			◉	
C. sp. cf. *C. shikamai*			○			○	

×: rare, ○: common, ◉: abundant, K: Kurohara F., Y: Yotsushiro F., TL: Lower Member of Tosakamo F., TU: Upper Member of Tosakamo F., B: Bunjo F., HI: Hibihara F., HA: Hagino F.

the occurrence of ammonites, *Chelloniceras* spp., their bivalve faunas differ considerably from each other (see Table 1).

References

Amano, M. (1957a): Upper Cretaceous molluscan fossils from Shimo-koshiki-jima, Kyushu. *Kumamoto Jour. Sci., Ser. B*, vol. 2, no. 2, p. 51—75, pls. 1—2.

—— (1957b): The Lower Cretaceous fauna from Hagino in southern Shikoku, Japan. *Ibid.*, vol. 2, no. 2, p. 77—121, pls. 1—2.

Conrad, T. A. (1862): Description of new genera, subgenera and species of Tertiary and

Recent shells. *Acad. Nat. Sci., Philadelphia, Jour. 1862*, p. 284—291.

Dhondt, A. V. (1973): Systematic revision of the subfamily Neitheinae (Pectinidae, Bivalvia, Mollusca) of the European Cretaceous. *Mem. Inst. Roy. Sci. Nat. Belgique*, no. 176, p. 1—101, pls. 1—5.

Fukuji, S. (1941): Geology of the Ochi basin, province of Tosa, Shikoku. *Jour. Geol. Soc. Japan*, vol. 48, no. 579, p. 547—559.

Hayami, I. (1965): Lower Cretaceous marine pelecypods of Japan, Pt. 1. *Mem. Fac. Sci., Kyushu Univ., Ser. D, Geol.*, vol. 15, no. 2, p. 221—349, pls. 27—52.

——(1966a): Lower Cretaceous marine pelecypods of Japan, Pt. 2. *Ibid.*, vol. 17, no. 2, p. 73—150, pls. 7—12.

——(1966b): Lower Cretaceous marine pelecypods of Japan, Pt. 3. *Ibid.*, vol. 17, no. 3, p. 151—249, pls. 22—26.

——(1975): A systematic survey of the Mesozoic Bivalvia from Japan. *Univ. Mus., Univ. Tokyo, Bull.*, no. 10, p. 1—249, pls. 1—10.

——and Noda, M. (1977): Notes on the morphology of *Neithea* (Cretaceous pectinids) with taxonomic revision of Japanese species. *Trans. Proc., Palaeont. Soc. Japan, N.S.*, no. 105, p. 27—54, pls. 5—6.

——and Oji, T. (1980): Early Cretaceous Bivalvia from Choshi district, Chiba Prefecture, Japan. *Ibid.*, no. 120, p. 419—448, pls. 51—53.

Hirata, M. (1974): Mesozoic fossils in Kochi Prefecture (excluding the Ryoseki flora). *Hirata's Institute of Geology, Kochi*, 68 p., 16 pls.

Hujita, A. (1943): Geology of the Odochi area, Shikoku. *Jour. Geol. Soc. Japan*, vol. 50, p. 207—215.

Katto, J. and Tashiro, M. (1978): A study on the molluscan faunas of the Shimanto Terrain, southwest Japan, Part 1: On the bivalve fauna of the Doganaro Formation in Susaki area, Kochi Prefecture. *Res. Rep., Kochi Univ.*, vol. 27, p. 143—150, pls. 1—2.

——and —— (1981): On the Cretaceous system in the Sakawa area, Kochi, Japan. *Ibid.*, vol. 30, p. 109—119.

Kobayashi, T. (1957): *Nipponitrigonia* and *Rutitrigonia* in Japan. *Trans. Proc., Palaeont. Soc. Japan, N.S.*, no. 26, p. 51—61, pls. 10—11.

——and Suzuki, K. (1939): The brackish Welden fauna of the Yoshimo beds in Prov. Nagato,

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Explanation of Plate 75

Figs. 1—5, 13. *Gervillaria haradae* (Yokoyama) . . . . Page 373
Fig. 1 (KSG 3507), x 1, gum cast of external mould, Figs. 5 (gum cast of internal mould), 13 (internal mould), KSG 3506, x 1, Loc Bunjo of Ochi, Sakawa (8), Fig. 2 (KSG 3504), x 1, internal mould, Fig. 3, x 1, KSG 3508, internal mould, Loc. Ujidani of Kamo, Sakawa (4), Fig. 4, x 1.5, internal mould, Loc. Yotsushiro of Ochi, Sakawa (9).

Figs. 6, 12. *Modiolus falcatus* Amano . . . . Page 373
Fig. 6, x 1.2, KSG 3499, gum cast of external mould, Fig. 12, x 2, KSG 3500, internal mould, Loc. Bunjo of Ochi, Sakawa (8).

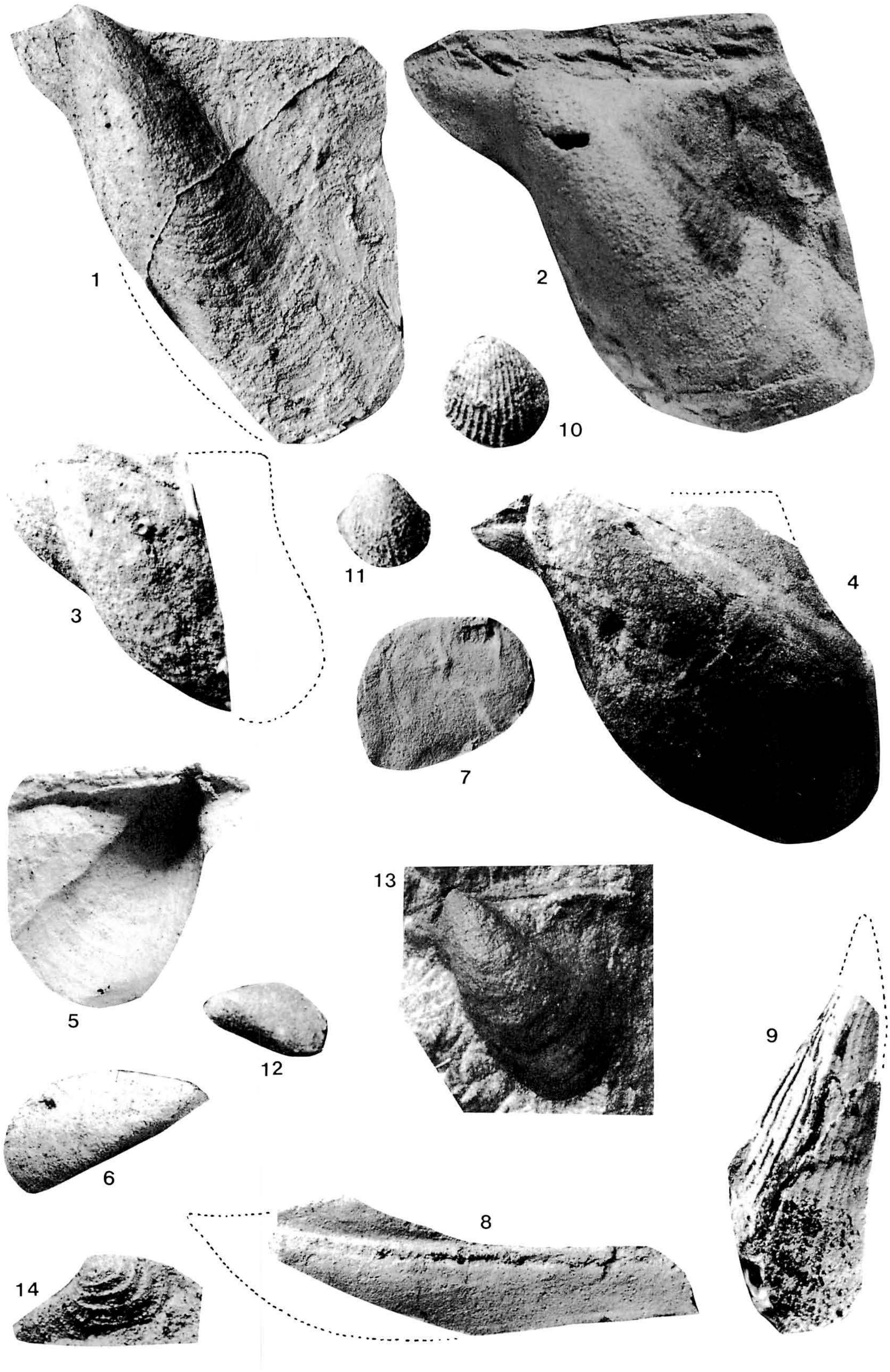
Fig. 7. *Isognomon* sp. . . . . Page 375
x 0.8, KSG 3512, gum cast of internal mould, Loc. Bunjo of Ochi, Sakawa (8).

Fig. 8. *Gervillia* (*Gervillia*) sp. cf. *G.* (*G.*) *forbesiana* d'Orbigny . . . . Page 374
x 1.2, KSG 3508, gum cast of external mould, Loc. Bunjo of Ochi, Sakawa (8).

Fig. 9. *Pinna* (*Pinna*) sp. cf. *P.* (*P.*) *robinaldina* d'Orbigny . . . . Page 373
x 1, KSG 3502, gum cast of external mould, Loc. Bunjo of Ochi, Sakawa (8).

Figs. 10—11. *Xenocardita amanoi* (Hayami) . . . . Page 380
x 4, Fig. 10 (KSG 3442), Fig. 11 (3446), gum casts of external moulds, Loc. Bunjo of Ochi, Sakawa (8).

Fig. 14. *Astarte* (*Astarte*) *subsenecta* Yabe et Nagao . . . . Page 381
x 2.5, gum cast of external mould, Loc. Ujidani of Kamo, Sakawa (4).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Japan. *Japan. Jour. Geol. Geogr.*, vol. 16, nos. 3—4, p. 213—224, pls. 13—14.

——and Nakano, M. (1957): On the Pterotrigoniinae. *Ibid.*, vol. 28, no. 4, p. 219—238, pls. 16—17.

Kurata, N. (1940): Geology of the Togano basin of Sakawa. *Jour. Geol. Soc. Japan*, vol. 47, no. 567, p. 507—516.

Matsukuma, A. (1979): Glycymeridid bivalves from Japan and adjacent areas, Pt. 1. *Venus* (*Japan. Jour. Malac.*), vol. 38, no. 2, p. 95—128.

Matsumoto, T. and Harada, M. (1964): Cretaceous stratigraphy of the Yubari dome, Hokkaido. *Mem. Fac. Sci., Kyushu Univ., Ser. D, Geol.*, vol. 15, no. 1, p. 79—115, pls. 9—11.

——, Hayami, I. and Asano, K. (1963): A survey of fossils from Japan illustrated in classical monographs, Part VII. *Palaeont. Soc. Japan, 25th Anniv. Vol.*, p. 27—32, pls. 44—51.

Nagao, T. (1934): Cretaceous Mollusca from the Miyako district, Honshu, Japan. *Jour. Fac. Sci., Hokkaido Imp. Univ., Ser. 4*, vol. 2, no. 3, p. 177—277, pls. 23—39.

Shikama, T. and Suzuki, S. (1972): Stratigraphy and tectonic development mainly of Cretaceous formations of Choshi Peninsula, Chiba Prefecture. *Sci. Rept., Yokohama Nat. Univ., Ser. 2*, vol. 19, p. 133—157, pls. 4—6.

Shinohara, I. (1951): Illustrated handbook of fossils from Shikoku. 30 p., 13 pls. (*Shumi-no-chigaku*).

Tamura, M. (1959): Taxodonta and Isodonta from the Upper Jurassic Sakamoto Formation in central Kyushu, Japan. *Trans. Proc., Palaeont. Soc. Japan, N.S.*, no. 34, p. 53—65, pl. 6.

——(1973): Two new species of Lower Cretaceous *Parvamussium* from Kyushu, Japan and Sarawak Borneo. *Geol. Pal. Southeast Asia*, vol. 11, p. 119—124, pl. 17.

Tashiro, M. (1976): Bivalve faunas of the Cretaceous Himenoura Group in Kyushu. *Palaeont. Soc. Japan, Spec. Pap.*, no. 19, p. 1—121, pls. 1—12.

——(1985): The bivalve faunas and their biostratigraphy of the Cretaceous in Japan. *Geol. Soc. Japan, Spec. Pap.*, no. 26, p. 43—75.

——and Kozai, T. (1984): Bivalve fossils from the type Monobegawa Group (Part 1). *Res. Rep., Kochi Univ.*, vol. 32, p. 259—293, pls. 1—4.

——, ——, Okamura, M. and Katto, J. (1980): A biostratigraphical study of the Lower Cretaceous formations of Monobe area, Kochi Prefecture, Japan. *Geol. Paleont. Shimanto Belt*, Taira and Tashiro *eds.*, *Kochi*, p. 71—82, pls. 10—11.

—— and Matsuda, T. (1983): A study of the pterotrigoniae from Japan, Part 1. *Mem. Fac. Sci., Kochi Univ., Ser. E, Geol.*, vol. 4, p. 13—52, pls. 1—13.

——, —— and Tanaka, H. (1985): Upper Albian bivalve fauna of the Haidateyama Group in Kyushu. *Ibid.*, vols. 5—6, p. 1—23, pls. 1—3.

——, Takahashi, K. and Katto, J. (1981): On the geological age of the Doganaro Formation of the Shimanto Belt in Kochi, Japan. *Jour. Geol. Soc. Japan*, vol. 88, no. 3, p. 203—205.

Vokes, H. E. (1946): Contributions to the paleontology of the Lebanon mountains, Republic of Lebanon; Part 3, the pelecypod fauna of the 'Olive locality' (Aptian) at Abeih. *Amer. Mus. Nat. Hist. Bull.*, vol. 87, art. 3, p. 139—216, pls. 1—10.

Woods, H. (1899—1903): A monograph of the Cretaceous Lamellibranchia of England. vol. 1, 227 p., 42 pls., *Palaeontogr. Soc. London*.

——(1904—1913): A monograph of the Cretaceous Lamellibranchia of England. vol. 2, 473 p., 62 pls., *Ibid.*

Yabe, H. (1927): Cretaceous stratigraphy of the Japanese islands. *Sci. Rep., Tohoku Imp. Univ., Ser. 2*, vol. 11, no. 1, p. 27—100, pls. 3—9.

——, Nagao, T. and Shimizu, S. (1926): Cretaceous Mollusca from the Sanchu graben in the Kwanto mountainland, Japan. *Sci. Rep., Tohoku Imp. Univ., Ser. 2*, vol. 9, no. 2, p. 33—76, pls. 12—15.

Yamashita, N. (1961): Geological map of Kochi Prefecture (1/200,000), fig. 5; Geology of Ochi basin and Yokokurayama in Kochi.

Yehara, S. (1915): The Cretaceous trigoniae from Miyako and Hokkaido. *Sci. Rep., Tohoku Imp. Univ., Ser. 2*, vol. 2, no. 2, p. 35—44, pls. 1—2.

——(1923): Cretaceous trigoniae from southwest Japan. *Japan. Jour. Geol. Geogr.*, vol. 2, no. 3, p. 59—84, pls. 8—13.

——(1927): Faunal and stratigraphical study of the Sakawa basin, Shikoku. *Ibid.*, vol. 5, nos. 1—2, p. 1—40, pls. 1—5.

Yokoyama, M. (1890): Versteinerungen aus der japanischen Kreide. *Palaeontographica*, vol. 36, p. 159—202, pls. 18—25.

——(1891): On some Cretaceous fossils from Shikoku. *Jour. Coll. Sci., Imp. Univ. Tokyo, Sec. 2*, vol. 4, no. 2, p. 357—366, pl. 40.

Bunjo 文城, Hagino 萩野, Hibihara 日比原, Hirooka 弘岡, Kaisekiyama 介石山, Kashiwagawa 柏川, Kamo 加茂, Kuroishi 黒石, Kurohara 黒原, Monobe 物部, Ochi 越知, Sakawa 佐川, To 砥用, Ujidani 宇治谷, Yotsushiro 四ツ白, Yamanokami 山ノ神.

Explanation of Plate 76

Figs. 1—2, 10. *Parvamussium kattoi*, sp. nov. . . . . Page 378
Figs. 1, 10, Paratypes, Fig. 1, x 1.5, KSG 3533, gum cast of external mould, Fig. 10, x 2, KSG 3532, gum cast of internal mould, Fig. 2 Holotype, x 2.5, KSG 3531, gum cast of external mould, Loc. Kurohara of Ochi, Sakawa (2).

Figs. 3, 5—6, 11—12. *Parvamussium tosaense*, sp. nov. . . . . Page 377
x 2, Fig. 3, Paratype, KSG 3530, gum cast of external mould, Loc. Kuroishi of Kamo, Sakawa (6), Fig. 5, Paratype, KSG 3528, gum cast of internal mould, Fig. 6, Holotype, KSG 3526, gum cast of internal mould, Fig. 11, Paratype, KSG 3529, gum cast of imperfect external mould, Loc. Yotsushiro of Ochi, Sakawa (2), Fig. 12, Paratype, KSG 3527, gum cast of internal mould, Loc. Kurohara of Ochi, Sakawa (6).

Fig. 4. *Cosmetodon tomochiensis*, sp. nov. . . . . Page 369
Paratype, KSG 3493, x 2, internal mould, Loc. Kuroishi of Kamo, Sakawa (6).

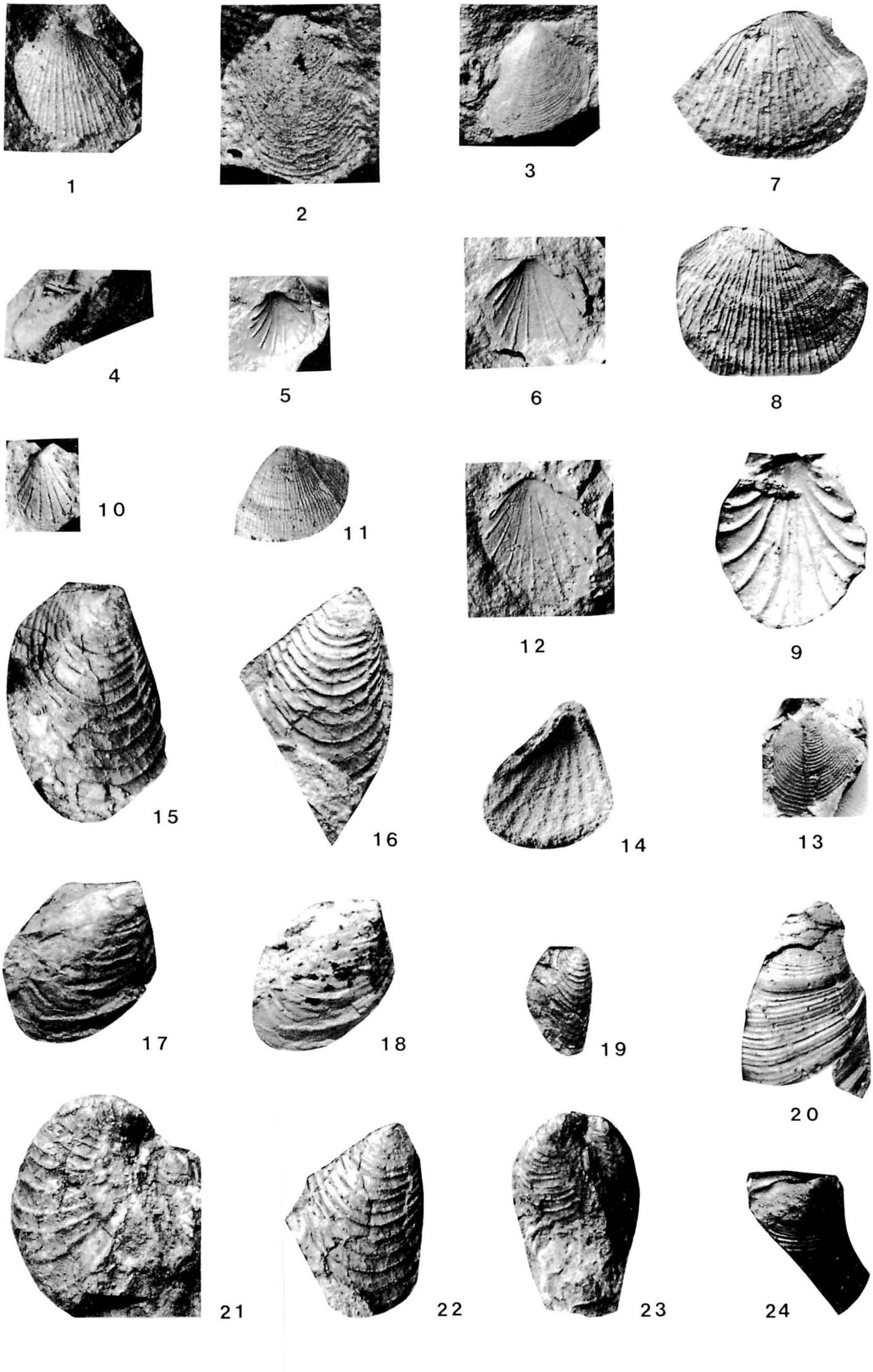
Figs. 7—9, 13. *Parvamussium hinagense* Tamura . . . . Page 376
Figs. 7—8, KSG 3525, x 1.5, Fig. 8, gum cast of external mould, Fig. 9, KSG 3523, x 2, gum cast of internal mould, Fig. 13, KSG 3524, x 1.5, gum cast of external mould, Loc. Kuroishi of Kamo, Sakawa (6).

Fig. 14. *Plicatula* sp. . . . . Page 378
x 2, KSG 3534, gum cast of internal mould, Loc. Bunjo of Ochi, Sakawa (8).

Figs. 15—16, 19, 21—23. *Inoceramus anglicus* Woods . . . . Page 375
x 1, exluding Fig. 21 (x 1.5), Figs. 16, 22, gum casts of external moulds of KSG 3513, Fig. 19, KSG 3514, Fig. 21, KSG 3515, Fig. 23, KSG 3516, posterior dorsal view of conjoined valves, Loc. Kurohara of Ochi, Sakawa (3).

Figs. 17—18. *Inoceramus* sp. aff. *I. crippsi* Mantell . . . . Page 375
x 1, Fig. 17, KSG 3517, internal mould and lateral view (Fig. 18) of external gum cast (Fig. 17), Loc. Kurohara of Ochi, Sakawa (3).

Figs. 20, 24. *Inoceramus* sp. . . . . Page 376
x 1.2, Fig. 20, KSG 3518, gum cast of external mould, Fig. 24, gum cast of external mould, Loc. Kurohara of Ochi, Sakawa (3).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高知県佐川町周辺の下部白亜系産二枚貝化石：高知県佐川町・越知町の下部白亜系から得られた二枚貝化石を検討した結果 22 属 33 種が識別されたので記載する。これらのうち 4 新種 (*Cosmetodon tomochiensis*, *Parvamussium kattoi*, *P. tosaense*, *Protocardia* (*Protocardia*) *amanoi*) を除けば，殆ど西南日本の Barremian から Albian に特徴的な二枚貝ばかりであるが，その大部分は，佐川地方からは始めて報告されるものである。また，これらの二枚貝は，高知県物部地域の下部白亜系の日比原層と萩野層のそれぞれの二枚貝フォーナを構成する種群に大別できるので，佐川地方と物部地方の下部白亜系を対比する上にも重要な材料である。

田代正之・松田智子

Explanation of Plate 77

Figs. 1—7. *Laevicardium*? *corpulentum* (Amano) . . . . Page 383
Gum cast of external mould (Fig. 1, KSG 3454, x 1.5) and surface ornamentation (Fig. 2, x 2), intrnal mould (Fig. 3, KSG 3456, x 1.5) and its dorsal view (Fig. 4, x 1.5) and anterior view (Fig. 5, x 1.5), Fig. 6, internal mould, KSG 3455, x 1.5, Fig. 7, surface ornamentation of gum cast of external mould, KSG 3457, x 3, Loc. Bunjo of Ochi, Sakawa (8).

Figs. 8—9. *Laevicardium*? *ishidoense* (Yabe et Nagao) . . . . Page 383
Fig. 8, lateral view (KSG 3452, x 2) and surface ornamentation in gum cast of external mould (Fig. 9), KSG 3453, x 3, Loc. about 800 m north of Hirooka of Kamo, Sakawa (5).

Figs. 10—14. *Protocardia* (*Protocardia*) *amanoi*, sp. nov. . . . . Page 382
x 1.6, Fig. 10, Holotype, KSG 3448, gum cast of imperfect external mould, and posterior view (Fig. 11), Figs. 12—14, Paratypes, KSG 3451 (Fig. 12), posterior view of gum cast of external mould, KSG 3450 (Fig. 13), gum cast of external mould and KSG 3449 (Fig. 14), posterior view of gum casts of external moulds, Loc. Bunjo of Ochi, Sakawa (8).

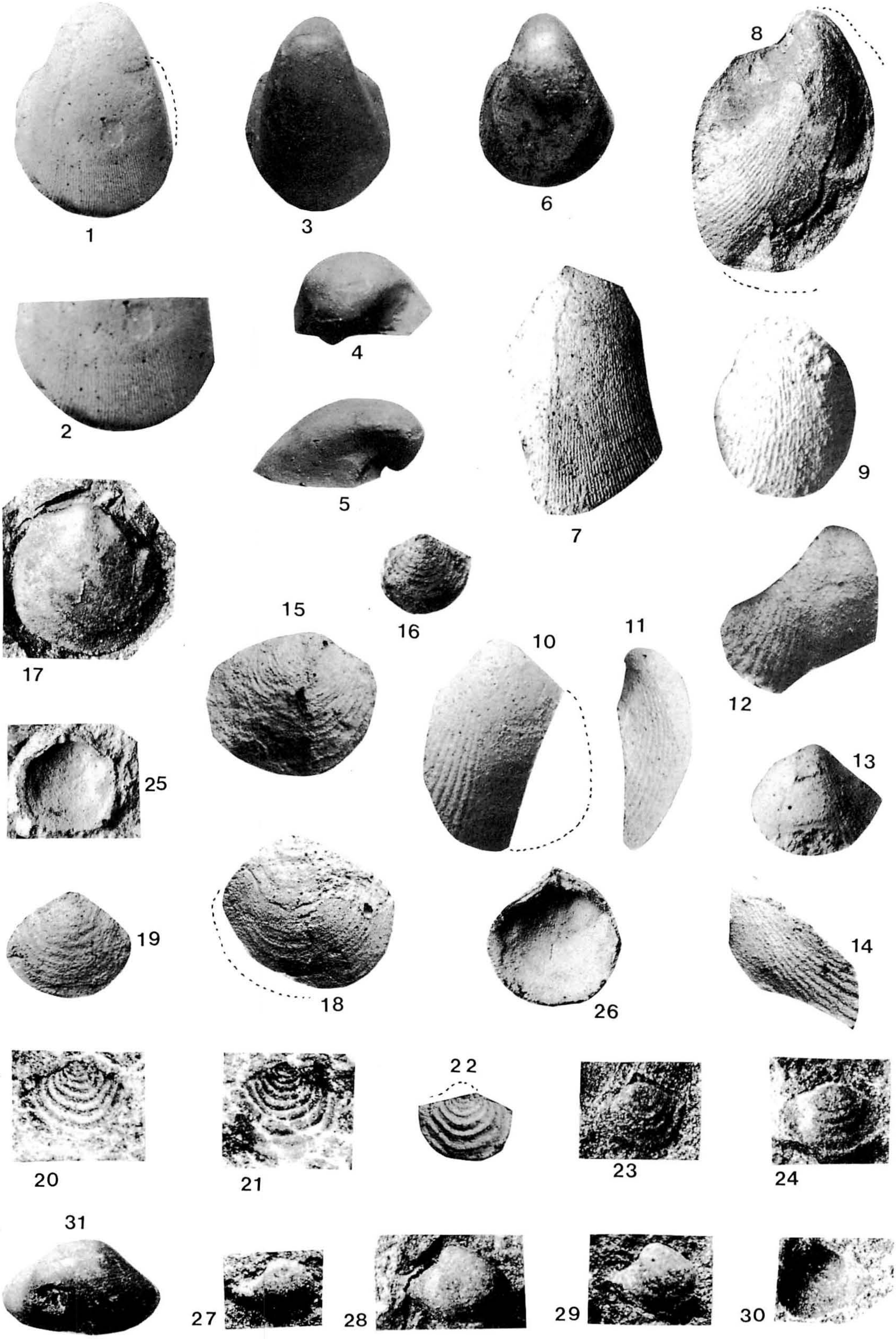
Figs. 15—16. *Lucinoma*? sp. . . . . Page 380
Fig. 15, x 1.6, KSG 3440, gum cast of external mould, Fig. 16, x 2, KSG 3441, gum cast of external mould, Loc. Ujidani of Kamo, Sakawa (4).

Figs. 17—19, 25—26. *Astarte* (*Astarte*) *subsenecta* Yabe et Nagao . . . . Page 381
Fig. 17, x 2, KSG 3476, internal mould, Fig. 18, x 1.2, KSG 3475, gum cast of external mould, Loc. about 800 m north of Hirooka, Kamo, Sakawa (5), Figs. 19, 25—26, x 1.2, Fig. 19, KSG 3474, gum cast of external mould, Fig. 25, KSG 3473, gum cast of internal mould, Fig. 26, KSG 3472, gum cast of internal mould, Loc. Ujidani of Kamo, Sakawa (4).

Figs. 20—24. *Astarte* sp. cf. *Astarte* (*Trautscholdia*) *minor* Nagao . . . . Page 381
x 2.2, Fig. 20, KSG 3469, external mould, Fig. 21, KSG 3471, external mould, Fig. 22, gum cast of imperfect external mould, Fig. 23, KSG 3466, internal mould, Fig. 24, KSG 3468, internal mould, Loc. Ujidani of Kamo, Sakawa (4).

Figs. 27—30. *Caestocorbula minima* Hayami . . . . Page 384
x 2.2, Fig. 27, KSG 3458, internal mould, Fig. 28, KSG 3459, internal mould, Fig. 29, KSG 3460, internal mould, Fig. 30, KSG 3463, internal mould, Loc. Ujidani of Kamo, Sakawa (4).

Fig. 31. *Caestocorbula* sp. cf. *C. shikamai* Hayami . . . . Page 385
x 1.5, KSG 3464, Loc. Ujidani of Kamo, Sakawa (4).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Trans. Proc. Palaeont. Soc. Japan, N.S., No. 142, pp. 393—399, pl. 78, June 30, 1986

814. *STRIATIFERA* AND *GIGANTOPRODUCTUS* FROM THE LOWER CARBONIFEROUS OF FUKUJI, CENTRAL JAPAN*

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Abstract. *Striatifera striata* (Fischer de Waldheim, 1837) and *Gigantoproductus* sp. are described from the lowest part of the Ichinotani Formation (Upper Visean) in Fukuji, Central Japan. *S. striata* is a large-sized linoproductid, distributed in the Upper Visean and Lower Namurian (rarely Upper Tournaisian) of the Old World, *viz.* Britain, France, Belgium, Germany, weastern part of the U.S.S.R., South China and Japan.

Introduction

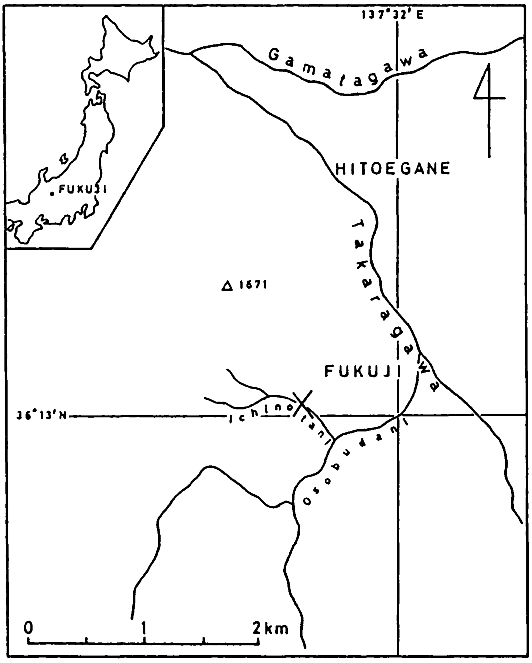
Occurrence of some productoid brachiopods in the Carboniferous rocks of Fukuji, Central Japan, was first noticed by Igo (1956, p. 223). Recently in his paper on the upper Palaeozoic stratigraphy of the Fukuji district, Niikawa (1980, p. 28) recorded *Striatifera* and *Gigantoproductus* from the lowest part of the Carboniferous Ichinotani Formation. However, these species have never been figured or described.

This paper reviews and describes the Niikawa's material collected by Dr. Y. Okazaki and some specimens made by Tazawa, both from the same locality of Igo, midstream in the Ichinotani Valley (Text-fig. 1), at which place fossiliferous black limestone of about 5 m thick, the lowest Ichinotani Formation is cropped out.

Two large-sized productoids, *Striatifera striata* (Fischer de Waldheim, 1837) and *Gigantoproductus* sp. are now disclosed from the collections mentioned above.

S. striata is the type species of the genus *Striatifera* Chao, 1927. And it has been known from the Upper Visean and Lower Namurian (Serpukhovian) of Britain, France, Belgium, Germany, western part of the Soviet Union, South China and Japan (Hina, Omi and Fukuji), except for the sole Upper Tournaisian occurrence in the Moscow Basin. The geographical distribution of this species is summarized and shown in Text-fig. 2. On the other hand, shells referred to the genus *Gigantoproductus* Prentice, 1950 have been recorded from the Visean (mostly Upper Visean) and Lower Namurian of Northeastern Africa, Europe, Asia, Australia and North America (*e.g.* Sarytcheva and Sokolskaja, 1952; Muir-Wood and Cooper, 1960; Legrand-Blain, 1973), although the occurrences from the last two regions are rare. *Gigantoproductus* sp. of Fukuji is morphologically close to *G. irregularis* (Yanishevsky,

*Received March 11, 1985; read February 3, 1985 at University of Tokyo.



Text-fig. 1. Map showing the fossil locality.

1954), a Russian Serpukhovian species.

The brachiopods from the lowest part of the Ichinotani Formation suggest that the age of the unit may be Late Visean to Early Namurian. This estimation nearly accords with previous opinion, a Late Visean age, based on fusulinids and corals (Igo, 1957; Minato and Kato, 1957; Fujimoto and Igo, 1958; Kato and Niikawa, 1977; Niikawa, 1978). In conclusion, we regard the black limestone occupying the basal, lower 5 m part of the Ichinotani Formation as an Upper Visean deposits in the Fukuji district.

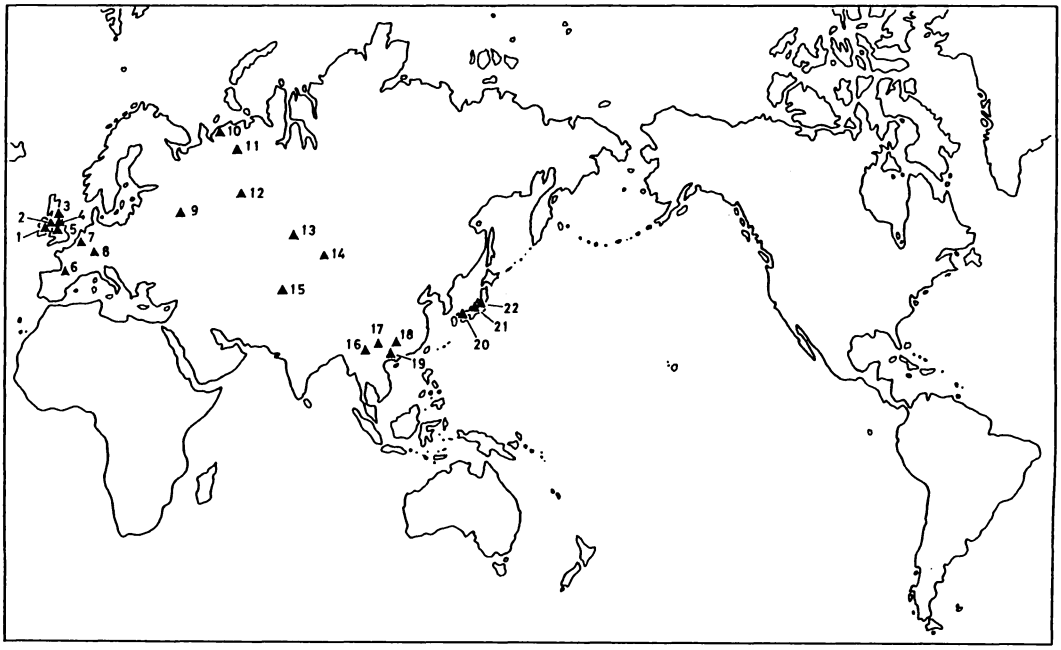
The specimens treated in the present study are housed in the Institute of Geology and Palaeontology, Faculty of Science, Tohoku University, Sendai.

Description of species

Family Linoproductidae Stehli, 1954

Subfamily Striatiferinae Muir-Wood and Cooper, 1960

Genus *Striatifera* Chao, 1927



Text-fig. 2. Distribution of *Striatifera striata* (Fischer de Waldheim). References to the numbers appended to solid triangles are in the text.

Striatifera striata (Fischer de Waldheim, 1837)

Pl. 78, Figs. 1—6.

Mytilus striatus Fischer, 1837, p. 181, pl. 19, fig. 4.

Productus striatus (Fischer): de Koninck, 1843 pars, p. 169, pl. 6, figs. 10a—d only; 1847 pars, p. 30, pl. 1, figs. 1a—b only; Davidson, 1861 pars, p. 139, pl. 34, figs. 1, 3—5; pl. 53, fig. 4 only; Gröber, 1908, p. 232, pl. 26, figs. 6—7; pl. 30, fig. 1; Vaughan (in Matley and Vaughan, 1908), p. 466, pl. 50, fig. 2; Mansuy, 1912, p. 88, pl. 16, figs. 8a—e; Yanishevsky, 1918, p. 29, pl. 1, fig. 8; pl. 6, fig. 8; Hayasaka, 1924, p. 29, pl. 5, fig. 7.

Striatifera striata (Fischer): Chao, 1927, p. 95, pl. 9, figs. 4—6; pl. 10, fig. 6; Sarytcheva, 1937, p. 24, 107, pl. 1, figs. 1—5; pl. 2, figs. 1—3; text-figs. 4—7; Sarytcheva (in Sarytcheva and Sokolskaja, 1952), p. 118, pl. 22, fig. 151; Muir-Wood and Cooper, 1960, pl. 126, figs. 1—2: Litvinovich (in Litvinovich, Aksenova and Razina, 1969), p. 195, pl. 20, figs. 2—3; Barchatova, 1970, p. 126, pl. 1, fig. 9; Gandl, 1970, p. 74, pl. 1, fig. 7; Kalashnikov, 1974, p. 79, pl. 24, fig. 5; Hase and Yokoyama, 1975, pl. 17, figs. 2—5; Volgin and Kushnar, 1975, p. 54, pl. 5, figs. 4—5; Yang, Ni, Chang and Zhao, 1977, p. 367, pl. 145, fig. 3; Feng and Jiang, 1978, p. 264, pl. 96, fig. 1; Yang, 1978, p. 117, pl. 26, fig. 6; pl. 30, figs. 1a—b; Liu, Tan and Ding, 1982, p. 188, pl. 136, fig. 7; Legrand-Blain, Delvolvé and Perret, 1983, p. 306, pl. 2, figs. 3—5.

Productus (*Linoproductus*) *striatus* (Fischer): Paeckelmann, 1931 pars, p. 200, pl. 20, fig. 2 only.

Striatifera striata var. *striata* (Fischer) emend. Sarytcheva: Lapina, 1957, p. 52, pl. 6, fig. 1.

Striatifera sp. Niikawa, 1980, p. 28.

non *Striatifera striata* (Fischer): Tazawa, 1981, p. 73, pl. 5, figs. 6a—e.

Type:—The original specimen of Fischer from "des sables de la colline à l'ouest d'Arkhangelsky" appear to be lost (Legrand-Blain, Delvolvé and Perret, 1983, p. 307). No type specimen has yet been selected. However, a detailed description and some fine figures of *S. striata* were given by Sarytcheva (1937, p. 24, 107, pl. 1, figs. 1—5; pl. 2, figs. 1—3; text-figs. 4—7), based on material from the Upper Visean and Serpukhovian of the Moscow Basin. The Russian specimens are stored in the Palaeontological Museum, Academy of Sciences, Moscow.

Material:—Six pedicle valves, collected by Y. Okazaki and J. Tazawa from the black limestone beds of the lowest Ichinotani Formation in the middle part of the Ichinotani Valley, Fukuji, Kamitakara-mura, Yoshiki-gun, Gifu Prefecture, Central Japan: IGPS coll. cat. nos. 98888—98893.

Description:—Shell large for genus, elongate trigonal to elongate oval in outline, with visceral disc tapering to umbo; greatest width occurring three-quarters length of shell or a little anterior to that; length 104 mm, width 72 mm in the best preserved specimen (IGPS coll. cat. no. 98888); length 128 mm, width 78 mm in the largest specimen (IGPS coll. cat. no. 98892).

Pedicle valve slightly convex in lateral profile, with greatest convexity just anterior to umbo, and not geniculated; anterior profile with broad, flattened venter and steep lateral slopes. Umbo acute, not incurved. Ears damaged in the present specimens. External ornament consisting of fine, flexuous costae and irregular, weak concentric rugae; costae having a density of 15—16 per 10 mm at about midvalve. Spine bases not observed.

Remarks:—The specimens from Fukuji are identical in size and shape to *Striatifera striata* (Fischer de Waldheim, 1837), which is characterized by its large, elongate, often mytiliform (of pelecypod) shell with less convex pedicle valve. But they have slightly coarser costae on the pedicle valve, comparing the typical specimens from the Upper Visean and Serpukhovian of the Moscow Basin (18—29 costae in 10 mm width, after Sarytcheva, 1937, p. 27).

S. magna Yanishevsky, 1934 emend. Sarytcheva, 1937 is a large, coarse-costate species comparable with *S. striata*, but differs from the latter in its more convex and broader pedicle valve.

S. coraesimilis Sarytcheva, 1937 somewhat resembles *S. striata* in size and shape, but differs in having several large spine bases on the venter.

S. angusta (Yanishevsky, 1910) is distinguished from the present species by its subcylindrical pedicle valve with ill-defined ears (see Sarytcheva, 1937, pl. 1, figs. 6a—c).

Shells identified as *S. striata* from the Visean Karoyama Formation of the southern Kitakami Mountains, Northeast Japan (Tazawa, 1981, p. 73, pl. 5, figs. 6a—e), are distinguished from the present species by their much coarser costae on the pedicle valve.

Stratigraphical distribution:—Upper Visean to Lower Namurian (Serpukhovian). The only one exception, Upper Tournaisian occurrence was recorded by Sarytcheva and Sokolskaja (1952, p. 254) from the Chernyshinsky Horizon of the Moscow Basin, U.S.S.R.

Geographical distribution:—Shown in Text-fig. 2: Loughshinny, County Dublin, Ireland (1); Isle of Man (2); Lowick, Northumberland, England (3); Settle, Yorkshire, England (4); Park Hill, Longnor, Derbyshire, England (5); Central French Pyrenees, France (6); Vise, Belgium (7); Frankenwald, Bavaria, Western Germany (8); Moscow Basin, U.S.S.R. (9); Northern Timan, U.S.S.R. (10); North Ural Mountains, U.S.S.R. (11); Central Ural Mountains, U.S.S.R. (12); Central Kazakhstan, U.S.S.R. (13); Central Tien Shan, U.S.S.R. (14); Fergana, U.S.S.R. (15); Yunnan, South China (16); Guizhou, South China (17); Hunan, South China (18); Guangxi, South China (19); Hina, Okayama Prefecture, Southwest Japan (20); Fukuji, Gifu Prefecture, Central Japan (21); Omi, Niigata Prefecture, Central Japan (22).

Family Gigantoproductidae Muir-Wood and Cooper, 1960

Subfamily Gigantoproductinae Muir-Wood and Cooper, 1960

Genus *Gigantoproductus* Prentice, 1950

Gigantoproductus sp.

Pl. 78, Fig. 7.

Gigantoproductus sp., Niikawa, 1980, p. 28.

Material:—One imperfect pedicle valve, IGPS coll. cat. no. 98894, collected by Y. Okazaki from the same horizon and the same locality of the shells of *S. striata* described above.

Remarks:—The single pedicle valve specimen, lacking the posterior portion, can be referred to the genus *Gigantoproductus* Prentice, 1950 on account of its size, shape and external ornament. The shell is of small size for the genus and moderately transverse; length is uncertain but more than 50 mm, width is about 76 mm. The pedicle valve is strongly convex in lateral profile, having a very shallow sulcus, and is ornamented by regular costae with a density of 9 per 10 mm at about the midvalve. There are numerous fine growth lines over the valve, but no spine bases or flutings are observed.

The Fukuji specimen most resembles the shells of *G. irregularis* (Yanishevsky, 1954), described and figured by Sarytcheva (in Sarytcheva and Sokolskaja, 1952, p. 132, pl. 36, fig. 182) from the Serpukhovian of the Moscow Basin in size, shape and external ornament. But the poor preservation of this material makes the accurate comparison difficult.

G. edelburgensis (Phillips, 1836) differs from the present species in its larger size, coarser costae and in having several large spine bases on the venter.

Acknowledgements

We wish to thank Dr. Yoshihiko Okazaki of Kitakyushu Museum of Natural History for providing specimens he collected; Prof. Koji Nakamura of Hokkaido University for helpful suggestions; Prof. Hisayoshi Igo of the University of Tsukuba for information on the fossil locality; and Mr. Shohei Otomo of Tohoku University for photography.

References

Barchatova, V.P. (1970): Бархатова, В.П.: Биостратиграфия карбона и нижней перми Северного Тимана. *Тр. ВНИРРИ*, вып. 283, p. 1-228, pls. 1-21.

Chao, Y. T. (1927): Productidae of China, Part 1: Producti. *Palaeont. Sinica, Ser. B,* vol. 5, fasc. 2, p. 1—244, pls. 1—16.

Davidson, T. (1861): British Fossil Brachiopoda, Vol. 2, Pt. 5, No. 4: Monograph of British Carboniferous Brachiopoda. *Palaeontogr. Soc.* (*1861*), p. 121—210, pls. 27—47.

Feng, R. and Jiang, Z. (1978): Phylum Brachiopoda. *In* Geological and Palaeontological Team of Guizhou (ed.): *Palaeontological Atlas of Southwest China; Guizhou, Part 2: Carboniferous to Quaternary,* p. 231—305, pls. 85—108, Geological Publishing House, Beijing (in Chinese).

Fischer de Waldheim, G. (1837): *Oryctographie du gouvernement de Moscou.* 202 p., 7 pls., Moscow.

Fujimoto, H. and Igo, H. (1958): Stratigraphic position of the corals in the Ichinotani Formation (Carboniferous), Fukuji district, Hida Massif, Central Japan. *Proc. Japan Acad.,* vol. 34, no. 3, p. 159—163.

Gandl, J. (1970): Ein biostratigraphischer Beitrag zur Stellung des Wurstkonglomerates (Unterkarbon) im Frankenwald. *Senck. Leth.,* Bd. 51, Nr. 1, p. 67—91, pls. 1—3.

Gröber, P. (1908): Ueber die Faunen des untercarbonischen Transgressionsmeeres des zentralen Tian-schan, die in der Umgebung des Sartdschol-Passes gefunden worden sind. *N. Jb. f. Min. Geol. Paläont.,* Bd. 26, Ht. 2, p. 213—248, pls. 25—30.

Hase, A. and Yokoyama, M. (1975): Geological age and structure of the Hina Limestone, Okayama Prefecture, Southwest Japan. *J. Sci., Hiroshima Univ., Ser. C,* vol. 7, no. 3, p. 167—182, pls. 16—18.

Hayasaka, I. (1924): On the fauna of the Anthracolithic limestone of Omi-mura in the western part of Echigo. *Sci. Rep., Tohoku Imp. Univ., 2nd Ser.,* vol. 8, no. 1, p. 1—83, pls. 1—7.

Igo, H. (1956): On the Carboniferous and Permian of the Fukuji district, Hida Massif, with special reference to the fusulinid zones of the Ichinotani Group. *J. Geol. Soc. Japan,* vol. 62, no. 728, p. 217—240 (in Japanese).

—— (1957): Fusulinids of Fukuji, southeastern part of the Hida Massif, Central Japan. *Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C,* vol. 5, no. 47, p. 153—246, pls. 1—15.

Kalashnikov, N. V. (1974): Калашников, Н. В.: Раннекаменноугольные брахиоподы Печорского Урала. 220 p., 52 pls., Наука, Ленинград.

Kato, M. and Niikawa, I. (1977): *Kueichouphyllum* from Central Japan. *Earth Sci.* (*Chikyu Kagaku*), vol. 31, no. 6, p. 243—249, pls. 1, 2.

Koninck, L. G. de (1842—1844): *Description des animaux fossiles qui se trouvent dans le terrain Carbonifère de Belgique.* 650 p., 55 pls., Liége.

—— (1847): *Recherches sur les animaux fossiles, Premiere Partie: Monographie des genres Productus et Chonetes.* 246 p., 20 pls., Liége.

Lapina, N. N. (1957): Лапина, Н. Н.: Брахиоподы каменноугольных отложений Пермского Приуралья. *Тр. ВНИГРИ,* вып. 108, p. 1-184, pls. 1-24.

Legrand-Blain, M. (1973): Les gigantoproductides (brachiopodes) du Sahara Algerien. *Bull. Soc. Hist. Nat. Afr. Nord. Alger,* t. 64, fasc. 1, 2, p. 79—157, pls. 1—4.

——, Delvolvé, J. and Perret, M. (1983): Les brachiopodes carbonifères des Pyrénées Centrales Francaises, 1: Carde stratigraphique et sédimentaire; Étude des Strophomenida. *Geobios,* no. 16, fasc. 3, p. 285—327, pls. 1—4.

Litvinovich, N. V., Aksenova, G. G. and Razina, T. P. (1969): Литвинович, Н. В., Аксенова, Г. Г. и Разина, Т. П.: Стратиграфия и литология отложений нижнего карбона западной части Центрального Казахстана. 448 p., 72 pls., Недра, Москва.

Liu, Z., Tan, Z. and Ding, Y. (1982): Phylum Brachiopoda. *In* Geological Bureau of Hunan (*ed.*): *The Palaeontological Atlas of Hunan,* p. 172—216, pls. 125—159, Geological Publishing House, Beijing (in Chinese).

Mansuy, H. (1912): Étude géologique du Yunnan Oriental, Seconde Partie: Paléontologie. *Mém. Serv. Géol. Indochine,* vol. 1, fasc. 2, p. 1—147, pls. 1—25.

Matley, C. A. and Vaughan, A. (1908): The Carboniferous rocks at Loughshinny (County Dublin). *Quart. J. Geol. Soc. London,* vol. 64, no. 255, p. 413—474, pls. 49—50.

Minato, M. and Kato, M. (1957): On the Carboniferous coral zones at Fukuji, Gifu Prefecture, Central Japan. *Proc. Japan Acad.,* vol.

33, no. 9, p. 547—552.

Muir-Wood, H. M. and Cooper, G. A. (1960): Morphology, classification and life habits of the Productoidea (Brachiopoda). *Geol. Soc. Amer. Mem.*, 81, p. 1—447, pls. 1—135.

Niikawa, I. (1978): Carboniferous and Permian fusulinids from Fukuji, Central Japan. *J. Fac. Sci., Hokkaido Univ., Ser. 4*, vol. 18, no. 4, p. 533—610, pls. 1—14.

—— (1980): Geology ad biostratigraphy of the Fukuji district, Gifu Prefecture, Central Japan. *J. Geol. Soc. Japan*, vol. 86, no. 1, p. 25—36 (in Japanese).

Paeckelmann, W. (1931): Die Brachiopoden des deutschen Unterkarbons, 2 Teil: Die Productinae und Productus-ähnlichen Chonetinae. *Abh. Preuß. Geol. Landesanst., N.F.*, Ht. 136, p. 1—440, pls. 1—41.

Phillips, J. (1836): *Illustrations of the geology of Yorkshire, Pt. 2: The Mountain Limestone district.* 253 p., 25 pls., John Murray, London.

Prentice, J. E. (1950): The genus *Gigantella* Sarytcheva. *Geol. Mag.*, vol. 87, no. 6, p. 436—438.

Sarytcheva, T.G. (1937): Сарычева, Т.Г.: Нижнекаменноугольные продуктиды Подмосковного Бассейна (Роды *Striatifera*, *Linoproductus* и *Cancrinella*). *Тр. ПИН*, т. 6, вып. 1, p. 1-123, pls. 1-7.

—— and Sokolskaja, A.N. (1952): Сарычева, Т.Г. и Сокольская, А.Н.: Определитель палеозойских брахиопод Подмосковной Котловины. *Тр. ПИН*, т. 38, p. 1-303, pls. 1-71.

Stehli, F. G. (1954): Lower Leonardian Brachiopoda of the Sierra Diablo. *Bull. Amer. Mus. Nat. Hist.*, vol. 105, art. 3, p. 262—358, pls. 17—27.

Tazawa, J. (1981): An Early Carboniferous brachiopod fauna from the Karoyama Formation in the Kitakami Mountains, Northeast Japan. *Saito Ho-on Kai Mus. Nat. Hist., Res. Bull.*, no. 49, p. 63—79, pl. 5.

Volgin, V.I. and Kushnar, L.V. (1975): Волгин, В.И. и Кушнарь, Л.В.: Поздневизейские брахиоподы и двустворчатые молюски Южной Ферганы. 112 p., 10 pls., Изд-во. Ленинград. Ун-Та., Ленинград.

Yang, D., Ni, S., Chang, M. and Zhao, R. (1977): Phylum Brachiopoda. *In* Geological Institute of Hubei *et al.* (*ed.*): *Palaeontological Atlas of South-central China, Part 2: Late Palaeozoic*, p. 303—470, pls. 129—188, Geological Publishing House, Beijing (in Chinese).

Yang, S. (1978): Lower Carboniferous brachiopods of Guizhou Province and their stratigraphic significance. *Prof. Pap. Strat. Palaeont.*, no. 5, p. 78—142, pls. 17—39 (in Chinese).

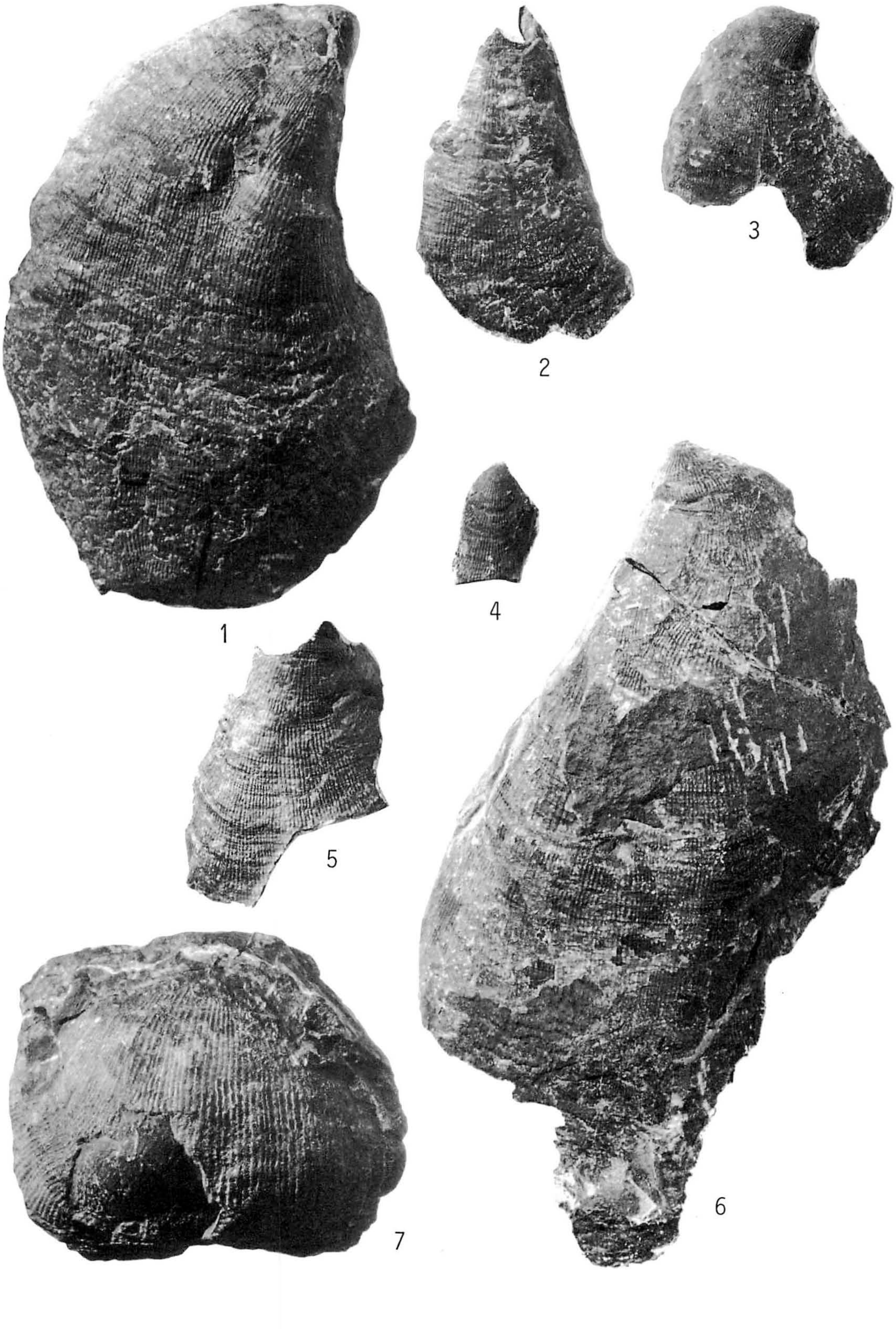
Yanishevsky, M.E. (1918): Янишевский, М.Э.: Материалы к изучению нижнекаменноугольной фауны Ферганы. *Тр. Геол. Ком., Н.С.*, вып. 162, p. 1-145, pls. 1-8.

Explanation of Plate 78

(All figures are natural size.)

Figs. 1—6. *Striatifera striata* (Fischer de Waldheim)
Ventral views of pedicle valves. 1: IGPS coll. cat. no. 98888; 2: IGPS coll. cat. no. 98893; 3: IGPS coll. cat. no. 98889; 4: IGPS coll. cat. no. 98891; 5: IGPS coll. cat. no. 98890; 6: IGPS coll. cat. no. 98892.

Fig. 7. *Gigantoproductus* sp.
Anterior view of pedicle valve, IGPS coll. cat. no. 98894.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Fukuji 福地, Gifu 岐阜, Hina 日南, Ichinotani 一の谷, Kamitakara-mura 上宝村, Karoyama 加労山, Kitakami 北上, Niigata 新潟, Okayama 岡山, Omi 青海, Yoshiki-gun 吉城郡.

福地の下部石炭系産腕足類 *Striatifera* および *Gigantoproductus*：岐阜県吉城郡上宝村福地の一の谷層最下部（上部ビゼー統）より得られた2種の腕足類, *Striatifera striata* (Fischer de Waldheim, 1837) と *Gigantoproductus* sp. について記載する。

S. striata は大型のリノプロダクタス科の1種であり，これまでにイギリス・フランス・ベルギー・ドイツ・ソ連邦西部・中国南部・日本の上部ビゼー統〜下部ナムール統から産出が知られている。わずか1例ではあるが，上部トルネー統からの報告もある。

田沢純一・加藤　誠

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 142, pp. 400—408, pls. 79—80, June 30, 1986

815. SOME PERMIAN CYCLOLOBACEAE FROM THE SOUTHERN KITAKAMI MASSIF, NORTHEAST JAPAN*

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Abstract. Five specimens of the Middle to Upper Permian ammonoids, *Stacheoceras otomoi*, sp. nov., *S.* sp. and *Timorites intermedium* (Wanner) are described from the Ogatsu, Utatsu and Okago districts in the Southern Kitakami Massif. *Stacheoceras* sp. from the Okago district occupies the highest stratigraphic horizon of the genus in Japan. *Timorites* from the Utatsu district is associated with the Dzhulfian ammonoids. Thus the genus *Timorites* ranges upward to the Dzhulfian, in Japan.

Introduction and acknowledgments

Permian rocks are widely distributed in the Southern Kitakami Massif, Northeast Japan, where they consist of various fossiliferous marine strata. Although the ammonoid cephalopods constitute a relatively rare component of these faunas, significant specimens for correlation have been reported from the Middle to Upper Permian since the first discovery of *Stacheoceras* from the Iwaizaki Limestone by Mabuti (1935). Recently, rather rich fauna belonging to 9 genera were described from the Upper Permian (Ehiro and Bando, 1985).

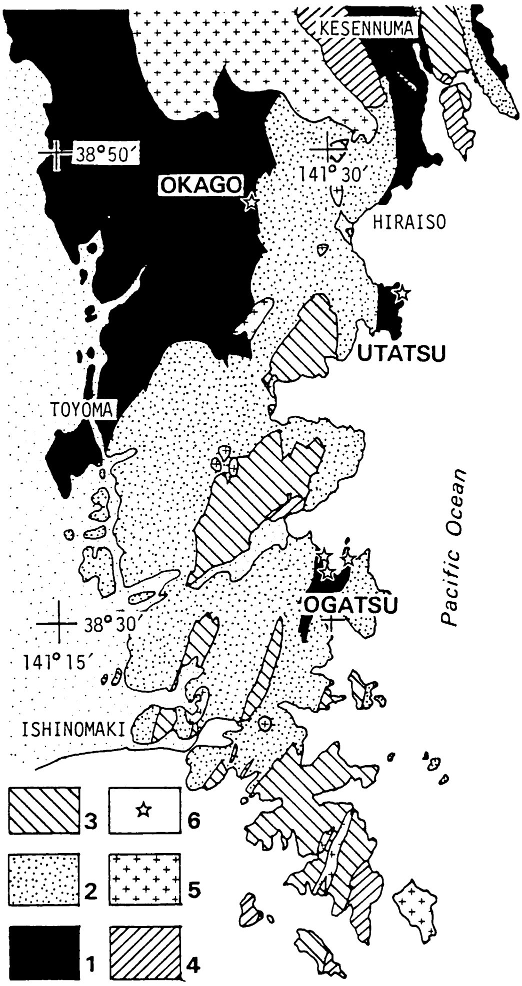
In addition to these specimens, some cyclolobacean ammonites, which have been collected from the Permian in the Southern Kitakami (Text-fig. 1) are at hand. The three species described in this paper are as follows:

Stacheoceras otomoi, sp. nov. — from the basal part of the Toyoma Formation at the northern coast of Obama, Ogatsu district.

Stacheoceras sp. — from the lower part of the Toyoma Formation at the northwestern coast of Obama, Ogatsu district and from the uppermost part of the Senmatsu Formation, Okago district.

Timorites intermedium (Wanner) — from the Oyakejima Formation at Koyakejima, Ogatsu district and from the lower part of the Suenosaki Formation at Ishihama, Utatsu district.

*Received June 24, 1985; Read June 16, 1985 at Osaka City University.



Text-fig. 1. Map showing the distribution of the Permian in the southern part of the Southern Kitakami Massif and the fossil localities.
1. Permian, 2. Triassic, 3. Jurassic, 4. Lower Cretaceous, 5. Cretaceous intrusive rocks, 6. fossil localities.

Before going further, the writers wish to express their deep gratitude to the late Professor Yuji Bando of Kagawa University for his valuable encouragement during the course of the study. We are also much indebted to Professor Tamio Kotaka of the Institute of Geology and Paleontology, Faculty of Science, Tohoku University, for his critical reading of the manuscript. Thanks are expressed to Mr. Tetsuro Otomo of Kakuda High School for the permission to study his specimen.

Stratigraphic note of the ammonite localities

The Permian in the Southern Kitakami Massif is divided into the Sakamotozawan, Kanokuran and Toyoman Series, in ascending order.

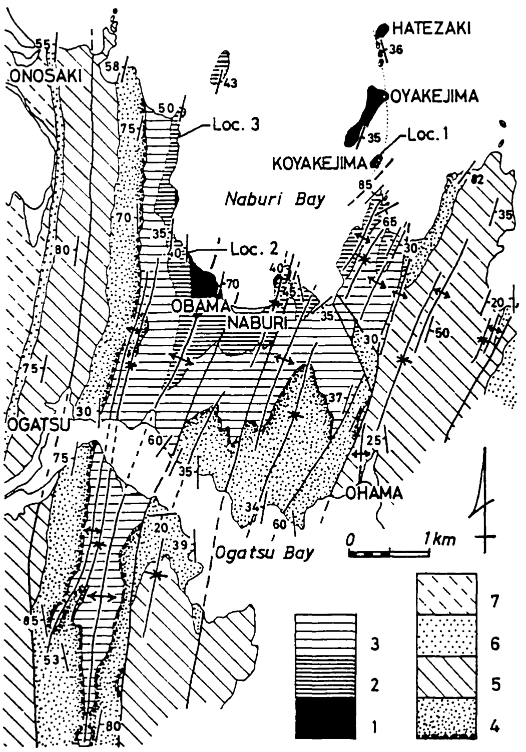
In the Ogatsu district, the Permian formations distribute in relatively limited areas constructing an anticlinolium plunging southward. They are unconformably overlain by the Lower Triassic Hiraiso Formation (Text-fig. 2). The stratigraphy of the Permian was studied by Inai and Takahashi (1940), and recently revised by Murata and Shimoyama (1979). The Permian is divided into the Oyakejima Formation below and the Toyoma Formation above. The former, the correlative of the Kanokura Formation, includes the Oyakezima (Oyakejima) Sandstone, Koyakezima (Koyakejima) Conglomerate and Sandstone, and Kohama (Obama) Limestone of Inai and Takahashi (1940). The latter corresponds to the Toyoma Slate of Inai and Takahashi (1940).

The Oyakejima Formation consists of sandy shale, with beds and lenses of conglomerate, in the lower part and limestone and calcareous sandstone in the upper part. The lower part is mainly exposed in the small islets in the eastern part of Naburi Bay, such as Oyakejima and Koyakejima. The lithologic sequence of the Koyakejima section is as follows:

6. conglomerate, cobble to pebble. 15 m+.
5. sandy shale, dark grey. 15 m.
4. granule, lenticular, with crinoid fragments. 0.3 m–.
3. sandy shale, dark grey. 8 m.
2. granule, lenticular, with calcareous matrix. 0.4 m.
1. sandy shale, dark grey.15 m+.

Timorites intermedium was collected from the unit 4 of the above mentioned sequence (Loc. 1, Text-fig. 2).

The upper part of the Oyakejima Formation is exposed sporadically in the small areas at the northeastern cape of Naburi, northern coast of Obama and northwestern coast of Obama. At the



Text-fig. 2. Geological map of the Ogatsu district (modified from Murata and Shimoyama, 1979). Locs. 1—3 are ammonite localities.
1—3. Permian (1. Oyakejima Formation, 2. lower part of the Toyoma Formation, 3. upper part of the Toyoma Formation), 4—7. Lower-Middle Triassic (4. Hiraiso Formation, 5. Osawa Formation, 6. Fukkoshi (Kazakoshi) Formation, 7. Isatomae Formation).

northern coast of Obama it forms an anticline plunging to the south. On the west flank of the anticline the upper part of the formation is about 30 m in thickness. Its lower half is composed of calcareous, fossiliferous sandstone and interbedded with thin (less than 1 m) impure limestone in the middle part. The upper half consists of pebbly limestone and calcareous sandstone. Hayasaka (1940) described *Stacheoceras* sp. from the limestone of Obama. *Lepidolina kumaensis* and *L. multiseptata* were also reported from the uppermost part of the formation (Murata and Shimoyama, 1979).

The Toyoma Formation, conformably overlies the Oyakejima Formation, is divided into two parts (Murata and Shimoyama, 1979). The lower part consists of sandy shale interlaminated or interbedded with sandstone and sometimes contains calcareous nodules. It attains about 500 m in thickness and yields some molluscan fossils, such as *Euphemitopsis kitakamiensis* and *Astartella toyomensis*, which characterize the Lower Toyoman Series (Murata and Shimoyama, 1979). *Stacheoceras otomoi*, sp. nov. was collected from the basal part of the Toyoma Formation, 0.5 m above the base, at the northern coast of Obama (Loc. 2, Text-fig. 2) and the present specimen of *Stacheoceras* sp. was collected from the upper part of the lower part at the northwestern coast of Obama (Loc. 3).

The upper part of the Toyoma Formation is composed of rather massive black shale with calcareous nodules, and attains 300 m in thickness. *Palaeoneilo ogachiensis*, *Nuculites kimurai*, *Protocycloceras* cf. *P. cyclophorum*, etc. were reported from this horizon (Hayasaka, 1924). The first two characterize the Middle Toyoman.

The stratigraphy and the ammonite fauna of the Utatsu and Okago districts are already reported by Ehiro and Bando (1985). In the Utatsu district the Permian is divided into the Suenosaki Formation (Uppermost Kanokuran to Lower-Middle Toyoman) and the Tonoura Formation (Upper Toyoman). The lower part of the Suenosaki Formation (Lowermost Toyoman) yields some ammonite fossils, such as *Stacheoceras iwaizakiense*, *Pseudogastrioceras* sp., *Araxoceras* cf. *A. rotoides* and *Prototoceras japonicum*, in association with *Euphemitopsis kitakamiensis* and *Astartella toyomensis*, at the eastern coast of Ishihama. The present specimen of *Timorites intermedium* was collected from the same locality of ishihama, loc. 3 of Ehiro and Bando (1985, fig. 2).

The Middle to Upper Permian in the Okago district is divided into the Higashifukakaya, Shinden, Okago and Senmatsu Formations in ascending order. The Okago and Senmatsu Formations are correlated to the Lower-Middle Toyoman and Upper Toyoman, respectively (Ehiro and Bando, 1985). *Xenodiscus* cf. *X. carbonarius* was reported from the lowermost part of the Okago Formation. The Senmatsu Formation yields the following ammonoids: *Cyclolobus* cf. *C. walkeri*, *Medlicottia kitakamiensis*, *Eumedlicottia* sp. and *Paratirolites*? sp. The present specimen of *Stacheoceras* sp. was collected from the uppermost part of the Senmatsu Formation near Nagasakiyama (loc. 16 in fig. 4; Ehiro and Bando, 1985), associated with *Medlicottia kitakamiensis*.

Faunal consideraiton

Of the present ammonoids, *Stacheoceras* is one of the common element in the Permian strata in the Tethyan Province and North America. Some specimens have also been known from the Middle to Upper Permian in Japan, especially in the Southern Kitakami Massif. *Stacheoceras iwaizakiense* was first described by Mabuti (1935) from the lower part of the Iwaizaki Limestone, *Monodiexodina matsubaishi* zone, in the Southern Kitakami and additional specimens were recently reported from the Dzhulfian bed of Utatsu (Ehiro and Bando, 1985). *Stacheoceras* sp. was described by Hayasaka (1940) from the upper part of the Oyakejima Formation at Obama. Other species previously known from the Southern Kitakami, though not described, are *Stacheoceras* cf. *S. trimurti* from the lower part of the Toyoma Formation at Toyoma (Working Group, 1975), *S.* sp. from the Kanokura Formation at Tagara, Kesennuma City (Akiyama, 1958; Hayasaka, 1960) and *S.* sp. from the upper part of the Iwaizaki Limestone at Iwaizaki (Koizumi, 1967).

In addition to these Kitakami specimens, *Stacheoceras* aff. *S. grünwaldti* from the Kanokuran Kashiwadaira Formation of the Abukuma Massif, Northeast Japan (Hayasaka, 1965) and *S.*? sp. from the Akasaka Limestone, corresponds to the Kanokura Formation, in Central Japan (Hayasaka, 1955) have been known from Japan. The stratigraphic horizon of above mentioned *Stacheoceras* is from Kungurian to Lowermost Dzhulfian.

Stacheoceras otomoi, sp. nov. from Obama was collected from the basal part of the Toyoma Formation and the horizon is nearly the same as that of *S. iwaizakiense* from Utatsu. Ogatsu specimen of *Stacheoceras* sp. was collected from the upper part of the lower part of the Toyoma Formation, slightly higher horizon than that of *S. otomoi* and is of Late Early Dzhulfian. The Okago specimen of *Stacheoceras* sp. was collected from the uppermost part of the Senmatsu Formation. This formation is correlated to the Dorashamian (Ehiro and Bando, 1985). Therefore, the present specimens of *Stacheoceras* sp. occupy the higher stratigraphic horizon than those of the specimens of the genus *Stacheoceras* previously reported from Japan and that of the Okago specimen is the highest.

Timorites intermedium is of great importance, because the species of *Timorites* are index fossils of the zone of *Timorites* (Miller and Furnish, 1940) or of the Capitanian and Amarassian of Furnish (1973). *T. intermedium* was first described from Timor as *Waagenoceras intermedium* by Wanner (1932) and later found from the Kanokura Formation in the Southern Kitakami, Japan (Hayasaka, 1954). Other species of *Timorites* have been reported from the Amarassi Bed in Timor, including the type species, *T. curvicostatus* (Haniel, 1915; Smith, 1927), from the Capitanian in North America (Miller and Furnish, 1940; Miller, 1944), from Far East of USSR (Ruzhentsev, 1955) and from the Maokouan in South China (Liang, 1983) and Tibet (Sheng, 1984). Amarassian of Furnish (1973) is now considered to be equivalent to the Abadehian (Iranian-Japanese Research Group, 1981).

The Ogatsu specimen of *Timorites* was collected from the lower part of the Kanokuran Oyakejima Formation and the horizon is probably correlated to the Capitanian, because the horizon is slightly lower than that of *Lepidolina kumaensis* which is correlated to the Abadehian (Ehiro and Bando, 1985). On the other hand, the Utatsu specimen was found in association with typical Dzhulfian ammonoids, such as *Araxoceras* cf. *A. rotoides* and *Prototoceras japonicum*. Therefore, in Japan, the stratigraphic range of the genus *Timorites* is considered to range up to the Dzhulfian, at least to its lower part.

Systematic description

Superfamily Cyclolobaceae Zittel, 1895

Family Vidrioceratidae Plummer and Scott, 1937

Genus *Stacheoceras* Gemmellaro, 1887

Type species:—*Stacheoceras mediterraneum* Gemmellaro, 1887.

Stacheoceras otomoi, sp. nov.

Pl. 79, Figs. 1a—d; Text-fig. 3A.

Material:—One specimen, a phragmocone, a half of the last whorl is missing, collected by T. Otomo in 1957 from the basal part of the Toyoma Formation at Obama, Ogatsu-cho, Monoo-gun, Miyagi Prefecture. IGPS coll. cat. no. 98895.

Description:—The conch is involute, subglobular to subdiscoidal, with closed umbilicus, rounded-convex sides and broadly rounded venter. The phragmocone attains a diameter of at least 40 mm, and at the adoral end the height is 24 mm and the umbilical diameter is about 3 mm. The width is estimated at about 19 mm from half part of it. But, the material is slightly deformed obliquely and the original width is more wider, may be 22 mm or so. Shell ornamentation is unknown, but the surface of the inner mould is smooth. Suture is well preserved as shown in Text-fig. 3A and consists of ventral lobe and nine lateral lobes. The ventral lobe is broad and bifid. The first lateral lobe is primarily bifid, but secondary quadrifid. The second to fifth lateral lobes are trifid and all diminish in size and complexity toward umbilicus. Subsequent lobes are rounded but those nearest the umbilicus sometimes slightly bifid.

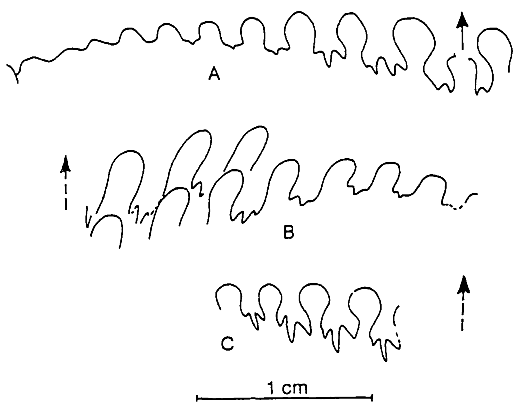
Remarks:—The present new species is characterized by its slightly compressed shell form and the shape of the suture, particularly by the quadrifid first lateral lobe and simpler lateral lobes near umbilicus.

The present species resembles *Stacheoceras iwaizakiense* Mabuti (Mabuti, 1935, p. 147, pl. 14, figs. 1—7), which also occurs from Permian in the Kitakami, in the shell form, but easily distinguished from the latter by its large number of lateral lobes. Regarding the suture line, especially the form of the first lateral lobe, the number of lateral lobes, and the shell outline, the present species is closely related to *Stacheoceras trimurti* Diener (Diener, 1897, p. 9, pl. 1, figs. 1a—e) from the Chitichum Limestone of Central Himalayas, *S. tridens* (Rothpletz) (Rothpletz, 1892, p. 87, pl. 9, figs. 4, 4a—b; Haniel, 1915, p. 105, text-fig. 35; Smith, 1927, p. 50, pl. 13, figs. 18—21) from Timor, *S. gordoni* Miller, Furnish and Clark (Miller *et al.*, 1957, p. 1062, text-fig. 3, pl. 134, figs. 1—4) from California and other allied species. But the Ogatsu species differs from the Himalayan, Timorian and Californian species in simpler form of lateral lobes near umbilicus.

Stacheoceras sp.

Pl. 79, Figs. 2a—b, 3; Text-figs. 3B, 3C.

Material:—Two fragmental specimens, collected by S. Shimoyama in 1972 from the lower part of the Toyoma Formation at the northwestern coast of Obama, Ogatsu-cho, Monoo-gun, Miyagi Prefecture, IGPS coll. cat. no. 98896 and collected by M. Ehiro in 1983 from the



Text-fig. 3. Suture lines of *Stacheoceras*. A. *Stacheoceras otomoi*, sp. nov., IGPS coll. cat. no. 98895. B. *S.* sp., IGPS coll. cat. no. 98896. C. *S.* sp., IGPS coll. cat. no. 98899.

uppermost part of the Senmatsu Formation near Nagasakiyama, Senmatsu, Fujisawa-cho, Higashiiwai-gun, Iwate Prefecture, IGPS coll. cat. no. 98899.

Remarks:—The specimens at hand are fragmental and deformed, but in both specimens a part of the suture is preserved as shown in Text-Fig. 3B—C. They have characteristic forms of *Stacheoceras* and consist of entire lateral saddles and trifid lateral lobes, all diminish in size gradually toward umbilicus. The Ogatsu specimen has a closed umbilicus. The outer whorls of it, in appearance, have acutely arched venter, but it is due to deformation.

Family Cyclolobidae Zittel, 1895

Genus *Timorites* Haniel, 1915

Type species:—*Timorites curvicostatus* Haniel, 1915.

Timorites intermedium (Wanner, 1932)

Pl. 79, Figs. 4a—b; Pl. 80, Figs. 1a—d;
Text-figs. 4A—4B.

1932. *Waagenoceras intermedium* Wanner, p. 272, text-figs. 1a—b, pl. 9, fig. 1, pl. 10, fig. 1.
1933. *Hanieloceras intermedium* (Wanner), Miller, p. 413.
1940. *Timorites intermedium* (Wanner), Miller and Furnish, p. 173.
1944. *Timorites intermedius* (Wanner), Miller, p. 114, pl. 43, figs. A—C.
1957. *Timorites curvicostatus* Haniel, Miller *et al.*, L. 50, figs. 66A—C.
1975. *Timorites curvicostatus* (Haniel), Koizumi, pl. 16, figs. 3a—b.
?1954. *Hanieloceras intermedium* (Wanner), Hayasaka, p. 368, pl. 23, figs. 4a—c.
?1975. *Timorites intermedium* (Waagen), Koizumi, p. 72, pl. 16, figs. 1a—b.

Material:—Two deformed and partly squashed specimens, collected by S. Shimoyama in 1972 from the lower part of the Oyakejima Formation at Koyakejima, Ogatsu-cho, Monoo-gun, Miyagi Prefecture, IGPS coll. cat. no. 98897 and collected by M. Ehiro in 1983 from the lower part of the Suenosaki Formation at the eastern coast of Ishihama, Utatsu-cho, Motoyoshi-gun, Miyagi Prefecture, IGPS coll. cat. no. 98898.

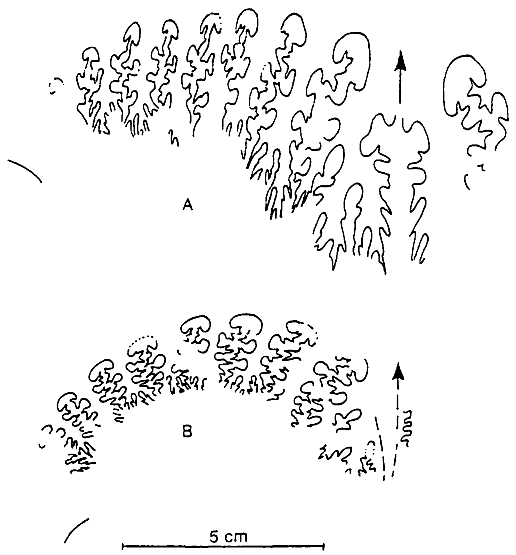
Description:—The conch is fairly large for *Timorites*, measuring about 250 mm in diameter at the end of the phragmocone for the Ogatsu specimen, though it is nearly parallel to the longest axis of the elliptically deformed. Corresponding height, width and umbilical diameter are about 110, 77 and 52 mm, respectively. The Utatsu specimen measures more than 300 mm in diameter.

The conch is involute, with a narrow umbilicus, about 20 percent of the conch diameter. Outer whorl embraces completely inner whorls. In the Ogatsu specimen, venter is narrowly rounded, sides are flattened and grade round into venter. Umbilical wall is almost perpendicular. Faint radial swellings are recognized along the umbilical edge. The shell is thin, less than 2 mm in the Ogatsu specimen and not quite 1 mm in the Utatsu specimen, with weakly sigmoidal, fine, simple transverse ribs on the phragmocone, but it seems to be smooth, as seen in the Ogatsu specimen, on the body-chamber.

The sutures are rather well preserved as shown in Text-fig. 4. It is convex anteriorly. There are at least seven, probably eight or nine outer lobes between the ventral lobe and the umbilical shoulder. The ventral lobe is the largest, widest and deepest, but narrowed anteriorly, divided into two part by a median saddle, about 2/3 height of the ventral lobe. External and lateral saddles, with mushroom-shaped apexes, are digitate along their flanks and lateral lobes are also digitate. External saddles are convex toward umbilicus, whereas axes of all other saddles are practically straight. Lateral saddles and lobes diminish gradually in size toward umbilicus.

Remarks:—The present specimens are clearly identified with *Timorites intermedium* (Wanner) in the large size, compressed shell form, the ornamentation of shell surface and the characteristic features of septa.

The holotype of *Timorites intermedium* was originally described by Wanner (1932) as *Waagenoceras intermedium* from the Basleo Bed of



Text-fig. 4. Suture lines of *Timorites intermedium* (Wanner).
A. IGPS coll. cat. no. 98897. B. IGPS coll. cat. no. 98898.

Timor. The second specimen was found from the Kanokura Formation in the Southern Kitakami, Japan (Hayasaka, 1954). However, it should seem to be difficult to identify the specific level. Assignment of Hayasaka's specimen to *T. intermedium* made on the basis of outward appearance of shell form and complexity of suture, is tentative, because it is a fragmental, deformed inner mould and detailed shell form and ornamentation of shell surface are unknown.

References

Akiyama, T. (1958): On the fossil cephalopods from the Permian Kanokuran Series. *Chigaku Kenkyu* (*Jour. Soc. Earthsci. Amateurs Japan*), vol. 10, p. 119—121 (in Japanese).

Diener, C. (1897): The Permocarboniferous fauna of Chitichum, No. I. *India Geol. Surv. Mem., Palaeont. Indica, Ser. 15*, vol. 1, pt. 3, p. 1—105.

Ehiro, M. and Bando, Y. (1985): Late Permian ammonoids from the Southern Kitakami Massif, Northeast Japan. *Trans. Proc. Palaeont. Soc. Japan, N.S.*, no. 137, p. 25—49.

Furnish, W. M. (1973): Permian stage names. *In* Logan, A. and Hills, L. V. (eds.), The Permian and Triassic Systems and their mutual boundary. *Mem. Canad. Soc. Petrol. Geol.*, no. 2, p. 522—548.

Haniel, C. A. (1915): Die Cephalopoden der Dyas von Timor. *Paläont. von Timor*, Lief. 3, Abh. 6, p. 1—153.

Hayasaka, I. (1924): Fossils in the roofing slate of Ogachi, Prov. Rikuzen. *Japan. Jour. Geol. Geogr.*, vol. 3, p. 45—53.

—— (1940): On two Permian ammonoids from the Kitakami Mountains, north Japan. *Jour. Geol. Soc. Japan*, vol. 47, p. 422—427.

—— (1954): Younger Palaeozoic cephalopods from the Kitakami Mountains, Japan. *Jour. Fac. Sci., Hokkaido Univ., Ser. 4*, vol. 8, p. 361—374.

—— (1955): On the Permian cephalopods in Japan. *Chigaku Kenkyu* (*Jour. Soc. Earthsci. Amateurs Japan*), vol. 8, p. 71—76 (in Japanese).

—— (1960): A new Permian species of *Foordi-*

Explanation of Plate 79

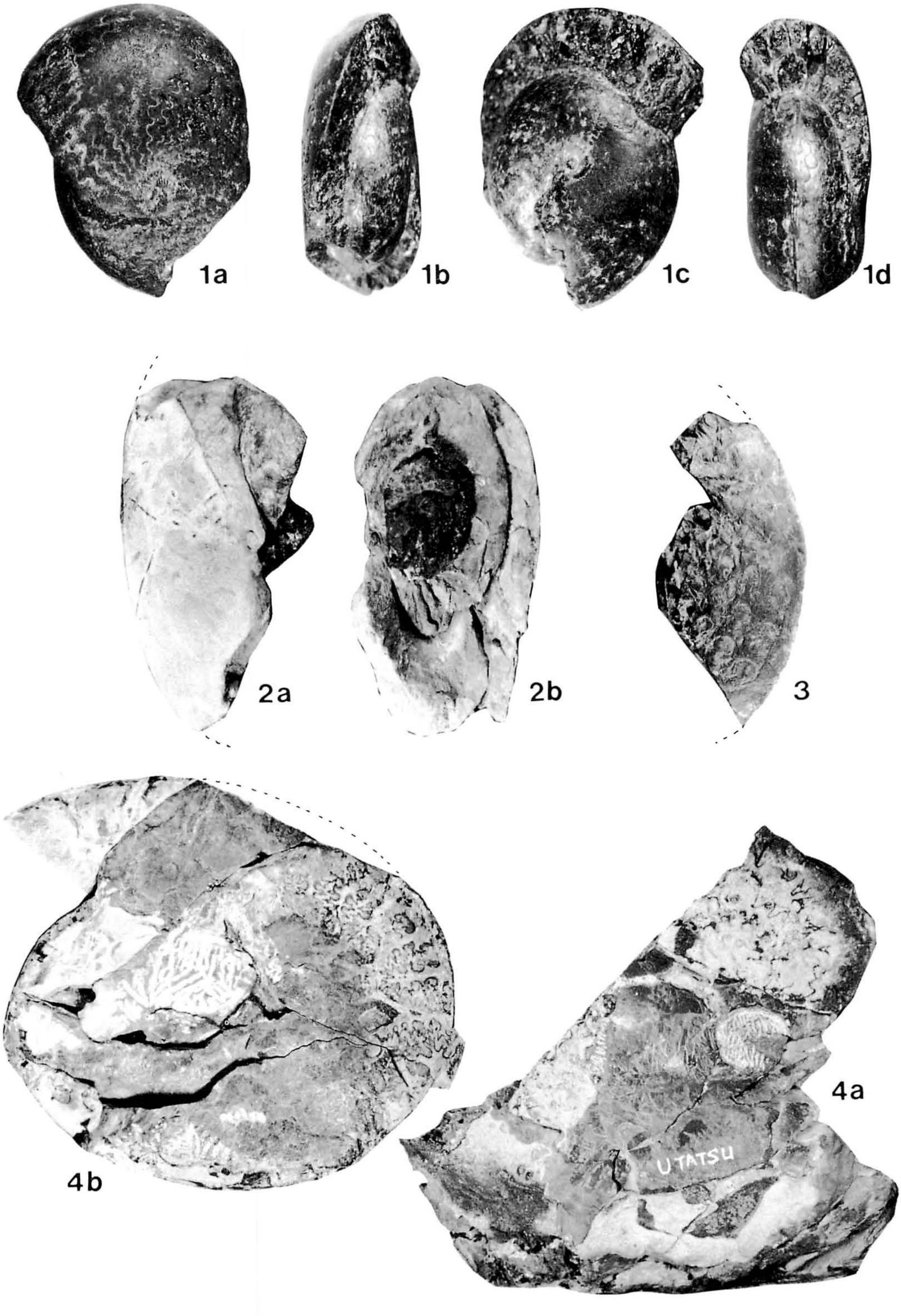
Figs. 1a—d. *Stacheoceras otomoi*, sp. nov. . . . . Page 404
IGPS coll. cat. no. 98895, lateral (a, c), back (b) and front (d) views, x 1.2.

Figs. 2a—b. *Stacheoceras* sp. . . . . Page 404
IGPS coll. cat. no. 98896, lateral (a) and front (b) views, x 0.7.

Figs. 3. *Stacheoceras* sp. . . . . Page 404
IGPS coll. cat. no. 98899, lateral view, x 1.5.

Figs. 4a—b. *Timorites intermedium* (Wanner) . . . . Page 405
IGPS coll. cat. no. 98898, lateral view (a), x 0.25 and lateral view of inner whorl (b), x 0.45.

All specimens illustrated here are preserved in the Institute of Geology and Paleontology, Faculty of Science, Tohoku University, Sendai.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ceras from the Kitakami Mountains. *Bull. Nat. Sci. Mus.*, vol. 5, p. 86—94.

——(1965): Some cephalopods in the Permian faunule of Takakura-yama, Fukushima Prefecture, Japan (with a note on the geology of the district, by Ichiro Yanagisawa and Mamoru Nemoto). *Trans. Proc., Palaeont. Soc. Japan, N.S.*, no. 57, p. 8—27.

Inai, Y. and Takahashi, T. (1940): On the geology of the southern part of the Kitakami Massif. *Contr. Inst. Geol. Palaeont., Tohoku Univ.*, no. 34, p. 1—40 (in Japanese).

Iranian-Japanese Research Group (1981): The Permian and the Lower Triassic Systems in Abadeh Region, Central Iran. *Mem. Fac. Sci., Kyoto Univ., Ser. Geol. Mineral.*, vol. 47, p. 61—133.

Koizumi, H. (1967): On the Palaeozoic Permian cephalopods from Japan, Pt. 1. *Chigaku Kenkyu* (*Jour. Soc. Earthsci. Amateurs Japan*), vol. 18, p. 130—135 (in Japanese).

——(1975): *Palaeozoic cephalopods of Japan.* 149 p. Teiseki Bunko, Chiba (in Japanese).

Liang, X. (1983): New material of Permian ammonoids with discussion on the origin, migration of Araxoceratidae and the horizon of the *Paratirolites. Acta Palaeont. Sinica*, vol. 22, p. 606—615 (in Chinese with English abstract).

Mabuti, S. (1935): On the occurrence of *Stacheoceras* in the Kitakami Mountainland, Northeast Honshu, Japan. *Saito Ho-on Kai Mus., Res. Bull.*, no. 6, p. 143—149.

Miller, A. K. (1933): Age of the Permian limestones of Sicily. *Amer. Jour. Sci., 5 Ser.*, vol. 26, p. 409—427.

——(1944): Part IV. Permian cephalopods. *In* King, R. E., Dunber, C. O., Cloud, P. E. Jr. and Miller, A. K., Geology and palaeontology of the Permian area northwest of Las Deliceous, southwestern Coahuila, Mexico. *Geol. Soc. Amer., Spec. Pap.*, no. 52, p. 71—127.

——and Furnish, W. M. (1940): Permian ammonoids of the Guadalupe Mountain Region and adjacent areas. *Ibid.*, no. 26, p. 1—242.

——, —— and Clark, D. L. (1957): Permian ammonoids from Western United States. *Jour. Paleont.*, vol. 31, p. 1057—1068.

——, —— and Schindewolf, O. H. (1957): Palaeozoic Ammonoidea. *In* Moore, R. C. (*ed.*), *Treatise on invertebrate paleontology, Pt. L. Mollusca, 4. Ammonoidea*, L. 11—79. Geol. Soc. America and Kansas Univ. Press.

Murata, M. and Shimoyama, S. (1979): Stratigraphy near the Permian-Triassic boundary and the Pre-Triassic unconformity in the Kitakami Massif, Northeast Japan. *Kumamoto Jour. Sci., Geol.*, vol. 11, p. 11—31 (in Japanese with English abstract).

Rothpletz, A. (1892): Die Perm-, Trias- und Jura-Formation auf Timor und Rotti im indischen Archipel. *Palaeontographica*, Bd. 39, p. 57—106.

Ruzhentsev, V. E. (1955): The Family Cyclolobidae Zittel. *Acad, Sci., USSR, Doklady*, vol. 103, p. 701—703 (in Russian).

Sheng, H. (1984): Late Lower Permian ammonoids from Xiukang Formation, Lhaze District, Xizang (Tibet). *In* Zhou, W. and Wang, S. (*eds.*), *Himalayan Geology II. Part of achievements in geoscientific investigation of Sino-French cooperation in the Himalayas in 1981*, p. 219—243. Geol. Publ. House, Beijing (in Chinese with English abstract).

Smith, J. P. (1927): Permian ammonoids of Timor. *Mijnw. Nederlandsch-Indië Jaarb., Jaarg. 55*, Verh. 1, p. 1—58.

Wanner, J. (1932): Beiträge zur Paläontlogie des Ostindischen Archipels, III. Zur Kenntnis der permischen Ammonoideen-fauna von Timor. *N. Jahrb. Min. Geol. Paläont.*, Beil.-Bd. 67, p. 257—278.

Working Group on the Permian-Triassic Systems (1975): Stratigraphy near the Permian-Triassic boundary in Japan and its correlation. *Jour. Geol. Soc. Japan*, vol. 81, p. 165—184 (in Japanese with English abstract).

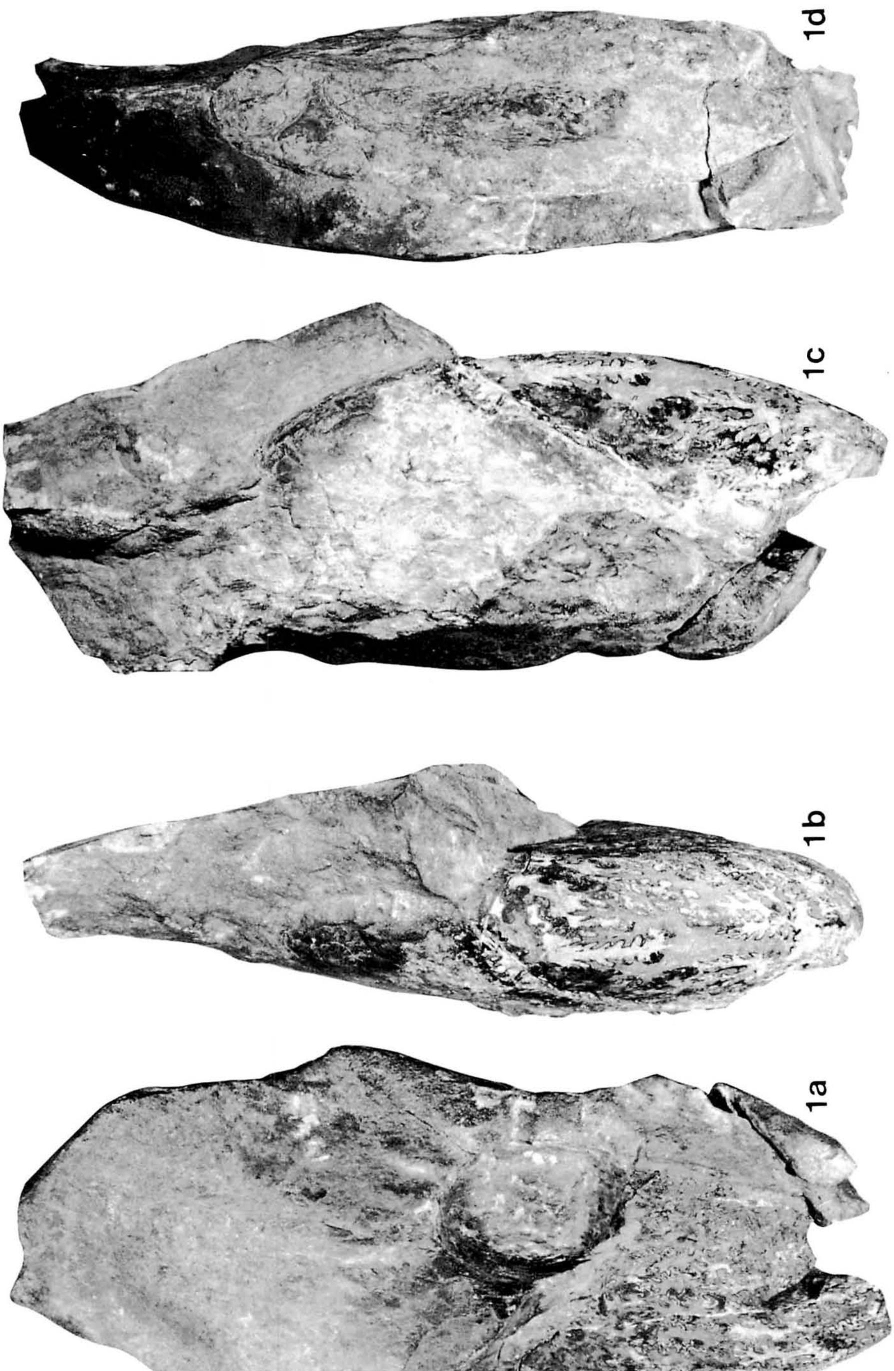
Abukuma 阿武隈, Akasaka 赤坂, Fujisawa-cho 藤沢町, Fukkoshi (Kazakoshi) 風越, Higashi-fukakaya 東深萱, Higashiiwai-gun 東磐井郡, Hiraiso 平磯, Isatomae 伊里前, Ishihama 石浜, Iwaizaki 岩井崎, Kanokura 叶倉, Kashiwadaira 柏平, Kesennuma 気仙沼, Kitakami 北上, Koyakejima 小八景島, Monoo-gun 桃生郡, Motoyoshi-gun 本吉郡, Naburi 名振, Nagasakiyama 長崎山, Obama 小浜, Ogatsu(-cho) 雄勝(町), Okago 大籠, Osawa 大沢, Oyakejima 大八景島, Sakamotozawa 坂本沢, Senmatsu 千松, Shinden 新田, Suenosaki 末の崎, Tagara 田柄, Tanoura 田の浦, Toyoma 登米, Utatsu(-cho) 歌津(町)

南部北上山地産ペルム紀サイクロロバス上科アンモナイト：南部北上山地の雄勝，歌津および大籠地域の中・上部ペルム系産アンモナイト3種 *Stacheoceras otomoi*, sp. nov., *S.* sp. および *Timorites intermedium* (Wanner) を記載した。大籠産の *Stacheoceras* sp. はこれまで日本から報告された *Stacheoceras* の中で最も上位の層準を占める。歌津産の *Timorites intermedium* はズルファー期アンモナイト化石と共産するので，日本における *Timorites* 属のレンジはズルファー期にまで延長される。 永広昌之・下山正一・村田正文

Explanation of Plate 80

Figs. 1a—d. *Timorites intermedium* (Wanner) . . . . Page 405
IGPS coll. cat. no. 98897, lateral (a, c) and ventral (b, d) views, × 0.4.

Specimen illustrated here is preserved in the Institute of Geology and Paleontology, Faculty of Science, Tohoku University, Sendai.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	開　催　地	開　催　日	講演申込締切日
1987年　年会・総会	静　岡　大　学	1987年1月30日～2月1日	1986年11月15日

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お 知 ら せ

○1987年度年会・総会では「日本とその周辺の新三紀動植物相」世話人土　隆一ならびに「南部フォッサマグナにおける衝突と古生物地理」世話人新妻信明でシンポジュームが計画されています。

○昭和61年6月20日現在で報告・紀事の手持ちの原稿は10編です。ただいま投稿されますと，1年以内に出版される予定ですのでふるってご投稿ください。

○文部省科学研究費補助金（研究成果刊行費）による。

1986年6月25日　印　刷
1986年6月30日　発　行

ISSN 0031-0204
日本古生物学会報告・紀事
新　篇　142号
2,500円

発 行 者　日本古生物学会
文京区弥生 2-4-16
日本学会事務センター内
(振替口座東京84780番)
(電　話　03－817－5801)
編 集 者　猪郷久義・浜田隆士
編集幹事　野田浩司
印 刷 者　東京都練馬区豊玉北2ノ13
学術図書印刷株式会社　富　田　潔
(電　話　03－991－3754)

Transactions and Proceedings of the Palaeontological Society of Japan

New Series No. 142 June 30, 1986

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