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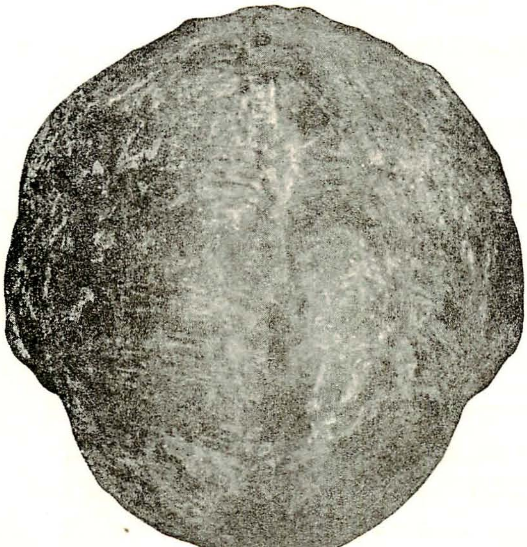

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624. EVOLUTION AND MODE OF LIFE OF *INOCERAMUS* (*SPHENOCERAMUS*) *NAUMANNI* YOKOYAMA EMEND., AN UPPER CRETACEOUS BIVALVE*

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白亜紀後期二枚貝 *Inoceramus* (*Sphenoceramus*) *naumanni* YOKOYAMA emend. の進化と生活様式： 南樺太内淵地域・北海道中軸北部達布地域および中軸南部浦河地域に分布する上部白亜系サントニアン〜カンパニアンから連続的に採集された *Inoceramus* (*Sphenoceramus*) *naumanni* の集団標本について，個体群に基づき産状・成長を生物統計学的に考察した。その結果サントニアンの標本については，外層の厚さが殻高に対して著しい劣成長にあることや，産状ならびに形態から，全期間を通じて足糸で流木や海藻に付着した擬浮遊性の生活様式を有していたと考えられる。これに対してカンパニアンの標本については，個体発生の途中でそれまでの同心円肋に加えて分岐肋の発生が認められ，しかも時間とともに次第に早く現われるようになる。分岐肋の発生に伴って殻高に対する殻の膨らみ・外層の厚さは，それまでの劣成長から優成長に変わることや，プリズムのサイズが急に大きくなることから，このような成長は殻の重量の急激な増加を引き起こすと考えられる。したがって本種における分岐肋の発生は，擬浮遊性から底生への生活様式の変化に伴う適応形態と考えられる。さらにこの変化は，本種の個体発生のみならず系統発生においても認められることを明らかにした。

棚 部 一 成

Introduction

Among various Mesozoic Bivalvia, the Inoceramidae has been utilized stratigraphically as important index fossils, because of their diverse shell morphology and wide geographic distributions, but the biological significances such as the mode of life and the relation between morphology and function have not yet been known to our satisfaction.

Studies of the mode of life of the Inoceramidae have been undertaken by many paleontologists, such as HAUFF (1921), SEITZ (1962), JEFFERIES and MINTON (1965), KAUFFMAN (1965, 1967, 1969), MATSUMOTO and NODA (1968), HAYAMI (1969) and STANLEY (1972). In these studies, HAUFF (1921), and JEFFERIES and MINTON (1965), pointed out that the mode of life of the Lower Jurassic inoceramid, *Pseudomytiloides dubius* (SOWERBY) was pseudoplanktonic because some individuals of this species attached themselves to the surface of drift wood. KAUFFMAN (1965, 1967) discussed the mode of life of the Late Cretaceous inoceramids in the western interior of the United States. His discussion was mainly based on the mode of fossil occurrence and the relation between shell morphology and lithofacies. HAYAMI (1969) contributed a work on the mode of life of certain Mesozoic Bivalvia. According to him,

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such Mesozoic Bivalvia as *Bositra*, *Daonella*, *Monotis*, *Buchia* and *Inoceramus* were nektoplanktonic or pseudoplanktonic. STANLEY (1972) mentioned that some Cretaceous inoceramids, such as the subgenus *Inoceramus* (*Mytiloides*), exibit definite endobyssate features.

However, most of these studies on the mode of life of the Mesozoic Bivalvia were founded on the mode of fossil occurrence. Little has been done on the analysis of relative growth and on the transportational or buoyancy mechanism of the shells.

In the present paper, I have dealt with *Inoceramus* (*Sphenoceramus*) *naumanni* YOKOYAMA emend, which almost corresponds to the group of *Inoceramus naumanni* of NAGAO and MATSUMOTO (1940). This species occurs abundantly in the Coniacian to the Campanian of the Upper Cretaceous in the Japanese Islands and Sakhalin, showing a wide geographic distribution, especially in the north Pacific province. The present species is very interesting for its successive occurrences showing low articulation ratios and a high degree of clustering. The forms from the Santonian and the Campanian are quite similar to each other except for the occurrence of divergent ribs in the latter.

In this paper, I study the mode of fossil occurrence and examine biometrically the shell characters, discussing the evolution and mode of life of the present species. I give special consideration to the numerous specimens which were successively collected from the Upper Cretaceous of Hokkaido and south Sakhalin.

Acknowledgements

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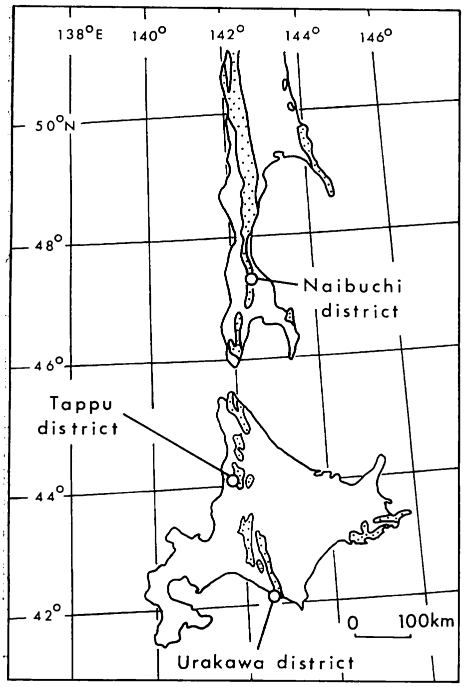
Thanks are extended to to Dr. Yasuhide IWASAKI of the University Museum of the University of Tokyo and Mr. Yasumitsu KANIE of the Yokosuka City Museum for allowing me to study the specimens preserved at their respective museums.

Material

Outline of stratigraphy.—In the central axial belt of Hokkaido extending to Sakhalin, marine Cretaceous deposits are widely distributed. They are divided litho-stratigraphically into five groups as follows: the Sorachi group (Jurassic to Neocomian), the Lower Yezo group (Upper Aptian to Middle Albian), the Middle Yezo group (Upper Albian to Turonian), the Upper Yezo group (Turonian to Lower Campanian), the Hakobuchi group (Lower Campanian to Maestrichtian), in ascending order (MATSUMOTO, 1954).

Numerous calcareous nodules are contained in the middle to the upper part of the deposits, and sometimes well-preserved marine fossils such as ammonoids, bivalves, especially inocerami, gastropods, echinoids, and others, are found in them. The specimens of *Inoceramus* (*Sphenoceramus*) *naumanni* YOKOYAMA emend., treated in this paper, were collected from the Naibuchi district of south Sakhalin, the Tappu district of northern central Hokkaido, and the Urakawa district of southern central Hokkaido (see Text-fig. 1).

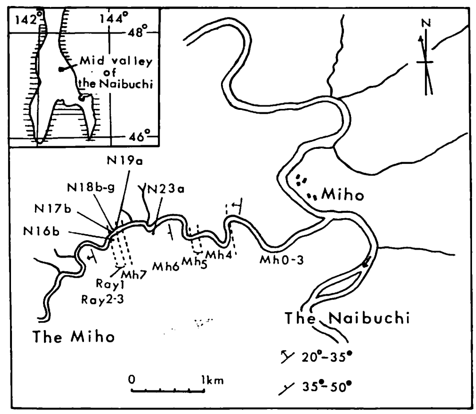


Text-fig. 1. Index map showing the Cretaceous outcrops and the areas studied.

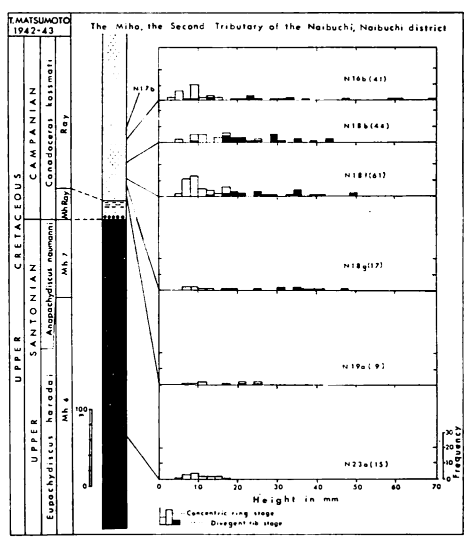
Sampling method.—Random sampling was made from a single fossil-bearing calcareous nodule in most cases, and from a fossil-bearing bed in the case of the samples N19a, N18g and N17b from the Naibuchi district and the sample U120 from the Urakawa district.

As there are no data on the absolute age of the Upper Cretaceous in the areas studied, the stratigraphic position of each sample is expressed by the thickness (m) in a sequence measured from the first occurrence of the present species, as well as by MATSUMOTO'S (1959) biostratigraphic subdivision of the Upper Cretaceous in Japan.

Other species of *Inoceramus* that may be associated with the present species in the same nodules, are *I.* (*Platyceramus*) *amakusensis* NAGAO and MATSUMOTO and *I.* (*Sphenoceramus* ?) *pseudosulcatus* NAGAO and MATSUMOTO. They



Text-fig. 2. Map showing the fossil localities in the Naibuchi district (adapted from MATSUMOTO, 1942).



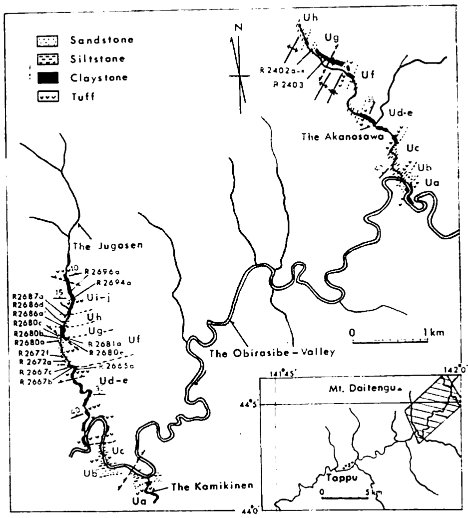
Text-fig. 3. Stratigraphic position and size-frequency distribution in samples from the Naibuchi district.

are easily distinguishable from *I.* (*S.*) *naumanni* by the analyses of the individual relative growth and the apical angle.

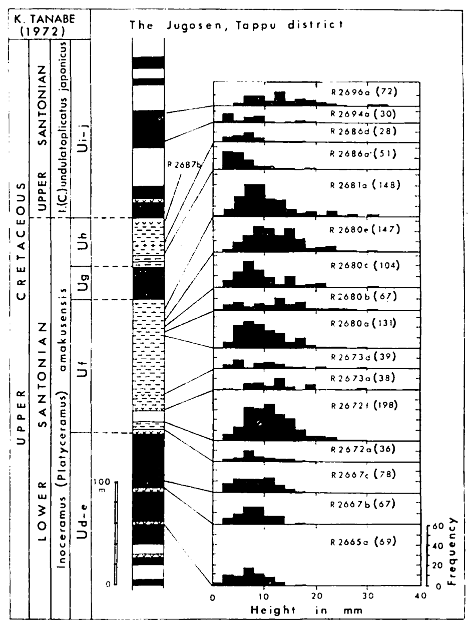
Samples from the Naibuchi district.—7 samples are used in the present study. They were collected from the Upper Santonian to the Campanian in the R. Miho, the second tributary of the R. Naibuchi. The fossil localities and their stratigraphic positions are shown in Text-figs. 2-3. The stratigraphy of the Upper Cretaceous in the district is after MATSUMOTO (1942).

Samples from the Tappu district.—19 samples are used in the present study. They were collected from the upper part of the Upper Yezo group (Santonian) in the R. Jugosen (R 2665a, R 2667b, R 2667c, R 2672a, R 2672f, R 2673a, R 2673d, R 2680a, R 2680b, R 2680c, R 2680e, R 2681a, R 2686a', R 2686d, R 2687b, R 2694a and R 2696a) and the R. Akanosawa (R 2402a-x and R 2403), the tributaries of the Obirashibe Valley. The fossil localities and their stratigraphic positions are shown in Text-figs. 4-5. The stratigraphic division of the Upper Yezo group in the district is after TANAKA (1963). According to him, the age of the group is from Turonian to Lower Campanian, but in my opinion the upper limit of the group is probably Upper Santonian, because of the occurrence of *Inoceramus* (*Cladoceramus*) *undulatoplicatus japonicus* NAGAO and MATSUMOTO in the uppermost horizon.

Samples from the Urakawa district.—12 samples are used in the present study. They were collected from the upper part of the Upper Yezo group (Upper Santonian to Upper Campanian) in the upper course of the R. Chinomi (U 142, U 143r, U 147-2, U 120, U 128c and U 115), the lower course of the R. Chinomi (U 446-4), the upper course of the R. Urokobe-

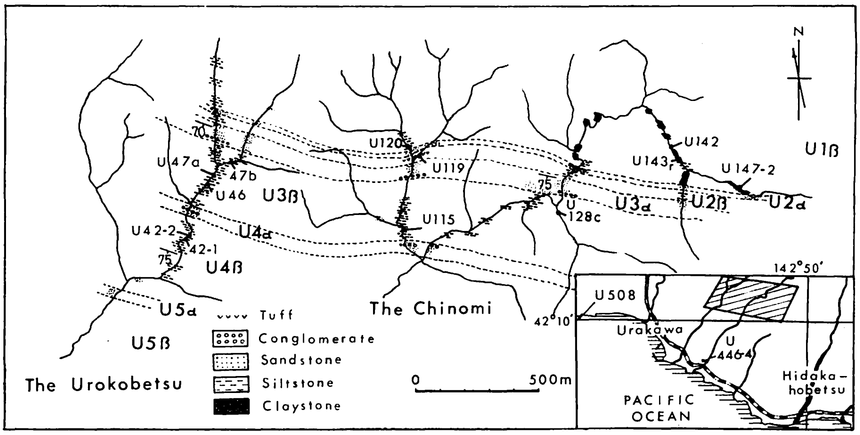


Text-fig. 4. Map showing the fossil localities in the Tappu district.

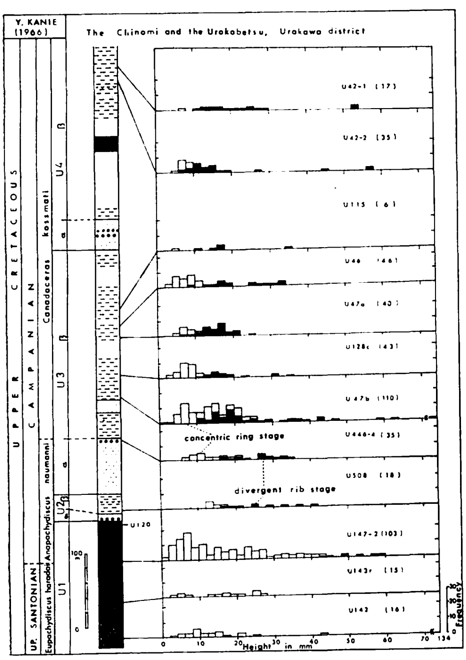


Text-fig. 5. Stratigraphic position and size-frequency distribution in samples from the Tappu district.

tsu (U 47a, U 47b, U 46, U 42-2 and U 42-1) and the coast of Ikandai (U 508). The fossil localities and their stratigra-



Text-fiig. 6. Map showing the fossil localities in the Urakawa district.



Text-fig. 7. Stratigraphic position and size-frequency distribution in samples from the Urakawa district.

phic positions are shown in Text-figs. 6-7. The stratigraphic divisions of this group in the district are based on KANIE (1966).

Mode of fossil occurrence

Mode of fossil occurrence.—The mode of fossil occurrence of the present species is very similar to that of the Lower Jurassic nektoplanktonic or pseudoplanktonic bivalve, *Bositra buchi* (RÖMER) (JEFFERIES and MINTON, 1965; STANLEY, 1972). In the above-mentioned three districts, the shells occur crowded in the calcareous nodules throughout the successive sequence. This fact indicates that the material is suitable for the study from the viewpoint of the population concept (NEWELL, 1956). The fossil occurrence is generally independent of the lithofacies. The articulation ratio and the chi-square test of the valves in each sample from the Naibuchi, the Tappu and the Urakawa districts are summarized in Table 1. The articulation ratio is especially low in the specimens from the Santonian and it is also low in the concentric ring stage from the Campanian. In contrast to this, most specimens of certain associated bivalves, e. g. *Nanonavis sachalinensis* (SCHMIDT), *Nuculana mactraeformis* NAGAO, *Propeamussium cowperi yubarense*

(YABE and NAGAO) and *Inoceramus* (*Platyceramus*) *amakusensis* NAGAO and MATSUMOTO, are complete and conjoined as seen in the samples R 2667c, R 2680a–c and R 2686d. As BOUCOT (1953) pointed out, the articulation ratio is controlled by such physical conditions as the velocity of the current on dead shells, the depositional process and the strength of the ligament. The ligament of the present species is considered to be weak, judging from the poorly developed ligamental pits and very thin shell. The common occurrence of an associate thin-shelled bivalve, *Propeamussium cowperi yubarense* with complete conjoined valves, in spite of weak ligamental intensity, makes it difficult to explain the low articulation ratio of the present species only by the weakness of ligamental intensity. A similar clustered occurrence, with a low articulation ratio, has been observed also in the Santonian sequences along the R. Sakasagawa in the Kamihaboro district, along the R. Kotanbetsu in the Kotanbetsu district, nothern central Hokkaido, and along the R. Shutta-zawa, tributary of the R. Hobetsu, southern central Hokkaido (see Plate 27). In most cases, the result of the chi-square test indicates that the difference between the frequencies of the two valves is not statistically significant at the 95% level, and, therefore, the question of the selective transportation and deposition of the valves remains unanswered.

A definite orientation of the shells is not usually observed, but in the case of R 2696a, the fossil-bearing layers are sharply separated from the barren layers in a nodule. This is somewhat similar to the mode of fossil occurrence of the very thin shells in some pelagic sediments, as exemplified by the Ohse formation of the Sambosan belt in southern

Table 1. Articulation ratio and chi-square test of the valves in samples from the Naibuchi, the Tappu and the Urakawa districts (Articulation ratio shows the value of the concentric ring stage and that of the divergent rib stage, respectively).

	sample	N	R.V.	L.V.	articulation ratio	chi-sqare test
Naibuchi district	N 23a	16 (0)	7 (0)	9 (0)	0 (----)	0.25 ●
	N 19a	11 (3)	7 (2)	4 (1)	0 (0)	0.82 ●
	N 18g	19 (12)	8 (5)	10 (7)	0.29 (0)	0.22 ●
	N 18f	69 (27)	26 (9)	43 (18)	0 (0)	4.19 ○
	N 18b	42 (23)	25 (15)	17 (8)	0 (0.09)	1.52 ●
	N 16b	44 (18)	27 (9)	17 (9)	0 (0)	2.27 ●
	N 17b	3 (3)	1 (1)	2 (2)	0 (0)	0.33 ●
Tappu district	R 2665a	73 (0)	49 (0)	24 (0)	0 (----)	8.56 ○
	R 2667b	72 (0)	38 (0)	34 (0)	0 (----)	0.22 ●
	R 2667c	87 (0)	46 (0)	41 (0)	0 (----)	0.89 ●
	R 2672a	43 (0)	20 (0)	23 (0)	0 (----)	0.21 ●
	R 2672f	232 (0)	119 (0)	113 (0)	0 (----)	0.02 ●
	R 2673a	40 (0)	23 (0)	17 (0)	0 (----)	0.90 ●
	R 2673d	39 (0)	23 (0)	16 (0)	0 (----)	1.26 ●
	R 2680a	138 (0)	85 (0)	53 (0)	0.01 (----)	7.42 ○
	R 2680b	70 (0)	39 (0)	31 (0)	0.03 (----)	0.91 ●
	R 2680c	122 (0)	70 (0)	52 (0)	0.02 (----)	2.70 ●
	R 2680e	172 (0)	90 (0)	82 (0)	0.01 (----)	0.37 ●
	R 2681a	157 (0)	82 (0)	75 (0)	0 (----)	0.31 ●
	R 2686a	55 (0)	32 (0)	23 (0)	0.04 (----)	1.47 ●
	R 2686d	29 (0)	16 (0)	13 (0)	0 (----)	0.31 ●
	R 2687b	7 (0)	4 (0)	3 (0)	0 (----)	0.14 ●
	R 2694a	34 (0)	21 (0)	13 (0)	0.06 (----)	1.88 ●
	R 2696a	85 (0)	37 (0)	48 (0)	0.07*(----)	1.42 ●
Urakawa district	U 142	23 (0)	13 (0)	10 (0)	0 (----)	0.44 ●
	U 143r	22 (0)	12 (0)	10 (0)	0 (----)	0.18 ●
	U 147-2	122 (7)	64 (5)	51 (2)	0.04 (----)	1.79 ●
	U 120	11 (8)	2 (1)	9 (7)	0 (0.22)	4.45 ○
	U 508	21 (8)	11 (3)	10 (5)	0 (0)	0.05 ●
	U 446-4	35 (18)	17 (9)	18 (9)	0 (0.50)	0.03 ●
	U 47b	126 (56)	60 (28)	66 (28)	0 (0.07)	0.29 ●
	U 128c	51 (22)	14 (12)	15 (10)	0 (0.09)	0.02 ●
	U 47a	42 (29)	25 (16)	17 (14)	0 (0)	1.52 ●
	U 46	52 (21)	15 (9)	16 (12)	0 (0.29)	0.31 ●
	U 42-2	40 (30)	23 (17)	17 (13)	0 (0)	0.90 ●
	U 42-1	21 (20)	9 (8)	12 (12)	0 (0)	0.43 ●

( ) --- Divergent rib stage
* --- Valve open position
● --- Not significant at 95% confidence level
○ --- Significant at 95% confidence level

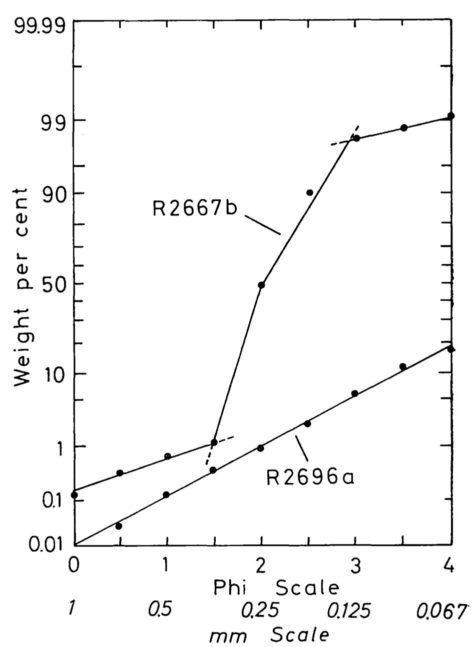
Kyushu (KANMERA, 1969, Plate 6) and the Upper Triassic to Jurassic "*Posidonia*" limestone of the West Carpathians (MISIK, 1966, Plates 33 and 46).

Faunal combination.—The Upper Cretaceous sediments in Hokkaido and Sakhalin are generally poor in bivalves other than inocerami. The present species holds an important position among the megafossils contained in nodules, except for ammonoids. This role has been ascertained in most nodules collected from the Senonian sequences of the districts studied. For example, the percentages of the number of individuals of this species among the molluscs in each sample, and also that of the bivalves taken separately from the R. Jugosen, Tappu district are as follows.

R 2665a :	80% (100%)	R 2680b :	89% (100%)
R 2667b :	85% (100%)	R 2680c :	85% (94%)
R 2667c :	93% (98%)	R 2680e :	97% (100%)
R 2672a :	75% (100%)	R 2681a :	84% (97%)
R 2672f :	89% (98%)	R 2686a' :	88% (100%)
R 2673a :	47% (87%)	R 2686d :	91% (100%)
R 2673d :	90% (90%)	R 2694a :	100% (100%)
R 2680a :	94% (97%)	R 2696a :	100% (100%)

No other marine megafossils were found in samples R 2694a and R 2696a. The percentage is generally high in claystone. Such a dominant occurrence of the present species in the Upper Cretaceous fauna can be observed also in the other two districts. This indicates that the present species was remarkably prolific.

Transportational mechanism of shells.—The main cause of a reduction in the articulation ratio is regarded as due to traction and saltation. VISHER (1969) indicated that the transportational mechanism consists of a combination of suspension, saltation and traction, based on the grain-size analysis of many recent and ancient clastic sediments. This mechanism of transportation is well exhibited by the three populations when the data are plotted on the log-probablity paper. I also tried the grain-size analysis of some nodules, after having collected fossils in the following manner. Crushed nodules were digested in hydrochloric acid in order to dissolve the carbonate; and then were neutralized with sodium hydroxide. The grains of the residue were separated by ultrasonic. The results are shown in Text-fig. 8. It is considered that the transportational mechanism of the sediments of R 2696a (claystone) was suspension and that of R 2667b (sandy siltstone) was a combination of traction, saltation and suspension. Although the transportational mechanism may not be the same between grains and shells, most shells in the examined samples were probably transported by currents and eventually fell to the sea bottom.



Text-fig. 8. Grain-size distributions of some nodules from the Tappu district.

Biometrical analysis

Abbreviations.—I use the following abbreviations in the present paper.

For univariate analysis
R. V.: Right valve; *L. V.*: Left valve; *N*: Number of individuals in a sample; *O. R.*: Observed range; $\bar{X}$: Arithmetic mean; *s*: Standard deviation; $\sigma\bar{x}$: Standard error of the mean; *P*: Probability level; ν: Degrees of freedom.

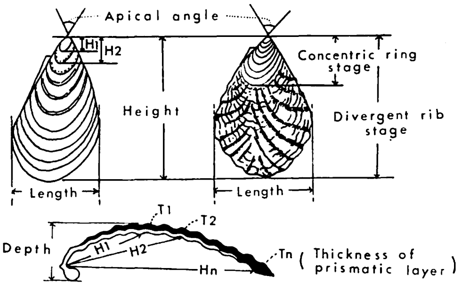
For bivariate analysis
R. M. A.: Reduced major axis; α: Growth index; β: Initial growth index: *r*: Correlation coefficient; σ_α: Standard error of α.

For Repositories
GK.: The prefix means that the specimens is kept in the type collection of the Kyushu University. The specimens of the samples U 142, U 143r, U 147-2, U 47b, U 128c and U 46 were collected by MATSUMOTO in 1940, and U 120, U 508, U 47a, U 115, U 42-2 and U 42-1 were collected by me in 1972. The specimens of R number samples (R 2665a—R 2696a, R 2402a-x and R 2403) were collected by HIRANO and me in 1971.
MM.: The prefix means that the specimens were collected by MATSUMOTO from the Naibuchi district in 1937, and are stored in the type collection of the University Museum of the University of Tokyo.

YCM.: The prefix means that the specimen is stored in the type collection of the Yokosuka City Museum. The specimens of the sample U 446-4 were collected by KANIE in 1969.

Basic morphology and measurements of the present species are diagrammatized in Text-fig. 9. A special comparator designed by SHUTO and a wide-view microscope were used for the measurements.

Size-frequency distributions.—The size-frequency distributions of the shell height in the samples from the Naibuchi, the Tappu and the Urakawa districts are shown in Text-figs. 3, 5, and 7, respectively.



Text-fig. 9. Basic morphology and measurements of the subgenus *Inoceramus* (*Sphenoceramus*).

According to BOUCOT (1953) and CRAIG (1967), the size-frequency distributions of the molluscan death assemblages are originally controlled by interaction of the mortality and the growth rates in each living population. The survivorship curve of many marine invertebrates shows the presence of a large number of larval and immature individuals, a moderate number of adults and a small number of gerontic individuals. In the death assemblages, the larval individuals have been damaged mostly by physical agents and are not preserved. Therefore, the size-frequency distribution indicates strong positive skewness with larval stages lacking (HALLAM, 1967).

The size-frequency distributions of the molluscan death assemblages are also controlled by chemical and biological conditions, and accordingly, the absolute growth of each living population and the representation of the physicochemical conditions are needed for a reasonable interpretation of the size-frequency distributions.

The size-frequency distributions of the samples from the Santonian in the Tappu district (Text-fig. 5) indicate that the pattern changed with time from moderate positive skewness (right skewed) to a bell-shaped normal distribution curve. Generally speaking, the range of each size-frequency distribution increases as the sequence goes upward. In the samples from the Naibuchi and the Urakawa districts, the range of each size-frequency distribution (Text-figs. 3 and 7) also increases with time during the Santonian. In the samples from the Campanian, the largest limit of the concentric ring stage is less than 50 mm in shell height. In comparison with the concentric ring stage, the range of the divergent rib stage is located on the right side of each size-frequency distribution. In the example U 128c, the pattern appears to be bimodal. The largest specimen in the divergent rib stage sometimes exceeds 30 cm in shell height, as observed for the Urakawa district.

Univariate analysis.—Method of univariate analysis of invertebrate fossils has been used by SIMPSON and ROE (1939), IMBRIE (1956), SYLVESTER-BRADLEY (1958), SIMPSON, ROE & LEWONTIN (1960), and many others. It is well known that a univariate analysis is insufficient to charge a growth relationship. In the case of the present species, the shell form represented by such characters as the simple ratio, D/H and T/H is changeable with growth. T is the thickness of the prismatic layer, H the shell height, and D the shell depth (= inflation). Consequently, only the shell height in the concentric ring stage has been examined for the univariate analysis.

In the later forms of the present species in the Campanian, two stages of growth are distinguished, namely the concentric ring stage and the divergent rib stage (see Text-fig. 9). The surface ornament changes from the former to the latter during ontogeny. In the specimens from the Lowest Campanian, the divergent ribs can be recognized in the later stage (e. g. Plate 28, fig. 12), but in the specimens from the Middle to the Upper Campanian, they can be clearly recognized from the middle or even early stage (e. g. Plate 28, figs. 13-18). The range of variation of the distance from beak to the point of the first appearance of the divergent ribs seems to be nearly constant in each sample.

Table 2. Measurements of the shell height in the concentric ring stage in samples from the Naibuchi and the Urakawa districts.

	sample	N	$\bar{X} \pm t_{0.05}\sigma\bar{x}$	V	s	$\sigma\bar{x}$	observed range
Naibuchi district	N 18g	11	17.40 ± 2.01	17.25	3.00	0.90	14.10 - 24.00
	N 18f	21	14.94 ± 1.34	19.58	2.93	0.64	10.65 - 21.60
	N 18b	24	12.25 ± 1.01	19.52	2.39	0.49	7.60 - 15.75
	N 16b	16	11.13 ± 1.45	24.54	2.73	0.68	5.90 - 14.80
	N 17b	3	6.57 ± 0.77	4.90	0.32	0.18	6.20 - 6.80
Urakawa district	U 147-2	6	27.08 ± 1.31	4.60	1.24	0.51	25.90 - 29.00
	U 120	7	21.25 ± 3.28	16.75	3.56	1.34	14.80 - 25.80
	U 508	8	17.74 ± 2.77	18.69	3.32	1.17	13.85 - 23.65
	U 446-4	15	13.59 ± 1.16	15.30	2.08	0.54	10.30 - 17.00
	U 47b	51	12.04 ± 0.62	18.36	2.21	0.31	8.20 - 15.90
	U 128c	16	10.24 ± 1.21	22.27	2.28	0.57	7.45 - 14.35
	U 47a	28	9.16 ± 0.53	15.03	1.38	0.26	6.70 - 11.90
	U 46	17	8.74 ± 0.72	15.93	1.39	0.34	6.30 - 11.20
	U 115	5	7.59 ± 0.11	1.27	0.10	0.04	7.50 - 7.75
	U 42-2	25	7.27 ± 0.62	20.58	1.50	0.30	4.75 - 10.90
	U 42-1	14	6.19 ± 0.43	12.31	0.76	0.20	4.75 - 7.75

Therefore, in order to show quantitatively the variation, $\bar{X}$ (at the 95% confidence level), s, $\sigma\bar{x}$, V and $O.R.$ of the distance in each sample from the Naibuchi and the Urakawa districts have been calculated. The results are summarized in Table 2. The shell size of the concentric ring stage was gradually decreased with time. The chi-square tests in each sample are as follows.

Samples from the Naibuchi district:

N 18g: $x^2=1.32 \ll 3.84 = x^2_{0.05(\nu=1)}$, $P \gg 0.05$, n. s.
N 18f: $x^2=0.15 \ll 3.84 =$ 〃, 〃, 〃
N 18b: $x^2=0.26 \ll 3.84 =$ 〃, 〃, 〃
N 16b: $x^2=1.41 \ll 3.84 =$ 〃, 〃, 〃

Samples from the Urakawa district:

U 147-2: $x^2=1.39 \ll 3.84 = x^2_{0.05(\nu=1)}$, $P \gg 0.05$, n. s.
U 120 : $x^2=0.24 \ll 3.84 =$ 〃, 〃, 〃
U 508 : $x^2=0.71 \ll 3.84 =$ 〃, 〃, 〃
U 446-4: $x^2=0.59 \ll 3.84 =$ 〃, 〃, 〃
U 47b : $x^2=3.04 \ll 3.84 =$ 〃, 〃, 〃
U 128c : $x^2=0.29 \ll 3.84 =$ 〃, 〃, 〃
U 47a : $x^2=0.43 \ll 3.84 =$ 〃, 〃, 〃
U 46 : $x^2=4.83 \ll 6.64 = x^2_{0.01(\nu=1)}$, $P \gg 0.01$, 〃
U 115 : $x^2=2.11 \ll 3.84 = x^2_{0.05(\nu=1)}$, $P \gg 0.05$, 〃
U 42-2 : $x^2=2.23 \ll 3.84 =$ 〃, 〃, 〃
U 42-1 : $x^2=0.06 \ll 3.84 =$ 〃, 〃, 〃

n. s.: non-significant

The results of the chi-square test indicate that the null hypothesis for a normally distributed population is not rejected for the character considered.

In order to show the difference of $\bar{X}$ between the two samples, A (N_1, $\bar{X}_1$, s_1) and B (N_2, $\bar{X}_2$, s_2), a F-test was made. This is represented by the following formula: $F=s_1^2/s_2^2$, $\because s_1>s_2$

The results of the F-test between a pair of samples from the Naibuchi and the Urakawa districts are summarized in Table 3.

If the ratio s_1^2/s_2^2 between the two samples is not significant statistically, the significance of the difference between $\bar{X}_1$ and $\bar{X}_2$ is given by the following well known formula (STUDENT'S t-test).

$$t=\frac{(\bar{X}_1-\bar{X}_2)\sqrt{\dfrac{N_1\cdot N_2}{N_1+N_2}}}{\sqrt{\dfrac{(N_1-1)\cdot s_1^2+(N_2-1)\cdot s_2^2}{N_1+N_2-2}}}$$

$$\nu=N_1+N_2-2$$

If the ratio s_1^2/s_2^2 between the two samples is significant statistically, t is calculated by the following formula (WELCH'S method for heterogeneous variances).

$$t=\frac{\bar{X}_1-\bar{X}_2}{\sqrt{\dfrac{s_1^2}{N_1}+\dfrac{s_2^2}{N_2}}},\quad \frac{1}{\nu}=\frac{C^2}{N_1-1}-\frac{(1-C)^2}{N_2-1}$$

$$C=\frac{\dfrac{s_1^2}{N_1}}{\dfrac{s_1^2}{N_1}+\dfrac{s_2^2}{N_2}}$$

The results of the t-test are shown in Table 4. They indicate that the means are often significantly different for a pair of samples.

Bivariate analysis.—As IMBRIE (1956) pointed out, an assumption of purely isometric growth is needed for the univariate analysis. Such methods as the regression of Y on X, the regression of X on Y, BARTLETT'S line, the major axis and the reduced major axis have been applied for the recognition of average relative growth (KERMACK and HALDANE, 1950; IMBRIE, 1956; SIMPSON, ROE & LEWONTIN, 1960; SOKAL and ROHLF, 1969). Among them, the reduced major axis is considered a useful approximate method for the representa-

Table 3. F-test of the shell height in the concentric ring stage between a pair of samples from the Naibuchi and the Urakawa districts.

F-test	N 19a	N 18g	N 18f	N 18b	N 16b
N 19a		1.05	1.58	1.21	90.0
N 18g	●		1.50	1.15	85.5
N 18f	●	●		1.30	57.1
N 18b	●	●	●		74.5
N 16b	○	○	○	○	

F-test	U 147-2	U 120	U 508	U 446-4	U 47b	U 128c	U 47a	U 46	U 115	U 42-2	U 42-1
U 147-2		8.22	7.16	2.81	3.17	3.35	1.23	1.25	154	1.46	0.38
U 120	∘		1.15	2.93	2.60	2.40	6.67	6.56	1267	5.63	21.8
U 508	∘	●		2.55	2.26	2.12	5.80	5.71	1102	4.90	19.0
U 446-4	●	•	●		1.13	1.20	2.28	2.24	433	1.92	7.47
U 47b	●	∘	•	●		1.07	2.57	2.53	488	2.17	8.41
U 128c	●	●	●	●	●		2.74	2.69	520	2.31	8.97
U 47a	●	○	○	•	○	∘		1.02	190	1.18	3.28
U 46	●	○	○	●	∘	•	●		193	1.17	3.33
U 115	●	○	○	○	○	○	○	○		225	58.0
U 42-2	●	○	○	●	∘	•	●	●	○		3.88
U 42-1	●	○	○	○	○	○	∘	∘	○	○	

● ratio of variances not significant at 90% confidence level

• " " " significant " "

∘ " " " " at 95% "

○ " " " " at 99% "

tion of average relative growth (IMBRIE, 1956; WALLER, 1969; HAYAMI and MATSUKUMA, 1970). Therefore, I have been examined the statistical discrimination of allometry by means of the reduced major axis method. In the present species "polyphasic" (meaning that more than one allometric relationship exist during ontogeny) allometry can be expected for the samples from the Campanian.

Average relative growth: In the study of the average relative growth, H and D were used for the bivariate characters. If growth is allometric, the relation between two variables, X and Y, is represented by the following equation (HUXLEY, 1932).

$Y=\beta X^{\alpha}$ or $\log Y=\alpha \log X+\log \beta$, and according to KERMACK and HALDANE (1950), σ_{α} is represented by the following formula.

$$\sigma_{\alpha}=\alpha\sqrt{\frac{1-r^2}{N}}$$

Changes of the reduced major axis with time for the samples from the Naibuchi and the Urakawa districts are illustrated in Text-fig. 10. As one might expect, a pronounced critical point of growth can be recognized between the

Table 4. STUDENT'S *t*-test of the shell height in the concentric ring stage between a pair of samples from the Naibuchi and the Urakawa districts.

t-test	N 19a	N 18g	N 18f	N 18b	N 16b
N 19a		2.24	5.46	5.63	(11.73)
N 18g	o		3.39	4.03	(12.58)
N 18f	O	O		1.37	(10.89)
N 18b	O	O	o		(6.45)
N 16b	O	O	O	O	

t-test	U 147-2	U 120	U 508	U 446-4	U 47b	U 128c	U 47a	U 46	U 115	U 42-2	U 42-1
U 147-2		(4.06)	(7.31)	14.7	16.3	17.0	29.3	28.5	34.7	29.9	46.6
U 120	O		1.98	6.40	(6.67)	8.87	(8.82)	(9.02)	(10.2)	(10.1)	(11.1)
U 508	O	●		3.70	6.31	6.52	(7.14)	(7.37)	(8.64)	(8.64)	(9.70)
U 446-4	O	O	O		2.42	4.26	8.38	7.84	(11.1)	11.1	(12.9)
U 47b	O	O	O	o		2.82	(7.12)	(7.21)	(14.2)	(11.1)	(15.8)
U 128c	O	O	O	O	O		(1.72)	2.30	(4.63)	5.04	(6.69)
U 47a	O	O	O	O	O	●		0.99	(5.93)	4.78	(8.98)
U 46	O	O	O	O	O	o	O		(3.38)	3.21	(6.48)
U 115	O	O	O	O	O	O	O	O		(1.06)	(6.73)
U 42-2	O	O	O	O	O	O	O	O	O		(2.98)
U 42-1	O	O	O	O	O	O	O	O	O	O	

( ) ----- Welch's method

O ----- ratio of variances significant at 99% confidence level

o ----- " " " " at 95% "

● ----- " " " non-significant at 80% "

concentric ring stage and the divergent rib stage. Moreover, each critical point is gradually decreased with time.

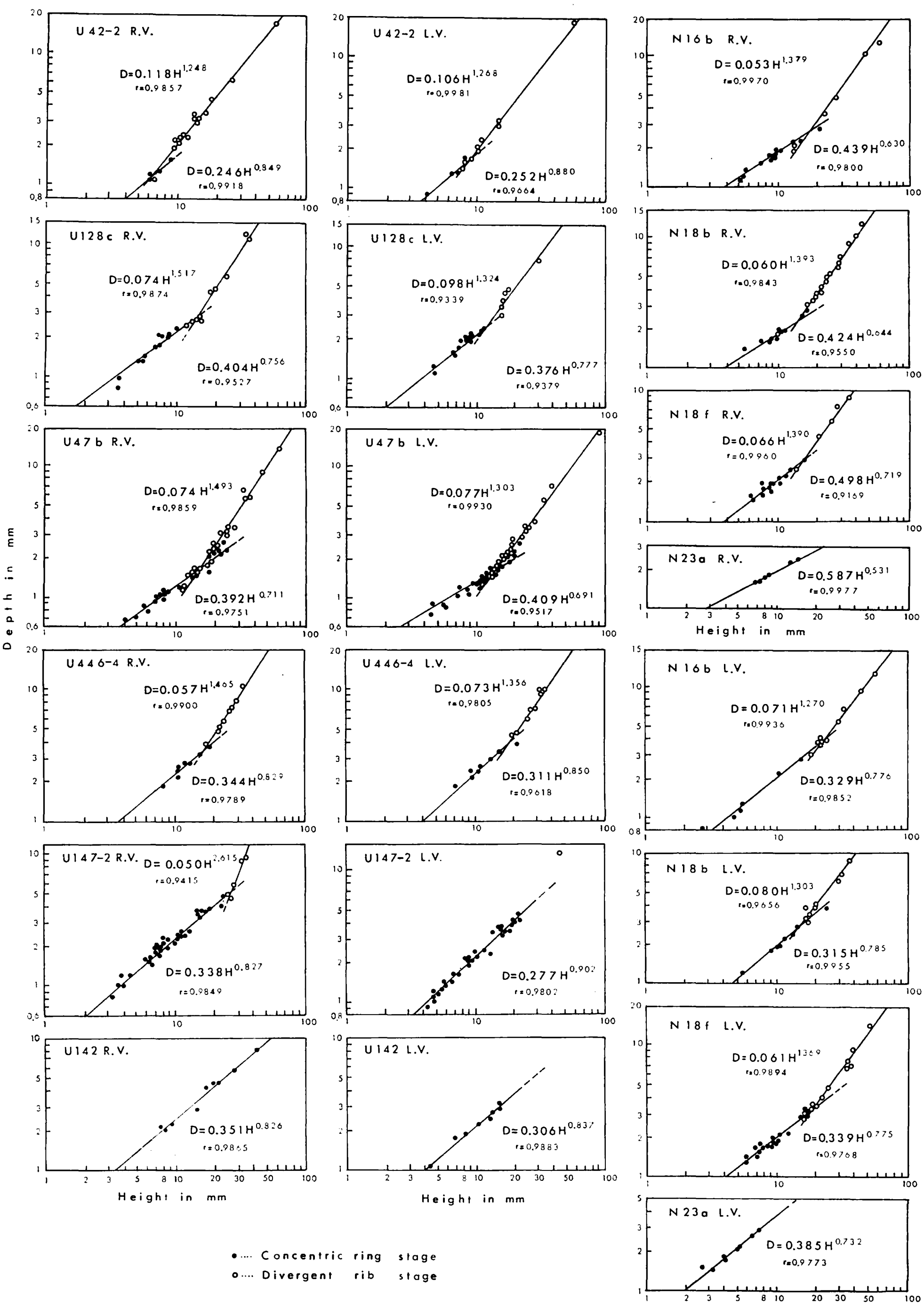
According to HAYAMI and MATSUKUMA (1970), the difference of isometry and allometry in average relative growth is represented by the following formula, with 95% confidence.

$$K=\frac{\alpha-1}{\alpha\sqrt{\frac{1-r^2}{N}}},$$

$-1.96 \leqq K \leqq 1.96$—isometry
$K < -1.96$—negative allometry
$K > 1.96$—positive allometry

I have calculated the value of K and tried to determinate the allometric relationship for each sample from the Naibuchi and the Urakawa districts. The results are summarized in Table 5. The growth of the concentric ring stage in most of the samples indicates negative allometry. On the contrary, that of the divergent rib stage indicates positive allometry.

Individual relative growth: As a result of the average relative growth, it is to be expected that the abrupt change of the growth index is in accord with the change of ornament from the concentric



Text-fig. 10. Changes of the reduced major axis between the shell depth (=inflation) and the shell height for the samples from the Naibuchi and the Urakawa districts.

Table 5. Approximate determination of allometry of the average relative growth between the shell depth and the shell height in each samples from the Naibuchi and the Urakawa districts.

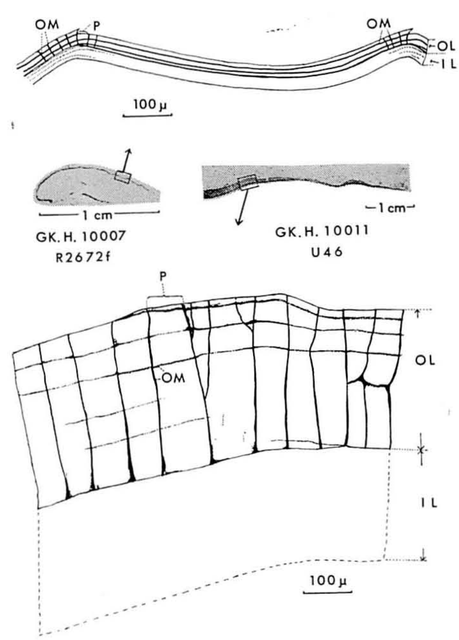
	sample		concentric ring stage	divergent rib stage
Naibuchi district	N 23a	R.V.	- 31.92 ●	---------------
		L.V.	- 4.89 ●	---------------
	N 18g	R.V.	---------------	---------------
		L.V.	- 20.94 ●	12.58 ○
	N 18f	R.V.	- 3.92 ●	7.01 ○
		L.V.	- 6.21 ●	6.43 ○
	N 18b	R.V.	- 5.89 ●	6.39 ○
		L.V.	- 8.17 ●	7.68 ○
	N 16b	R.V.	- 11.43 ●	8.69 ○
		L.V.	- 4.13 ●	5.95 ○
Urakawa district	U 142	R.V.	- 3.86 ●	---------------
		L.V.	- 3.61 ●	---------------
	U 147-2	R.V.	- 7.45 ●	4.10 ○
		L.V.	- 3.20 ●	---------------
	U 446-4	R.V.	- 2.47 ●	6.36 ○
		L.V.	- 1.93 ◎	3.79 ○
	U 47b	R.V.	- 8.98 ●	9.26 ○
		L.V.	- 7.28 ●	9.65 ○
	U 128c	R.V.	- 3.36 ●	6.81 ○
		L.V.	- 3.20 ●	1.68 ◎
	U 47a	R.V.	- 3.31 ●	2.68 ○
		L.V.	- 5.55 ●	1.69 ◎
	U 46	R.V.	- 4.78 ●	6.93 ○
		L.V.	- 1.80 ◎	7.11 ○
	U 42-2	R.V.	- 2.79 ●	4.57 ○
		L.V.	- 1.07 ◎	10.83 ○
	U 42-1	R.V.	---------------	5.95 ○
		L.V.	---------------	5.13 ○

● K< - 1.96 ---- Negative allometry
○ K > 1.96 ---- Positive allometry   Confidence level 95%
◎ 1.96< K< 1.96 -------- Isometry

rings to the divergent ribs.

The shell is very thin (almost less than 100 μ) and does not become thicker with growth in the specimens from the Santonian (e. g. Plate 28, figs. 1-4). However, in the specimens from the Campanian, the value of the growth index suddenly increases from the concentric ring stage to the divergent rib stage. According to WILBUR (1964, p. 244, fig. 1), the outer layer of bivalve shell substance increases in thickness with growth. The increase is observed to the point of the disappearance of the inner layer (KADO, 1953, text-fig. 2).

The shell structure of the Inocermidae is composed of an outer prismatic layer and an inner nacreous layer. It corresponds to the prismatic structure of KOBAYASHI'S (1971) generalization. The outer prismatic layer of the present species consists of numerous columnar calcite prisms. Each prism is bounded by organic matrix. The longitudinal axis of each prism is arranged nearly perpendicular to the shell surface (see Text-fig. 11). Accordingly, the transverse section along the direction of the shell growth is suitable for the measurement of the thickness



Text-fig. 11. Shell microstructure of *Inoceramus (Sphenoceramus) naumanni* YOKOYAMA emend. OL: Outer prismatic layer. IL: Inner nacreous layer. OM: Organic matrix. P: Prism.

of the prismatic layer.

The mean value of the growth index for a population is confined to the following range with 95% confidence by an approximate method (HAYAMI and MATSUKUMA, 1970), where $\bar{\alpha}$ and s_α are the mean and standard deviation of α for a sample.

$$\bar{\alpha} \pm \frac{t_{0.05}\, s_\alpha}{\sqrt{N}}$$

If the range includes 1, the hypothesis of isometry is not rejected. In other words, the ranges of isometry and allometry are represented as follows.

$$1-\frac{t_{0.05}\, s_\alpha}{\sqrt{N}} \leqq \bar{\alpha} \leqq 1+\frac{t_{0.05}\, s_\alpha}{\sqrt{N}} \text{—isometry}$$

$$\bar{\alpha} < 1-\frac{t_{0.05}\, s_\alpha}{\sqrt{N}} \text{—negative allometry}$$

$$\bar{\alpha} > 1+\frac{t_{0.05}\, s_\alpha}{\sqrt{N}} \text{—positive allometry}$$

Using this approach, I have tried to distinguish the allometric relationships between T and H for each sample. The results are summarized in Table 6. The growth index of the concentric ring stage in most samples indicates negative allometry. On the contrary, that of the divergent rib stage indicates positive allometry in all the samples. A pronounced critical point of growth between the two stages is observed from the ontogenetic allometry of the selected specimens (see Text-fig. 12). This evidence indicates that an intimate relationship exists between the appearance of the divergent ribs and the abrupt change in mode of thickening of the prismatic layer.

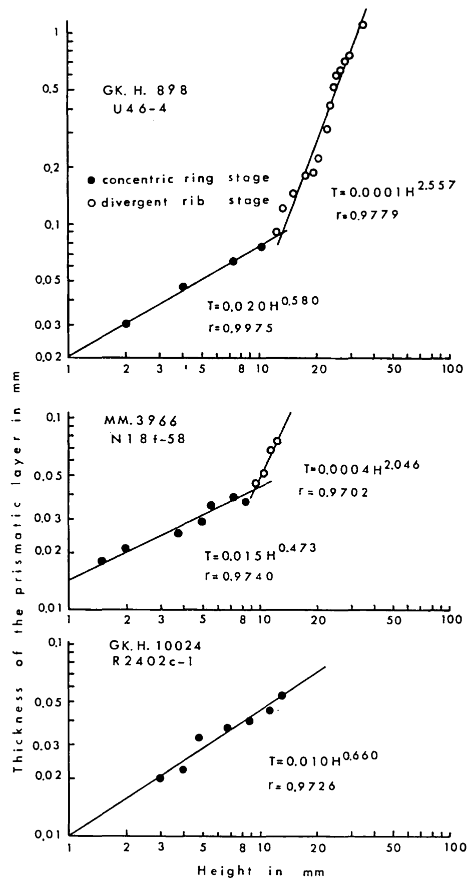
Table 6. Approximate determination of allometry of the individual relative growth between the thickness of the prismatic layer and the shell height in each sample from the Naibuchi, the Tappu and the Urakawa districts.

sample	concentric ring stage				divergent rib stage			
	N	$\bar{\alpha} \pm t_{0.05}\, s_\alpha$	s_α	allometry	N	$\bar{\alpha} \pm t_{0.05}\, s_\alpha$	s_α	allometry
R2665a	3	0.476 ± 0.525	0.214	◎	—	——	——	——
R2667c	3	0.533 ± 0.222	0.090	○	—	——	——	——
R2672f	2	0.797 ± 0.394	0.044	◎	—	——	——	——
R2680b	1	0.803	——	○	—	——	——	——
R2402c	1	0.660	——	○	—	——	——	——
R2402g	1	0.960	——	○	—	——	——	——
U 47 b	—	——	——	——	5	1.563 ± 0.401	0.323	●
U128c	2	0.416 ± 0.302	0.034	○	2	2.429 ± 0.059	0.007	●
U 46	3	0.623 ± 0.373	0.150	○	1	2.557	——	●
N18f	3	0.417 ± 0.237	0.095	○	4	1.885 ± 0.346	0.218	●
N16b	—	——	——	——	1	2.815	——	●

○ negative allometry $\bar{\alpha} < 1 - \frac{t_{0.05}\, s_\alpha}{\sqrt{N}}$

● positive allometry $\bar{\alpha} > 1 + \frac{t_{0.05}\, s_\alpha}{\sqrt{N}}$

◎ isometry $1 - \frac{t_{0.05}\, s_\alpha}{\sqrt{N}} \leqq \bar{\alpha} \leqq 1 + \frac{t_{0.05}\, s_\alpha}{\sqrt{N}}$



Text-fig. 12. Ontogenetic allometry between the thickness of the prismatic layer and the shell height of the selected specimens.

Paleobiological considerations

Mode of life.—Here I consider the mode of life of the present species on the grounds of the mode of fossil occurrence and the biometrical analysis.

The results of the allometric analysis of the samples from the Santonian indicate the growth of the prismatic layer in relation to the shell height to be negative allometric. The thickness of the inner layer of bivalve shell decreases with growth (WILBUR, 1964). Consequently, the thickness of shell of the above-mentioned specimens from the Santonian would make a remarkable case of negative allometry. Actually, the thickness of shell does not increase with growth (see Plate 28). In recent bivalves, such a case is found in some swimming and pseudoplanktonic forms (I. HAYAMI'S personal communication). Theoretical studies of the planktonic mode of life of bivalves were accomplished by JEFFERIES and MINTON (1965) and GOULD (1971). According to JEFFERIES and MINTON (1965), the physical forces acting on the planktonic shell are represented by the following formula.

$$Vs\rho sg + Vp\rho pg = (Vs + Vp)\rho wg + D$$

where Vs is volume of shell, Vp is volume of the protoplasm, ρs is the density of the shell, ρp is the density of the protoplasm, g is the acceleration due to gravity and D is the drag coefficient. Generally speaking, the growth of the protoplasm is harmonious with that of the shell. Consequently, the immersed weight of shell (Ws) is represented by the following formula (JEFFERIES and MINTON, 1965).

$$Ws = Vs\rho sg - Vs\rho wg = gVp(\rho w - \rho p) + D$$

According to them, D depends on the shape of the floating body. As ρs is much greater than ρw (ρs is nearly 2.7 and ρw is 1), Ws will increase with growth. In other words, the gravitational force scales as the cube of the shell length (L^3), while the total lifting forces that could balance it scale at smaller powers of L (GOULD, 1971).

The physical forces acting on the pseudoplanktonic shell are represented by the following formula.

$$Ws = Vs\rho sg - Vs\rho wg - B$$

where B is the force, affected by byssus.

From these lines of evidence, it is concluded that the mode of life of the present species was planktonic or pseudoplanktonic, at least, for the Santonian, the individuals of which lacked divergent ribs.

If we scrutinize the early stage of the present species, it is found that the critical point of growth exists at the of the Santonian stage of 3-4 mm of the shell height. The thickness of the prismatic layer increases little (less than 10 μ) from the beak to that stage, but at that stage, it increases abruptly, and then keeps a constant thickness (30-40μ). The growth index of the reduced major axis in the early stage of the selected specimens indicates near isometry, as follows.

GK. H. 10001 (sample R 2672f) : $T=0.009H^{1.089}$, $r=0.9805$
GK. H. 10002 (sample R 2672f) : $T=0.017H^{1.001}$, $r=0.9797$
GK. H. 871-1 (sample U 147-2) : $T=0.012H^{0.960}$, $r=0.9715$

The outline of the shell in the early stage is similar to that of veliger larvae of recent bivalves. But in the middle to the late stages, the outline becomes mytiliform, having a straight posterodorsal margin, and it is similar to that of the Lower Jurassic pseudoplanktonic inoceramid, *Pseudomytiloides dubius* (SOWERBY) (HAUFF, 1921). A byssal gape is sometimes observed in complete and conjoined valves (eg. GK. H. 10003, sample R 2680a; GK. H. 10004, sample R 2680b).

Consequently, it may be postulated that the present species changed its mode of life from planktonic to pseudoplanktonic at a point of around 3-4mm of shell height. It seems certain that the present species was pseudoplanktonic in the middle to the late stages of growth in the Santonian.

It is presumable that individuals of the present species attached themselves by the byssus to flotsam and jetsam.

The growth index of the reduced major axis of the thickness of the prismatic layer to the shell height also indicates negative allometry in the concentric ring stage of the specimens from the Campanian. The morphology of this stage cannot be distinguished from that of the Santonian species. On this evidence, it is reasonable to postulate that the mode of life of this stage was pseudoplanktonic.

On the contrary, at the beginning of the divergent rib stage of every specimen, the growth index of the reduced major axis of the thickness of the prismatic layer to the shell height abruptly increases and indicates remarkable positive allometry. In the divergent rib stage, the size of the prisms is much greater than in the concentric ring stage (see Text-fig. 11). As HAYAMI (1969) pointed out, growth of this kind will result in an increase of the settling velocity of the individual in seawater, because of the increased weight of the shell. Consequently, the growth of this stage is not suitable for maintaining a pseudoplanktonic mode of life. For example, in *Mytilus edulis* LINNÉ, which attaches itself by byssus threads to blanching object among the recent bivalves, the reduced major axis of the thickness of the prismatic layer (T) to the shell height (H) is

$$T=0.013H^{0.967},\ r=0.979,\ N=20.$$

The data were measured on a sample from Nokonoshima, Hakata Bay, Fukuoka Prefecture, Kyushu. The growth index is smaller than that of the divergent rib stage of the present species.

As the change of ornament from the concentric ring stage to the divergent rib stage in ontogeny is discontinuous, it is reasonable to consider that the mode of life changed from pseudoplanktonic to benthonic near the boundary of these two stages. Actually, in the early stage of growth of many recent bivalves with radial ribs (e. g. *Anadara subcrenata* (LISCHKE), *A. inflata* (REEVE), *Venerupsis* (*Amygdara*) *phillipinarum* (ADAMS and REEVE) etc.), radial ribs occur after the change in the mode of life from planktonic to benthonic (YOSHIDA, 1935a, 1935b, 1937).

With respect to the mode of life of fossil bivalves, there are many studies such as HAUFF (1921), GUILLAUME (1928), JEFFERIES and MINTON (1965), KAUFFMAN (1965, 1969), CARTER (1968), STANLEY (1968, 1972), KRIZ (1969), HAYAMI (1969) and GOULD (1970).

Butovicella migrans (BARRANDE), a Silurian bivalve, also displays a change of morphology during ontogeny, similar to that of the present species (KRIZ, 1969). KRIZ presumed the nepionic stage to be planktonic and the radial rib stage (his neanic to gerontic stages) as pseudoplanktonic, though he gave no concrete evidence.

JEFFERIES and MINTON (1965) discussed the mode of life of two Jurassic bivalves, *Bositra buchi* (RÖMER) and "*Posidonia*" *radiata* GOLDFUSS. They concluded that the two species were nektoplanktonic, from the analysis of the mode of fossil occurrence, the very thin shell, and a model experiment. A thin shell does not necessarily provide evidence for a nektoplanktonic mode of life and their conclusion is perhaps not justifiable, because they used aluminium for making a model of the inferred tentacles. Their conclusion was recently criticized by GOULD (1970) and STANLEY (1972) who regarded the two species as pseudoplanktonic. The relationship between shell thickness and length in *Bositra buchi* (JEFFERIES and MINTON, 1965, text-fig. 10) almost corresponds to that of the present species.

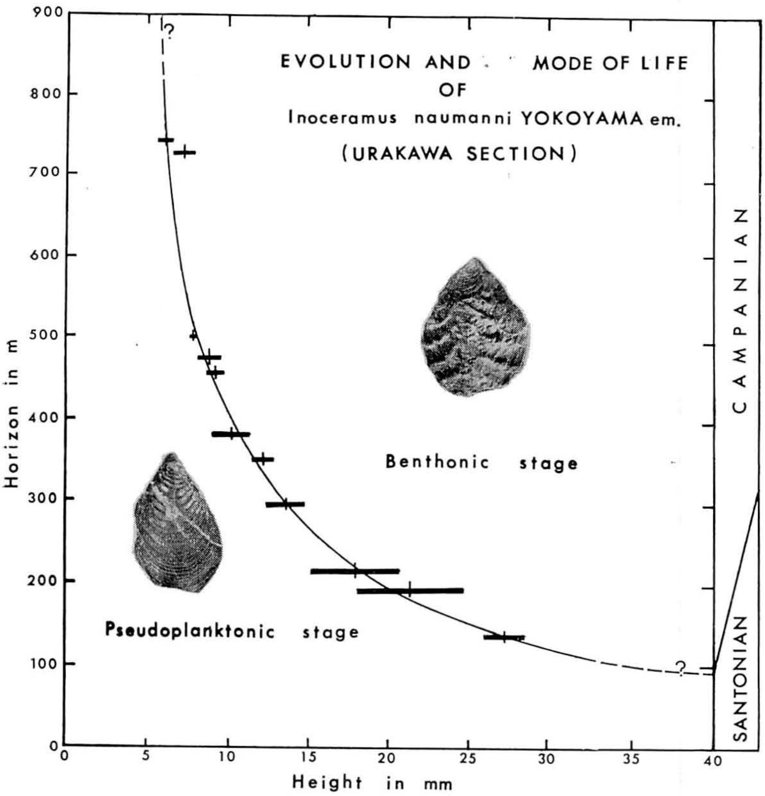
As regards the mode of life of the Inoceramidae, little direct evidence has been presented, except HAUFF'S (1921) observation.

It is very interesting that the shell morphology of the Cretaceous Inoceramidae is quite variable. Moreover, generally speaking, they show a wide geographic distribution. Such situations may have given rise to adaptive morphology of this family.

Evolution.—After having considered the mode of life of the present species, the occurrence of the divergent ribs is regarded as an adaptive morphology with the change of the mode of life from pseudoplanktonic to benthonic. The change can be observed not only in the ontogeny but also in the phylogeny of the present species. Indeed, there are no morphological difference between the specimens that were collected from the Santonian and those from the Campanian, apart from the occurrence of the divergent ribs and the thickening and enlargement of the shell in the latter.

Consequently, the main part of the group of *Inoceramus naumanni* of NAGAO and MATSUMOTO (1940) is regarded as a single chronospecies, *Inoceramus* (*Sphenoceramus*) *naumanni* YOKOYAMA emend., and it is divided into two chronological subspecies, namely *I.* (*S.*) *naumanni naumanni* YOKOYAMA emend. and *I.* (*S.*) *naumanni schmidti* MICHAEL emend.

The former is represented by the



Text-fig. 13. Evolution and mode of life of the chronospecies, *Inoceramus (Sphenoceramus) naumanni* YOKOYAMA emend. (Urakawa section, showing the mean and the 95% confidence interval of the mean of the shell height in the pseudoplanktonic stage).

specimens from the Coniacian to the Santonian and is ornamented with concentric rings only. The latter is represented by the specimens from the Campanian and has two stages of growth, namely, the stage with concentric rings alone and that with divergent ribs and concentric rings both.

The evolution of the present chronospecies is diagrammatically illustrated in Text-fig. 13.

According to the biostratigraphic division of the Upper Cretaceous of Vancouver Islands and the Gulf Islands, British Columbia (MULLER and JELETZKY, 1970) and that in California (MATSUMOTO, 1960), the same pattern of change in the morphology with time can be expected.

As regards the origin of the present species, I have no convincing evidence from the Turonian in Japan. At present, it can only be indicated that *Inoceramus (Mytiloides) labiatus* (SCHLOTHEIM), a Lower Turonian cosmopolitan species, is morphologically somewhat similar to the present species.

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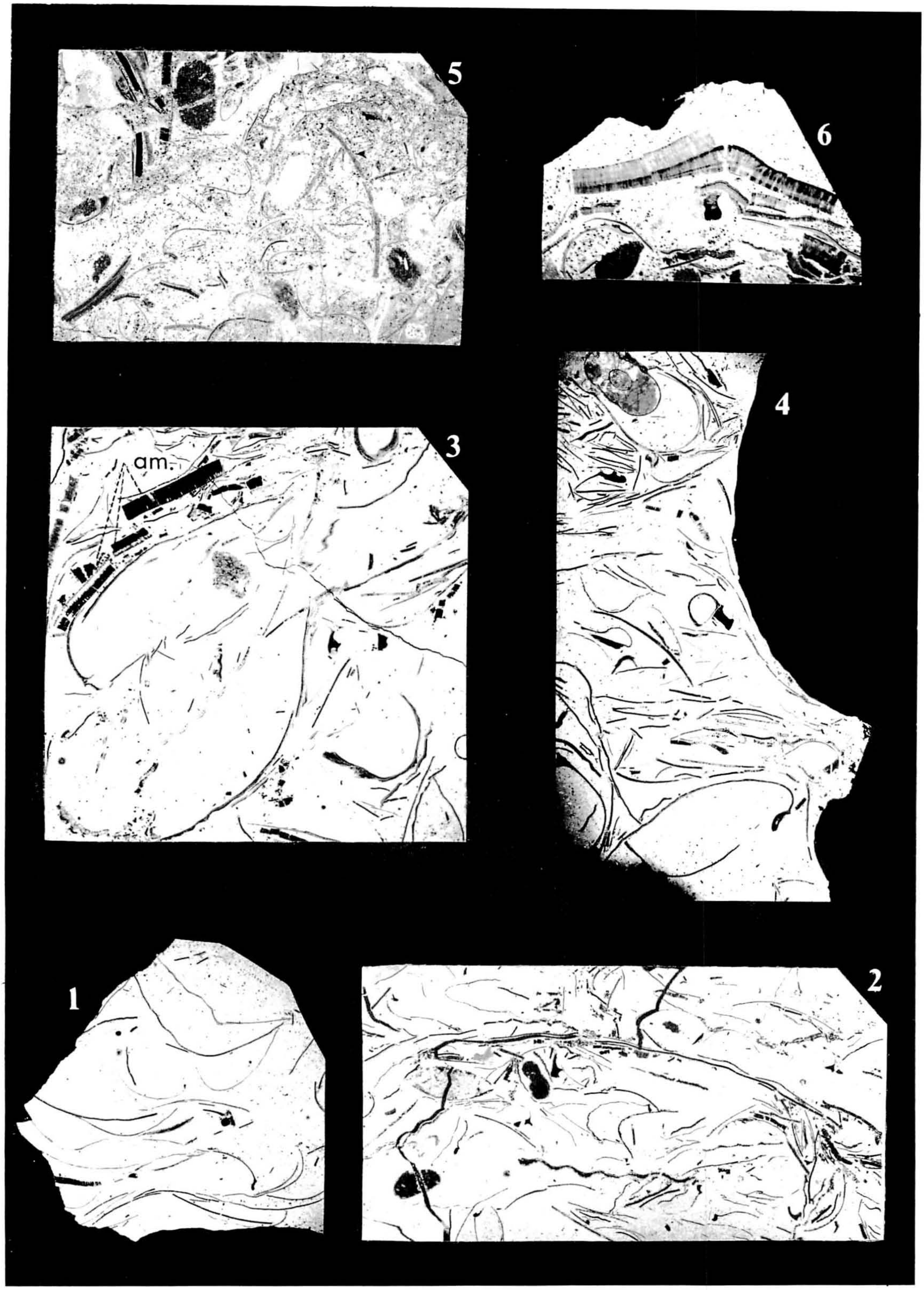
Explanation of Plate 27

Mode of fossil occurrence in calcareous nodule (×3).

Figs. 1–5. *Inoceramus (Sphenoceramus) naumanni naumanni* YOKOYAMA emend.

Fig. 1. Sample R 2665a, The R. Jugosen, Tappu district. Fig. 2. Sample H 2003b, The upper course of the R. Hobetsu, Prov. Iburi, southern central Hokkaido. Fig. 3. Sample R 2680b, The R. Jugosen, am; another species of *Inoceramus*, probably *I. (Platyceramus) amakusensis* NAGAO and MATSUMOTO. Fig. 4. Sample R 2672f, The R. Jugosen. Fig. 5. Sample R 2686a', The R. Jugosen.

Fig. 6. *Inoceramus (Sphenoceramus) naumanni schmidti* MICHAEL emend. Sample N 18f, the R. Miho, Naibuchi district.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Abeshinai	アベシナイ
Akanosawa	アカノ沢
Chinomi	乳呑
Hobetsu	穂別
Ikandai	井寒台
Jugosen	十五線
Kamihaboro	上羽幌
Kotanbetsu	古丹別
Miho	美保
Naibuchi	内淵
Obirashibe	小平蘂
Rumoi	留萠
Sakasagawa	逆川
Shutta-zawa	シュッタ沢
Tannosawa	炭の沢
Tappu	達布
Urakawa	浦河
Urokobetsu	ウロコ別

Explanation of Plate 28

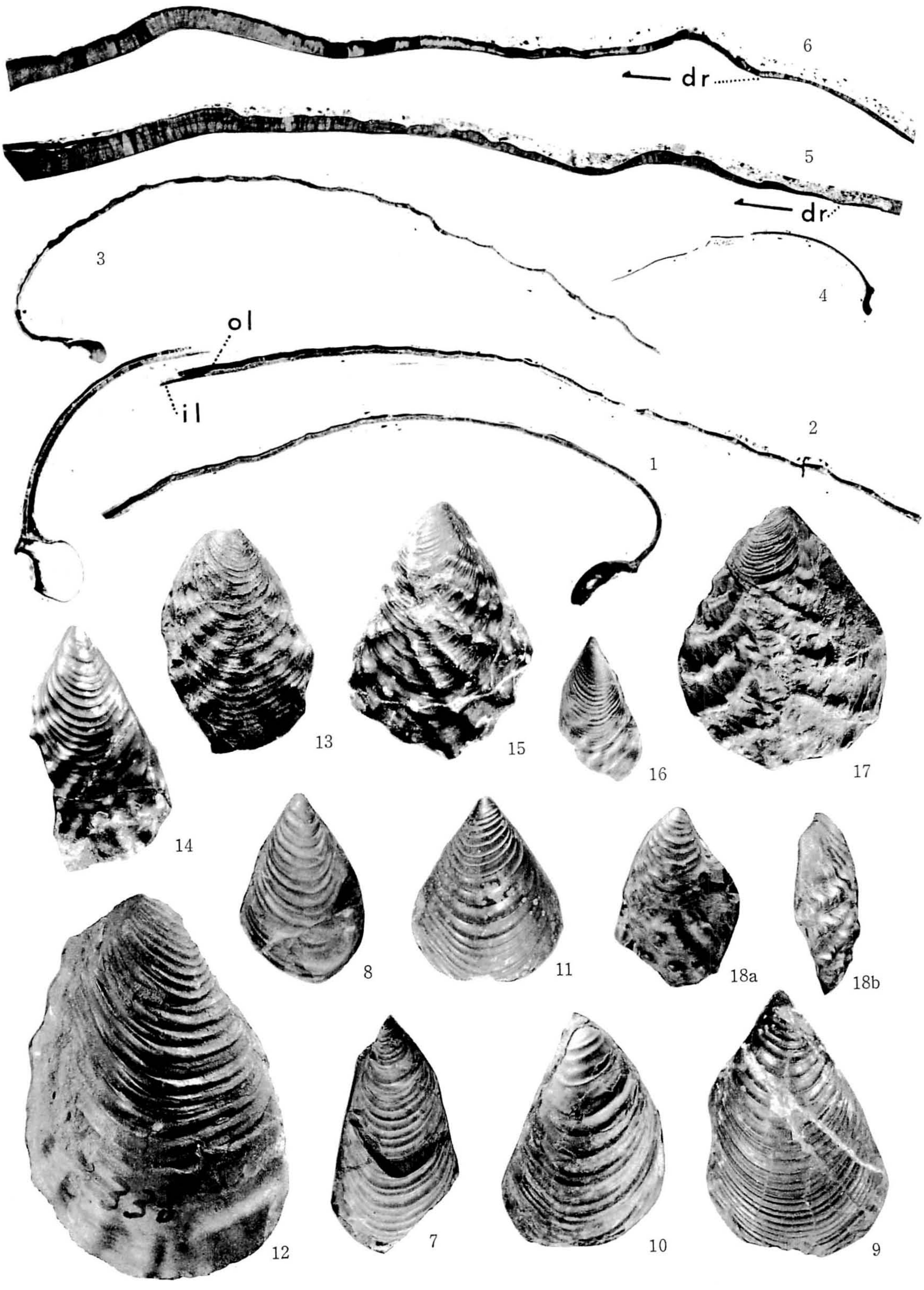
Figs. 1-4, 7-9. *Inoceramus (Sphenoceramus) naumanni naumanni* YOKOYAMA emend.

Fig. 1. GK. H. 10009, Sample R 2672f, The R. Jugosen (×10). Fig. 2. GK. H. 10005, Sample R 2680b, The R. Jugosen (×10). Fig. 3. GK. H. 10007, Sample R 2672f, The R. Jugosen (×10). Fig. 4. GK. H. 10004, Sample R 2680b, The R. Jugosen (×10). Fig. 7. Lateral view of right valve, GK. H. 10019, Sample R 2696a, The R. Jugosen (×1). Fig. 8. Lateral view of left valve, GK. H. 721a, Sample U 143r, The upper course of the R. Chinomi (×1).

Figs. 5-6, 10-18. *Inoceramus (Sphenoceramus) naumanni schmidti* MICHAEL emend.

Fig. 5. GK. H. 10011, Sample U 46, The upper course of the R. Urokobetsu, Urakawa district (×10). Fig. 6. GK. H. 10032, Sample T 1219 p (in a fallen or rolled nodule), The R. Tannosawa, Abeshinai district, northern central Hokkaido (T. MATSUMOTO coll.), comparative specimen (×3). Fig. 10. Lateral view of right valve, GK. H. 882, Sample U 147-2, the upper course of the R. Chinomi (×1). Fig. 11. Lateral view of right valve, GK. H. 871b, Sample and Loc. ditto (×1). Fig. 12. Left view of the conjoined valves, GK. H. 10034, Sample IA 336, Northwest of Tomiuchi station, Tomiuchi district (A. INOMA coll.), comparative specimen (×1). Fig. 13. Lateral view of left valve, MM. 3963, Sample N 18f, the R. Miho (×1). Fig. 14. Lateral view of left internal mould, YCM. U 446-4-1, Sample U 446-4, the lower course of the R. Chinomi (×1). Fig. 15. Lateral view of right valve, GK. H. 906a, Sample U 47b, the upper course of the R. Urokobetsu (×1). Fig. 16. Lateral view of left valve, GK. H. 935, Sample and loc. ditto. (×1). Fig. 17. Lateral view of right internal mould of the conjoined valves, GK. H. 903, Sample and Loc. ditto. (×1). Fig. 18a, b. Lateral and ventral view of right valve, GK. H. 930, Sample U 128c, The upper course of the R. Urokobetsu (×1).

ol: Outer prismatic layer, il: Inner nacreous layer, dr: Divergent rib stage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Trans. Proc. Palaeont. Soc. Japan, N.S., No. 92, pp. 185-199, pl. 29, December 20, 1973

625. LOWER CARBONIFEROUS CONODONTS FROM THE AKIYOSHI LIMESTONE GROUP, SOUTHWEST JAPAN.*

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Department of Earth Science, Tokyo Gakugei University

秋吉石灰岩層群の最下部層の地質時代に関しては異論が多い。筆者はこの問題を解決するため，大久保付近に分布する同石灰岩最下部層のコノドントを研究した。その結果，世界的に分布する *Gnathodus bilineatus* と *G. commutatus* を含むコノドント化石群を認めた。これらのコノドント化石群は，阿哲石灰岩の名越層と同様な化石群からなり，北米の Chesterian 下部，またはヨーロッパの Visean 上部に対比される。 猪 郷 久 治

Introduction and Acknowledgements

After the monumental research by Yoshiaki OZAWA (1923, 1927), geology and paleontology of the Akiyoshi Limestone Group distributed in the Akiyoshi plateau, Yamaguchi Prefecture, Southwest Japan, have been repeatedly studied by TORIYAMA (1954, 1958) and many others.

There are, however, several different conclusions concerning the geologic structure, biostratigraphic subdivision and correlation. The purpose of this research is to elucidate geologic age of the lowermost part of the Akiyoshi Limestone Group based upon the sequence of conodonts. Concerning geologic age and correlation of the lowermost Akiyoshi Limestone Group by foraminifers, brachiopods and corals seem to diverge somewhat as summarized below.

MURATA (1961) set the *Endothyra* Zone in the basal part of the Akiyoshi Limestone Group and correlated to the Lower Visean. OKIMURA (1963, 1966) worked out the endothyroid foraminifers collected from the lower part of the Akiyoshi Limestone Group.

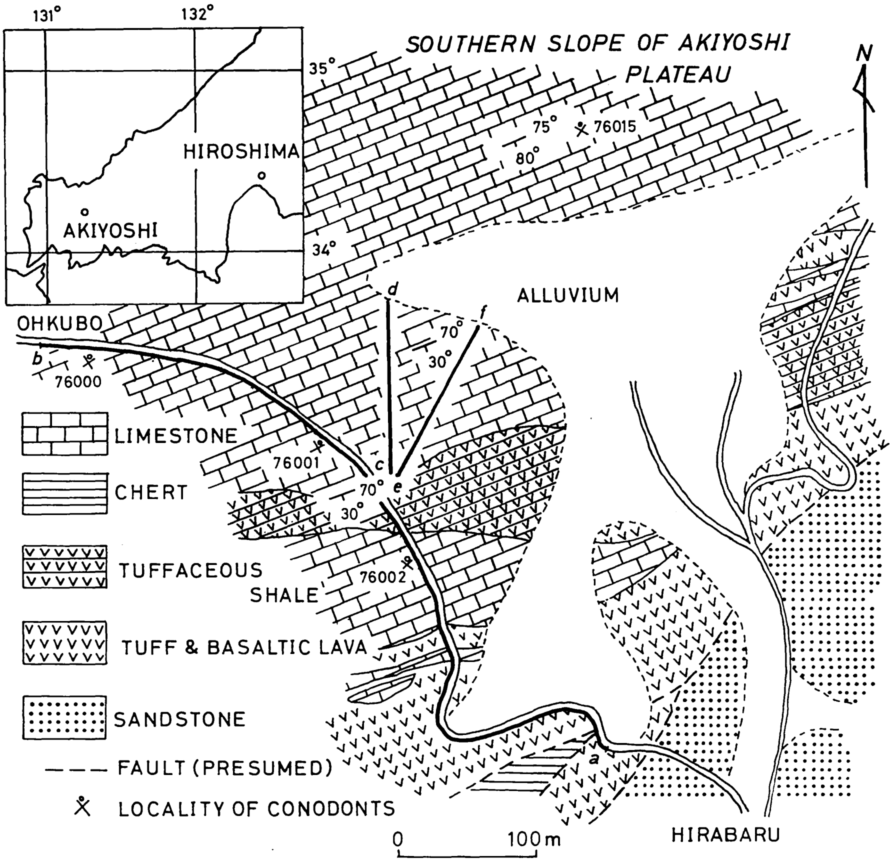
His lowermost biostratigraphic unit is the *Endothyra* sp. A Zone. He insisted that this zone can be correlated to the Lower Visean.

MINATO and KATO (1963) studied the corals and brachiopods collected from the reddish tuffaceous shale near the base of the Akiyoshi Limestone Group. They emphasized that the fauna is apparently younger than the Upper Visean Onimaru Series and equivalent to the Lowest Namurian.

Subsequently, however, YANAGIDA (1965) concluded that the mentioned fauna indicates the Lower to Middle Visean. OTA (1968) also discussed the age of the lowermost part of the Akiyoshi Limestone and considered that *Zaphrentoides* and other corals and brachiopods yielded from the limestone below the mentioned reddish tuffaceous shale show the Late Tournaisian to Early Visean in age.

I have studied the conodont fauna collected from the lowermost Akiyoshi

* Received Sept. 2, 1972; revised May 23, 1973; read Sept. 13, 1970 at Tokyo



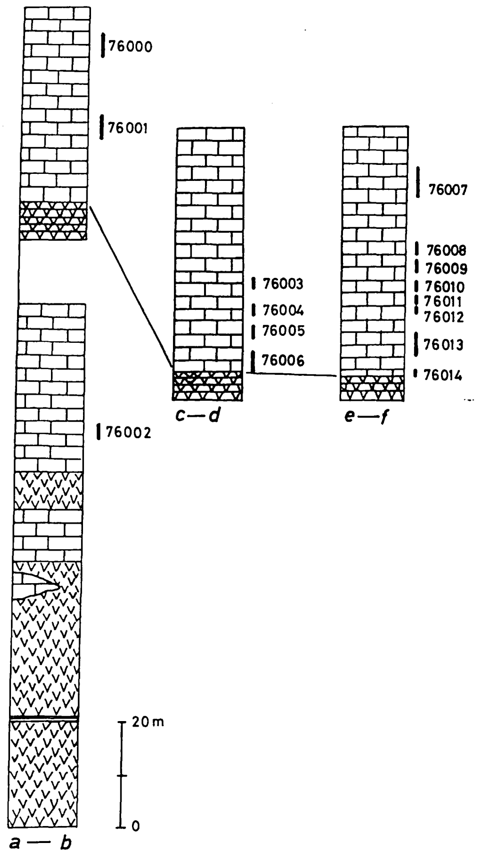
Text-fig. 1. Geological map of the Ohkubo—Hirabaru area, Akiyoshi Plateau.

Limestone Group distributed in the Ohkubo area, southern margin of the Akiyoshi plateau (Text-fig. 1). As a result, I am inclined to believe that this conodont fauna is apparently correlated to the Upper Visean of western Europe or the Chesterian of North American Mississippian.

This research based on a Master's thesis, is done at the Department of Earth Science, Tokyo Gakugei University. I wish to acknowledge continuous supervision of Professor Mosabro KANUMA of Tokyo Gakugei University. I am greatly indebted to Drs. Hisayoshi IGO and Toshio KOIKE of Tokyo University of Education for their guidance and fruitful discussion during the present research. I thank Dr. Masamichi OTA of the Akiyoshi-dai Science Museum for his kind facilities in the field.

Stratigraphic Summary

The lowermost part of the Akiyoshi Limestone Group is distributed in the Ohkubo area, southern margin of the Akiyoshi plateau. It crops out typically along the road-side cutting from Hirabaru to Ohkubo and consists mainly of massive limestone intercalating tuffaceous limestone, basic tuff and lava



Text-fig. 2. Columnar sections of the Ohkubo—Hirabaru area showing conodont-bearing levels. Index of lithology is the same with Text-fig. 1.

flows. They are trending N 50°E to N 70°E and dipping 30°S to 50°S. The following stratigraphic succession can be observed along the above-mentioned type section in descending order (Text-fig. 2).

Gray crinoidal massive limestone .... more than 20 m thick.
Greenish gray tuffaceous crinoidal well-bedded limestone intercalating reddish part toward lower ....20 m thick.
Reddish tuffaceous shale.................... ....10 m thick, as far as exposed.
Covered.............................15 m thick.
Gray massive crinoidal limestone ....30 m thick.
Green and variegated tuff intercalating lava flows, limestone lens of about 10 m thick near the top, and thin cherty layer near the base..........more than 45 m thick.

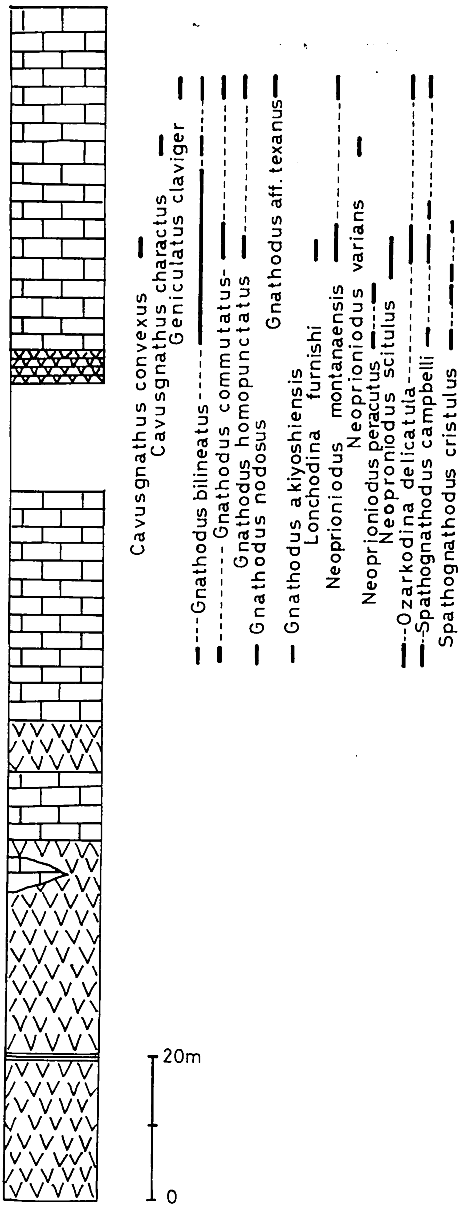
The lowermost unit is in contact with sandstone of the Ota Group by a fault. Although conodonts are barren in the limestone lens intercalated in this unit, OKIMURA (1965) reported the occurrence of *Endothyra* sp. A. Next younger limestone unit is also lacking in conodonts, but it represents the upper part of OKIMURA's *Endothyra* sp. A Zone. Gray massive crinoidal limestone situated above greenish tuff yields *Gnathodus bilineatus* and other conodonts, but their occurrence is restricted in the lower part of this lithologic unit. This unit represents OKIMURA's *Endothyra similis* Subzone.

Reddish tuffaceous shale yields *Pleurodictyum dechenianum* and other corals and brachiopods (MINATO and KATO, op. cit.). According to YANAGIDA *et al.* (1971), stratigraphic position of this fossil bed is included within OKIMURA's *Endostaffella delicata* Zone.

The next higher greenish gray tuffaceous limestone occurs numerous conodonts from various levels. OTA (1968) reported *Zaphrentoides* sp., *Cyathaxonia* sp., *Nagatophyllum satoi* OZAWA, *Syringothyris* sp., *Gigantoproductus* sp. and other fossils from this unit.

The uppermost lithologic unit of the present section also comprises the upper part of OKIMURA's *Endothyra similis* Subzone and it contains numerous conodonts. This is overlain by massive gray limestone containing *Millerella* sp., *Pseudostaffella antiqua* and other primitive fusulinaceans.

As already mentioned in earlier lines,



Text-fig. 3. Stratigraphic distribution of important species of conodonts.

the present sequence is dipping southwards, and OKIMURA (1963, 1966) insisted that this sequence is reverse in stratigraphic order and overturned based on the occurrence of endothyroid foraminifers. ETO (1967) supported OKIMURA's view by his sedimentological research. On the contrary, YANAGIDA and OTA (1964) concluded that this sequence is in normal stratigraphic order and the so-called schalstein does not occupy the base of the Akiyoshi Limestone Group.

According to YANAGIDA *et al.* (op. cit.), however, the basal part of the Akiyoshi Limestone Group predominates volcaniclastic rocks in the Shishidedai area, northeastern part of the Akiyoshi Limestone plateau.

Conodont Fauna and Correlation

Conodonts are recovered from 2 to 3 kg samples of carbonate rocks. Sampling was made from the measured section at intervals of 3 to 5 m.

The lowest conodont-bearing limestone (76002) yields *Gnathodus bilineatus* (ROUNDY), *G. commutatus* (BRANSON and MEHL), *G. nodosus* BISCHOFF, *G. akiyoshiensis* IGO, n. sp., *Ozarkodina delicatula* (STUFFER and PLUMMER), *O.* spp. and *Spathognathodus campbelli* REXROAD.

Of these species, *Gnathodus nodosus* and *G. bilineatus* are particularly abundant. *G. akiyoshiensis*, restricted in this level, is similar to *G. commutatus*.

The next higher conodont-bearing limestone (76006, 76014) is situated immediately above the reddish tuffaceous shale. It yields the following conodonts, namely, *Gnathodus bilineatus* (ROUNDY), *Hindeodella* spp., *Lonchodina* spp., *Ligonodina* spp., *Neoprioniodus peractus* (HINDE), *Ozarkodina* spp., *Spathognathodus campbelli* REXROAD and *S. cristulus* YOUNGQUIST and MILLER. Among the listed ones, *Gnathodus bilineatus, Hindeodella* spp. and *Spathognathodus campbelli* are particularly abundant but

Table 1. Distribution of conodonts from the Ohkubo area.
○ abundant △ common × rare

Species \ Locality	76000	76001	76002	76003	76004	76005	76006	76007	76008	76009	76010	76011	76012	76013	76014	76015
Cavusgnathus convexus		X														
C. charactus	X															
Geniculatus claviger								X								
Gnathodus bilineatus	Δ	o	Δ	o	X	X	X	Δ		X	X	X	X			Δ
G. commutatus		o	o	o				o								
G. homopunctatus		X						o								
G. nodosus			o													
G. aff. texanus								X								
G. akiyoshiensis n.sp.			o													
Hibbardella spp.		Δ														
Hindeodella spp.		o	Δ	Δ	Δ	X	o	o				X		X		Δ
Lonchodina furnishi		X														
L. spp.						X	Δ								X	X
Ligonodina spp.						X	Δ									
Neoprioniodus varians	X															
N. montanaensis		o		Δ				Δ								
N. peracutus						X	X									
N. scitulus		X			X							X				X
Ozarkodina delicatula			X		X			X			X					
O. spp.		X	X				X	X								X
Spathognathodus cristulus					X	X	X				X					
S. campbelli		o	Δ				o	o		X						o
Gen. et sp. indet.								X	X			X	X	X		

other species are subordinate in occurrence.

The localities 76004, 76005, 76012 and 76013 represent almost the same stratigraphic level situated about 3 m above the previous level.

I discriminated the following species, namely, *Gnathodus bilineatus* (ROUNDY), *Hindeodella* spp., *Lonchodina* spp., *Ligonodina* spp., *Neoprioniodus peractus* (HINDE), *N. scitulus* (BRANSON and MEHL), *Ozarkodina delicatula* (STUFFER and PLUMMER) and *Spathognathodus cristulus* YOUNGQUIST and MILLER. They are almost the same in individual number, and there are no predominating species.

The next younger conodont assemblage is yielded from the bedded limestone (76001, 76003, 76008, 76009, 76010) and it consists of *Gnathodus bilineatus* (ROUNDY), *G. commutatus* (BRANSON and MEHL), *Hindeodella* spp., *Neoprioniodus montanaensis* (SCOTT), *Ozarkodina delicatula* (STUFFER and PLUMMER), *Spathognathodus campbelli* REXROAD, *S. cristulus* YOUNGQUIST and MILLER, *Lonchodina furnishi* REXROAD, *Cavusgnathus convexus* REXROAD, *Gnathodus homopunc-*

tatus ZIEGLER, *Hibardella* spp., *Neoprioniodus scitulus* (BRANSON and MEHL) and *Ozarkodina* spp.. Among them, *Gnathodus bilineatus, G. commutatus, Neoprioniodus montanaensis, Spathognathodus campbelli* and unidentified *Hindeodella* are predominating species in this assemblage.

Gnathodus homopunctatus is very rare but this species becomes abundant in the higher levels.

The following three species are obtained from the limestone (76000) situated about 10 m above just aforementioned one, namely, *Cavusgnathus charactus* REXROAD, *Gnathodus bilineatus* (ROUNDY) and *Neoprioniodus varians* (BRANSON and MEHL). Brachiopodal limestone (76007) 4 m above the level (76008) contains a fauna of the following species: *Geniculatus claviger* (ROUNDY), *Gnathodus bilineatus* (ROUNDY), *G. commutatus* (BRANSON and MEHL), *G. homopunctatus* ZIEGLER, *G.* aff. *texanus* ROUNDY, *Hindeodella* spp., *Neoprioniodus montanaensis* (SCOTT), *Ozarkodina delicatula* (STUFFER and PLUMMER), *O.* spp. and *Spathognathodus campbelli* REXROAD. Abundant and distinctive species in this assemblage are *Gnathodus commutatus, G. homopunctatus, Hindeodella* spp. and *Spathognathodus campbelli.*

Although the precise stratigraphic relationship could not be settled in the field, *Gigantoproductus*-bearing coquinoid limestone (76015) yields the following conodonts which are assumed as the uppermost representative of conodont assemblage in the Ohkubo area.

They are *Gnathodus bilineatus* (ROUNDY), *Hindeodella* spp., *Lonchodina* spp., *Neoprioniodus scitulus* (BRANSON and MEHL), *Ozarkodina* spp. and *Spathognathodus campbelli* REXROAD.

Among the listed ones, the last mentioned species is extraordinarily abundant.

As described above, the conodont-bearing levels are not entirely continuous except for the middle part of the measured section. More extensive investigation throughout the lowermost part of the Akiyoshi Limestone Group distributed outside of the Okubo area seems to be necessary to settle the detailed conodont biostratigraphy and zonation. Therefore, detailed zonation of the present fauna is reserved in the future.

I will discuss the range of the several important species recovered from the present section hitherto pointed out by many authors in the following lines. *Gnathodus bilineatus* occurs from almost entire part of the measured sections in this area. Two different types are recognized within numerous specimens identified as *G. bilineatus* from the present area. The material obtained from the limestone below the reddish tuffaceous shale is typical *Gnathodus bilineatus* which is characterized by well-developed bilinear arrangements of the nodes on the inner platform. However, specimens yielded from higher levels decrease in number of the nodes on the inner platform and with shorter parapet-like transverse ridges on the outer platform compared with those of the typical one.

This type of *G. bilineatus* resembles MEISCHNER's (1970) *G. bilineatus schmidti.* He concluded that this subspecies is the descendant modification of *G. bilineatus bilineatus.*

G. bilineatus is a cosmopolitan species and has been reported from the Upper Meramecian Ste. Genevieve Limestone (to the Middle Chesterian Glen Dean Limestone) or equivalent ones of the USA. This species is also known from the uppermost CuII δ (upper part of the *Pericyclus*

Zone) to the E2 Zone (upper part of the *Eumorphoceras* Zone) in Germany, but it is characteristic in the Upper Visean.

G. commutatus is abundant and characteristic species in the present fauna. This well-known species has been reported from the Meramecian Ste. Genevieve Limestone through the Chesterian of the North American Mississippian. It is also known from the CuII β/γ (*Pericyclus* Zone) in Germany and the upper part of the D2 to E2 in the British Avonian Succession.

G. nodosus is also an important species in the present section, but it is restricted in the lower part. *G. nodosus* has been recorded from the CuIII β (middle *Goniatite* Zone) of Germany and from the D3 to E2 of the Avonian Succession.

G. homopunctatus is predominating in the upper part of the lowermost Akiyoshi Limestone Group. This species is having almost the same stratigraphic range with *G. commutatus* and has been known from the entire part of the Visean to the Lower Namurian in Europe.

G. aff. *texanus* came from the higher part of the present succession has slightly different ornamentation of the platform compared with ROUNDY's typical specimen (HASS, 1953). This species is ranging from the Upper Osagian to the Chesterian of the USA. It yields from the CuII β/γ to CuIII α of the German Carboniferous and from the C1 to S1 Zones of the British Avonian.

Geniculatus claviger is yielded from the higher part of the present sequence. This characteristic species was first described from the Barnett Shale in Texas (ROUNDY, 1926). Subsequently, BISCHOFF (1957), VOGES (1959), DRUCE (1969) and others reported this species from the CuIII α of German Carboniferous and Australia.

Spathognathodus campbelli is common throughout the present section. This species was described from the upper D2 to D3 in England and also from the Upper Meramecian to Chesterian of the USA.

Cavusgnathus convexus occurred from the immediately above reddish tuffaceous shale. This species is rather long-ranging and recorded from the Upper Osagian (?) to Upper Chesterian.

Many compound types of conodont are yielded from the present sections associated with the above mentioned important species. They are also characteristic species or allied ones with those of the North American Mississippian or Lower Carboniferous in Europe.

Based upon the foregoing discussion, I will express my views concerning the correlation of the present fauna with the faunas from other areas in Japan and from North America and Europe.

The present fauna is very similar to those from the lower part of the Atetsu Limestone, the Nagoe Formation which was studied by KOIKE (1967). There is, however, an important difference in the stratigraphic distribution of *G. nodosus*. This species is restricted in the lower part of the present succession, but it persists within the upper part of the Nagoe Formation. The other remarkable difference between the Nagoe and the present Akiyoshi is the occurrence of *Idiognathoides noduliferus*. *I. noduliferus* is dominant in the upper Nagoe Formation in association with *G. bilineatus*, but it is barren in the Ohkubo fauna. These differences recongnized between both faunas can not be confirmed whether interregional faunal differentiation or chronological problem.

The Uzura fauna of the Akiyoshi Limestone Group reported by IGO and KOIKE (1965) consists of quite dissimilar elements which were advocated as the

Lower Pennsylvanian. There is also striking difference between the present fauna and the Lower Pennsylvanian fauna described from the Omi Limestone (IGO and KOIKE, 1964).

The correlation of the present fauna with the faunas reported from Europe and North America is one of the most important purpose of the present investigation. Concerning the intercontinental correlation, as already discussed in earlier lines, the present fauna containes many species which are characteristic in the Chesterian of the "Upper Mississippi Valley Region" (COLLINSON *et al.*, 1962 and others). Moreover, the present fauna is entirely avoided the important Lower Pennsylvanian species. Also the present conodont assemblage is very similar to those from the *Gnathodus commutatus* and *G. nodosus* Zones which represent the Upper Visean of Europe. In conclusion, the present sequence of conodonts in the lowermost part of the Akiyoshi Limestone Group is very similar to those of the Chesterian of the USA and of the Upper Visean of Europe.

Description of Species

Genus *Cavusgnathus* HARRIS & HOLLINGSWORTH, 1933

Cavusgnathus charactus REXROAD

Pl. 29, fig. 26

Cavusgnathus characta REXROAD, 1957, p. 15, 16, pl. 1, figs. 1, 2; REXROAD & COLLINSON, 1963, p. 8, pl. 1, fig. 28; THOMPSON & GOEBEL, 1969, p. 22, pl. 1, figs. 1, 4, 7.
Cavusgnathus charactus, RHODES, AUSTIN & DRUCE, 1969, p. 79, 80, pl. 13, figs. 6a-7d, 13a-c.

Remarks:—A detailed synonymy was given by RHODES, AUSTIN and DRUCE (1969, p. 79, 80). The specimens obtained from Akiyoshi are very similar to the previously described ones.

Distribrution:—Restricted in locality 76000.

Reg. no. 1057.

Genus *Geniculatus* HASS, 1953

Geniculatus claviger (ROUNDY)

Pl. 29, fig. 28

Polygnathus? claviger ROUNDY, 1926, p. 14, figs. 1a-c, 2a, b.
Geniculatus claviger, HASS, 1953, p. 77, pl. 15, figs. 10-19; BISCHOFF, 1957, p. 21, pl. 1, figs. 1-6; WIRTH, 1967, p. 25, pl. 19, fig. 5; DRUCE, 1969, p. 60; MARKS & WENSINK, 1970, p. 257, pl. 1, fig. 4.

Remarks:—Detailed synonymy and description were given by HASS (1953, p. 77, 78). The Akiyoshi specimens are quite identical with the previous foreign ones.

Distribution:—Yielded from locality 76007.

Reg. no. 1082.

Genus *Gnathodus* PANDER, 1856

Gnathodus akiyoshiensis IGO, n. sp.

Pl. 29, figs. 24, 25

The unit consists of cup with sharply pointed posterior end and long free blade. Conspicuous large and high node-like denticle developed at center of platform. Surface of platform smooth and without any ornamentation. Outline of platform elliptical in shape. The aboral edge is straight in lateral view, but oral edge almost straight in the anterior four-fifths of unit and posteriorly declines with steep angle. Expanded basal cavity is elongated in outline.

Remarks:—This species resembles *Spathognathodus campbelli* REXROAD but distinguished from the latter in well developed platform and less numerous denticles. *Gnathodus commutatus* (BRANSON & MEHL) and *G. simplicatus* RHODES, AUSTIN & DRUCE are similar to the present new species, but *G. akiyoshiensis* has characteristic node-like denticle on the carina in the center of platform.

Distribution:—Restricted in limestone of 76002.

Reg. no. 1078, (Holotype).

Gnathodus bilineatus (ROUNDY)

Pl. 29, figs. 1–6

Polygnathus bilineatus ROUNDY, 1926, p. 13, pl. 3, figs. 10a–c.

Gnathodus bilineatus, HASS, 1953, p. 79, pl. 14, figs. 25–29; REXROAD & FURNISH, 1964, p. 670; DUNN, 1965, p. 1148, pl. 140, figs. 7–9; WIRTH, 1967, p. 205, pl. 19, figs. 6–9; KOIKE, 1967, p. 296, pl. 1, figs. 9–11; GLOBENSKY, 1967, p. 440, pl. 58, figs. 9, 13; RHODES, AUSTIN & DRUCE, 1969, p. 94, pl. 18, figs. 14–17; WEBSTER, 1969, p. 30, 31, pl. 5, figs. 11, 12; DUNN, 1970, p. 330, 331, pl. 62, figs. 13, 14; MARKS & WENSINK, 1970, p. 258, pl. 2, figs. 3a, b, 4.

Gnathodus bilineatus bilineatus, HIGGINS & BOUCKAERT, 1968, p. 29, pl. 3, fig. 9.

Remarks:—Numerous specimens from the present collection show two appreciable morphologic types. The material from the limestone below the reddish tuffaceous shale is typical *G. bilineatus* characterized by well-developed nodes on the inner platform. The transverse ridges also conspicuous and developed throughout the outer platform. However, the material yielded from the higher levels decreases in the numbers of the nodes on the inner side of the platform and has short parapet-like transverse ridges on the outer platform. This form resembles MEISCHNER's *G. bilineatus schmidti.*

Distribution:—This species is widely distributed in this area and was found from limestones 76000, 76001, 76002, 76003 76004, 76005, 76006, 76007, 76009, 76010, 76011, 76012 and 76015.

Reg. nos. 1011, 1012, 1014.

Gnathodus commutatus (BRANSON & MEHL)

Pl. 29, figs. 8–13

Spathognathodus commutatus BRANSON & MEHL, 1941, p. 98, pl. 19, figs. 1–4.

Gnathodus commutatus, REXROAD & BURTON, 1961, p. 1153, pl. 39, figs. 1–3; HIGGINS & BOUCKAERT, 1968, p. 30, pl. 2, fig. 5; RHODES, AUSTIN & DRUCE, 1969, p. 95, pl. 19, figs. 9–12; WEBSTER, 1969, p. 31, pl. 5, fig. 13.

Gnathodus commutatus commutatus, BISCHOFF, 1957, p. 23, pl. 4, figs. 2–6, 15; KOIKE, 1967, p. 296, pl. 1, figs. 12–16; WIRTH, 1967, p. 206, pl. 19, figs. 10, 11; DUNN, 1970, p. 331, pl. 62, figs. 11, 12; MARKS & WENSINK, 1970, p. 285, pl. 3, fig. 1a, b.

Gnathodus scotiaensis GLOBENSKY, 1967, p. 441, pl. 58, figs. 2–7, 10, 12.

Remarks:—A detailed synonymy was given by RHODES, AUSTIN & DRUCE (1969, p. 95, 96). There are two different morphologic types in this species. The specimens collected from the limestone below reddish tuffaceous shale have very thin and small unit with sharply pointed denticles and carina. However, the specimens from the higher levels are characterized by thick and large unit and with node-like carina.

Distribution:—This species was found in limestones 76001, 76002, 76003 and 76007.

Reg. nos. 1061, 1064.

Gnathodus homopunctatus ZIEGLER

Pl. 29, figs. 18-21

Gnathodus punctatus BISCHOFF, 1957, p. 24, pl. 4, figs. 7-11, 14.
Gnathodus commutatus homopunctatus, HIGGINS, 1961, pl. 10, fig. 9; HIGGINS, 1962, pl. 2, fig. 21; WIRTH, 1967, p. 206, pl. 19, fig. 12; MARKS & WENSINK, 1970, p. 259, pl. 3, fig. 2a, b.
Gnathodus homopunctatus, RHODES, AUSTIN & DRUCE, 1969, p. 103, pl. 19, figs. 5a-8d.

Remarks:—This material is similar to *Gnathodus nodosus*, but the former differs from the latter in having platform with sharply pointed end. *G. nodosus* has comparatively short, roundly pointed denticles, but *G. homopunctatus* shows sharply pointed higher denticles. This material shows a broad variation of nodes and some of them fused together and constitute parallel ridges on both sides of platform.

Distribution:—Yielded from limestones 76001 and 76007.

Reg. nos. 1023, 1025, 1030.

Gnathodus nodosus BISCHOFF

Pl. 29, figs. 14-17

Gnathodus commutatus nodosus BISCHOFF 1957, p. 23, 24, pl. 4, figs. 12, 13; HIGGINS, 1961, p. 213, pl. 10, figs. 7, 8; HIGGINS, 1962, pl. 2, fig. 19; KOIKE, 1967, p. 297, pl. 1, fig. 19; WIRTH, 1967, p. 207, 208, figs. 13-18; MARKS & WENSINK, 1970, p. 260, pl. 3, figs. 3, 4.
Gnathodus nodosus, RHODES, AUSTIN & DRUCE, 1969, p. 104, 105, pl. 19, figs. 16a-20c.

Remarks:—This species closely resembles *Gnathodus commutatus* (BRANSON & MEHL), but the former has several nodes on both sides of platform.

Distribution:—This species was found in limestone 76002.

Reg. nos. 1036, 1037.

Gnathodus aff. *texanus* ROUNDY

Pl. 29, fig. 7

Aff. *Gnathodus texanus* ROUNDY, 1926, p. 12, pl. 2, figs. 7, 8; HASS, 1953, p. 80, pl. 14, figs. 16-21; BISCHOFF, 1957, p. 25, pl. 2, figs. 21-25; THOMPSON & GOEBELL, 1963, p. 12, fig. 3; REXROAD & COLLINSON, 1965, p. 8, pl. 1, figs. 33-38; THOMPSON & GOEBEL, 1969, p. 24, pl. 4, figs. 1-3, 5; THOMPSON & FELLOWS, 1970, p. 89, pl. 2, figs. 15, 16; DUNN, 1970, p. 332, pl. 62, fig. 21.

Remarks:—A detailed synonymy was given by THOMPSON & FELLOWS (1970, p. 89). This material closely resembles *Gnathodus texanus* ROUNDY which has very narrow platform and its posterior portion is long and gradually tapered. However, *G.* aff. *texauns* has a large platform. Parapet is parallel to carina on the inner side, and ridge-like ornamentation developed at about right angle with carina. The present one also resembles *G. texanus pseudosemiglaber* THOMPSON described from the upper Osagian Series.

Distribution:—This species is restricted in 76007.

Reg. no. 1021.

Genus *Lonchodina* ULRICH & BASSLER, 1926

Lonchodina furnishi REXROAD

Pl. 29, fig. 33

Lonchodina furnishi REXROAD, 1958, p. 22, pl. 4, figs. 11-13; HIGGINS, 1961, pl. 11, fig. 8; RHODES, AUSTIN & DRUCE, 1969,

p. 141, 142, pl. 24, figs. 20a–23c; MARKS & WENSINK, 1970, p. 226, pl. 1, fig. 5.

Remarks:—A detailed synonymy was given by RHODES, AUSTIN & DRUCE (1969, p. 141, 142). No remarkable differences can be recognized in the present specimens compared with many other described ones.

Distribution:—Yielded from limestone 76001.

Reg. no. 1058.

Genus *Neoprioniodus* RHODES & MÜLLER, 1956

Neoprioniodus scitulus (BRANSON & MEHL)

Pl. 29, figs. 30, 31

Prioniodus scitulus BRANSON & MEHL, 1941, p. 173, pl. 5, figs. 5, 6.
Neoprioniodus scitulus, REXROAD, 1957, p. 35, pl. 2, figs. 22, 26; WEBSTER, 1969, p. 39, 40, pl. 7, fig. 13; RHODES, AUSTIN & DRUCE, 1969, p. 162, 163, pl. 22, figs. 9a–10b, 12a, b.

Remarks:—A detailed synonymy was given by WEBSTER (1969, p. 39, 40).

Distribution:—This species was found from limestones 76001, 76004, 76011 and 76015.

Reg. nos. 1067, 1068.

Neoprioniodus montanaensis (SCOTT)

Pl. 29, fig. 32

Lochreia montanaensis SCOTT, 1942, p. 298, 299, pl. 39, fig. 9, pl. 40, fig. 12.
Prioniodus singularis HASS, 1953, p. 88, pl. 16, fig. 4.
Neoprioniodus singularis, HIGGINS, 1961, pl. 11, fig. 5; HIGGINS, 1962, pl. 1, fig. 8; HIGGINS & BOUCKAERT, 1968, p. 45, pl. 1, fig. 8.
Neoprioniodus montanaensis, RHODES, AUSTIN & DRUCE, 1969, p. 160, 161, pl. 22, figs. 5a–8b; MARKS & WENSINK, 1970, p. 226, 227, pl. 1, figs. 9, 10.

Remarks:—A detailed synonymy was given by RHODES, AUSTIN & DRUCE (1969, p. 160, 161).

Distribution:—Recovered from limestones 76001, 76003 and 76007.

Reg. no. 1069.

Genus *Ozarkodina* BRANSON & MEHL, 1933

Ozarkodina delicatula (STUFFER & PLUMMER)

Pl. 29, fig. 29

Bryantodus delicatula STUFFER & PLUMMER, 1932, p. 29, pl. 2, fig. 27.
Ozarkodina delicatula, BISCHOFF, 1957, p. 39, pl. 1, figs. 25–28; HIGGINS, 1961, p. 220, pl. 12, fig. 13; DUNN, 1965, p. 1149, pl. 140, fig. 18; GLOBENSKY, 1967, p. 446, pl. 56, fig. 19; HIGGINS & BOUCKAERT, 1968, p. 45, pl. 13, fig. 3; RHODES, AUSTIN & DRUCE, 1969, p. 170, pl. 25, figs. 15, 16; WEBSTER, 1969, p. 42, 43, pl. 7, fig. 11; DUNN, 1970, p. 337, 338, pl. 62, fig. 31.

Remarks:—This material has numerous subequal, long and fused denticles. The apical denticle is subequal in size with other denticles. The basal margin is slightly arched. In aboral view the basal cavity is a slit-like.

Distribution:—This species is abundant in limestones 76002, 76004, 76007 and 76010.

Reg. no. 1040.

Genus *Spathognathodus* BRANSON & MEHL, 1941

Spathognathodus campbelli REXROAD

Pl. 29, fig. 23

Spathognathodus campbelli REXROAD, 1957, p. 37, pl. 3, figs. 13–15; REXROAD, 1958, p. 25, pl. 6, fig. 9; REXROAD & BURTON, 1961, p. 1156, pl. 141, fig. 15; HIGGINS, 1962, pl. 2, fig. 20; REXROAD & FURNISH, 1964, p. 674, pl. 3, figs. 23, 24; GLOBENSKY, 1967, p. 447, pl. 55, figs. 12, 20; KOIKE, 1967, p. 310, pl. 3, figs. 26–34; WIRTH, 1967, p. 233, 234, figs. 14–16; WEBSTER, 1969, p. 43, 44, pl. 7, fig. 5; DUNN, 1970, p. 339, pl. 64, fig. 31; MARKS & WENSINK, 1970, p. 270, pl. 4, figs. 9, 10.

Spathognathodus cf. *campbelli*, RHODES, AUSTIN & DRUCE, 1969, p. 223, pl. 8, figs. 1–4.

Remarks:—KOIKE (1967, p. 310) reported that this species has conspicuous variation in the arrangement of denticles. This Akiyoshi specimens has a similar tendency. This species is related to *Gnathodus akiyoshiensis* IGO n. sp., but the latter is characterized by a well-developed elliptical platform.

Distribution:—This species was found from limestones 76001, 76002, 76006, 76007, 76009 and 76015.

Reg. no. 1051.

Spathognathodus cristulus YOUNGQUIST & MILLER

Pl. 29, fig. 22

Spathognathodus cristula YOUNGQUIST & MILLER, 1949, p. 621, pl. 101, figs. 1–3; GLOBENSKY, 1967, p. 447, pl. 57, figs. 15, 16.

Spathognathodus cristulus, RHODES, AUSTIN & DRUCE, 1969, p. 227, 228, pl. 8, figs. 14a–18d; DUNN, 1970, p. 339, pl. 64, fig. 30.

Remarks:—A detailed synonymy was given by RHODES, AUSTIN & DRUCE, (1969, p. 227, 228).

Distribution:—This species is yielded from limestones 76004, 76005, 76006 and 76010.

Reg. no. 1083.

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Explanation of Plate 29

Figs. 1-6. *Gnathodus bilineatus* (ROUNDY).
1. Outer lateral view. 2, 5, 6. Oral views. 3, 4. Aboral views. ×40.

Fig. 7. *Gnathodus* aff. *texanus* ROUNDY.
Oral view. ×20

Figs. 8-13. *Gnathodus commutatus* (BRANSON & MEHL).
8, 11. Aboral views. 9, 12. Oral views. 10, 13. Lateral views. ×40.

Figs. 14-17. *Gnathodus nodosus* BISCHOFF.
14, 16. Oral views. 15. Lateral view. 17. Aboral view. ×40.

Figs. 18-21. *Gnathodus homopunctatus* ZIEGLER.
18. Lateral view. 19-21. Oral views. ×40.

Fig. 22. *Spathognathodus cristulus* YOUNGQUIST & MILLER.
Lateral view. ×60.

Fig. 23. *Spathognathodus campbelli* REXROAD.
Lateral view. ×60.

Figs. 24, 25. *Gnathodus akiyoshiensis* IGO, n. sp.
24. Lateral view. 25. Oral view. Holotype. ×60.

Fig. 26. *Cavusgnathus charactus* REXROAD.
Inner lateral view. ×40.

Fig. 27. *Ozarkodina* sp.
Lateral view. ×60.

Fig. 28. *Geniculatus claviger* (ROUNDY).
Oral view. ×40.

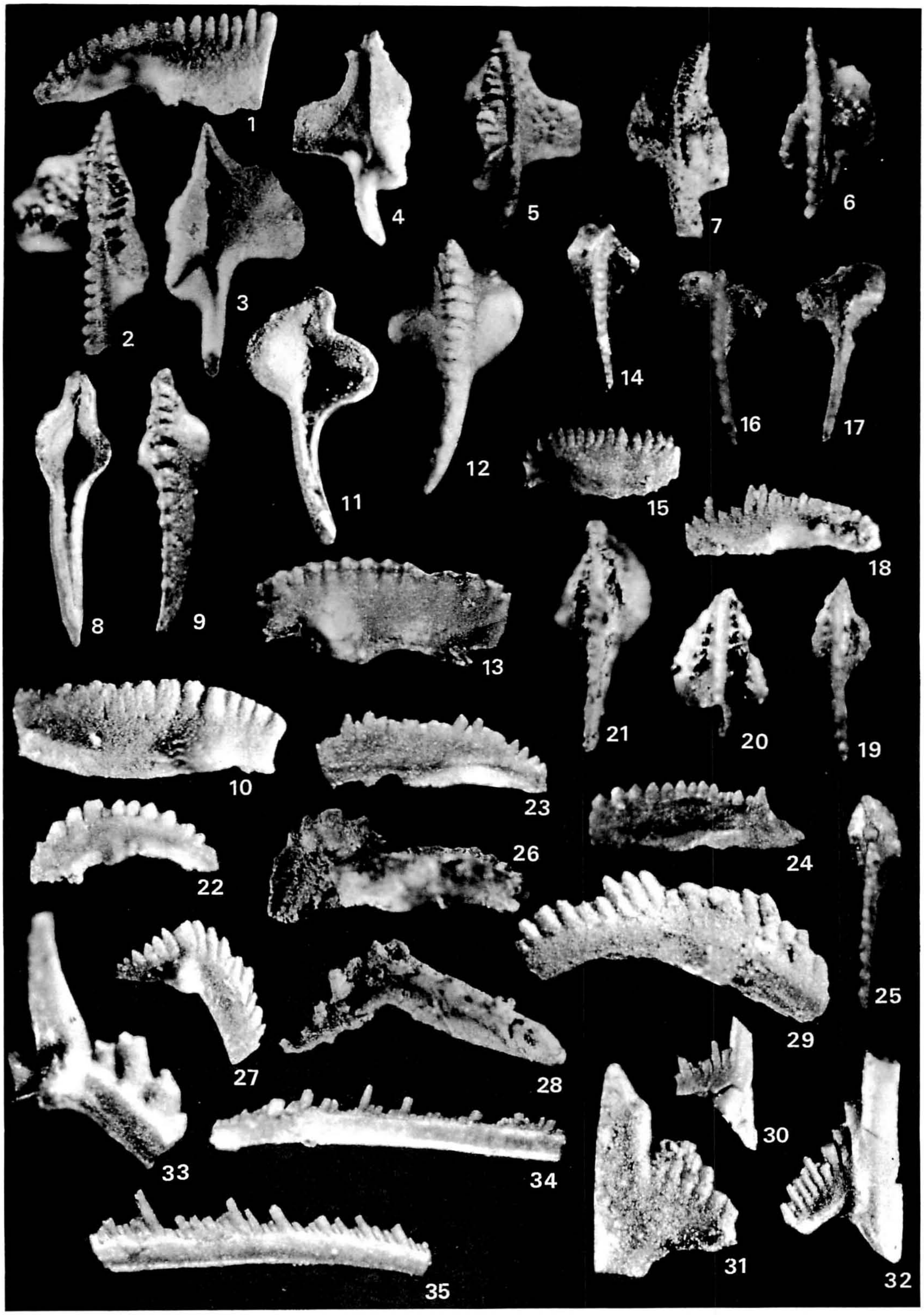
Fig. 29. *Ozarkodina delicatula* (STUFFER & PLUMMER).
Lateral view. ×60.

Figs. 30, 31. *Neoprioniodus scitulus* (BRANSON & MEHL).
Lateral view. ×60.

Fig. 32. *Neoprioniodus montanaensis* (SCOTT).
Inner lateral view. ×60.

Fig. 33. *Lonchodina furnishi* REXROAD.
Lateral view. ×40.

Figs. 34, 35. *Hindeodella* spp.
Lateral views. ×60.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All of the specimens treated in this paper are preserved in the collection of the Department of Earth Science, Tokyo Gakugei University.

Atetsu	阿　哲	Hirabaru	平　原
Nagoe	名　越	Ohkubo	大久保
Omi	青　海	Onimaru	鬼　丸
Ota	大　田	Shishidedai	猪出台

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 92, pp. 200-219, pls. 30, 31, December 20, 1973

626. FUSULINIDS OF THE NAGAIWA FORMATION*

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長岩層の紡錘虫化石について：模式地の長岩層より採集した4新種を含む9属，21種の紡錘虫化石を記載する。本層には下位より，*Eostaffella ultragigantea*, *Pseudostaffella antiqua*, *Eoschubertella* sp. A, *Pseudostaffella japonica*, *Parastaffella* cfr. *vlerki* の5亜帯が識別され，前二者は *Millerella* 帯に，後三者は *Profusulinella* 帯に相当する。なお長岩層下部はバシキリアン下部に，上部はモスコヴィアン下部に対比される。

小林文夫

Introduction and acknowledgements

Middle Carboniferous Nagaiwa Formation, distributed in the Southern Kitakami Massif, Iwate Prefecture, Northeast Japan, has been studied by many workers, such as ONUKI (1937), MINATO *et al.* (1953, 1959), YAMADA (1958, 1959) and others. Although the Nagaiwa Formation is selected as a standard section of the Japanese Middle Carboniferous, no comprehensive paleontological study has been published. In the previous paper (KOBAYASHI, 1973), entitled "On the Middle Carboniferous Nagaiwa Formation", the writer reported the stratigraphy of the Nagaiwa Formation as summarized in Text-fig. 2. In the present article, the writer describes twenty one species, including four new species, from nine genera of fusulinid fossils ranging from the lower Bashikirian to the lower Moscovian. The following fusulinid zones and subzones are established in decending order.

Zone of *Profusulinella*	*Parastaffella* cfr. *vlerki* subzone *Pseudostaffella japonica* subzone *Eoschubertella* sp. A subzone
Zone of *Millerella*	*Pseudostaffella antiqua* subzone *Eostaffella ultragigantea* subzone

Detailed discussion of this biostratigraphical subdivision should be referred to the previous paper (KOBAYASHI, 1973).

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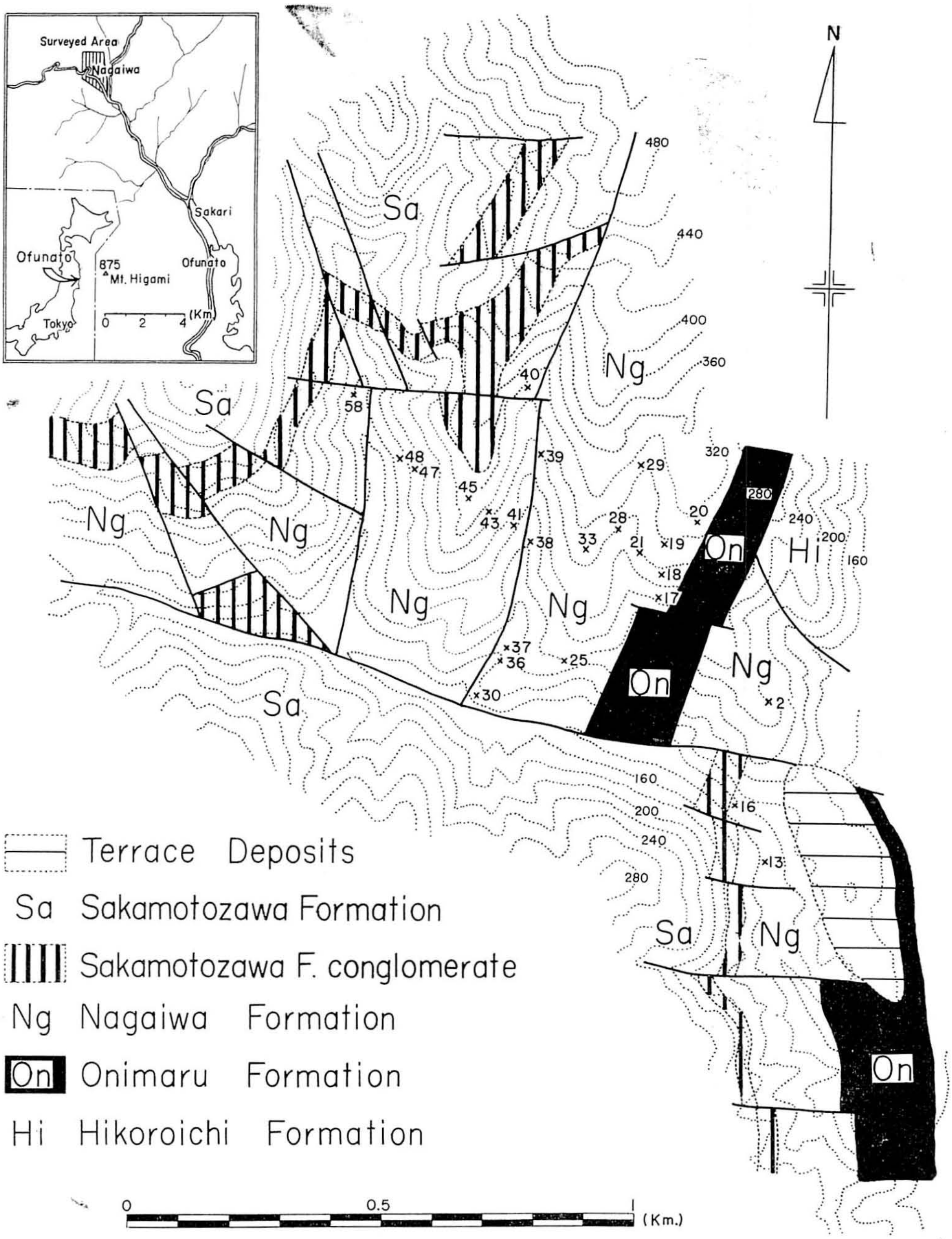
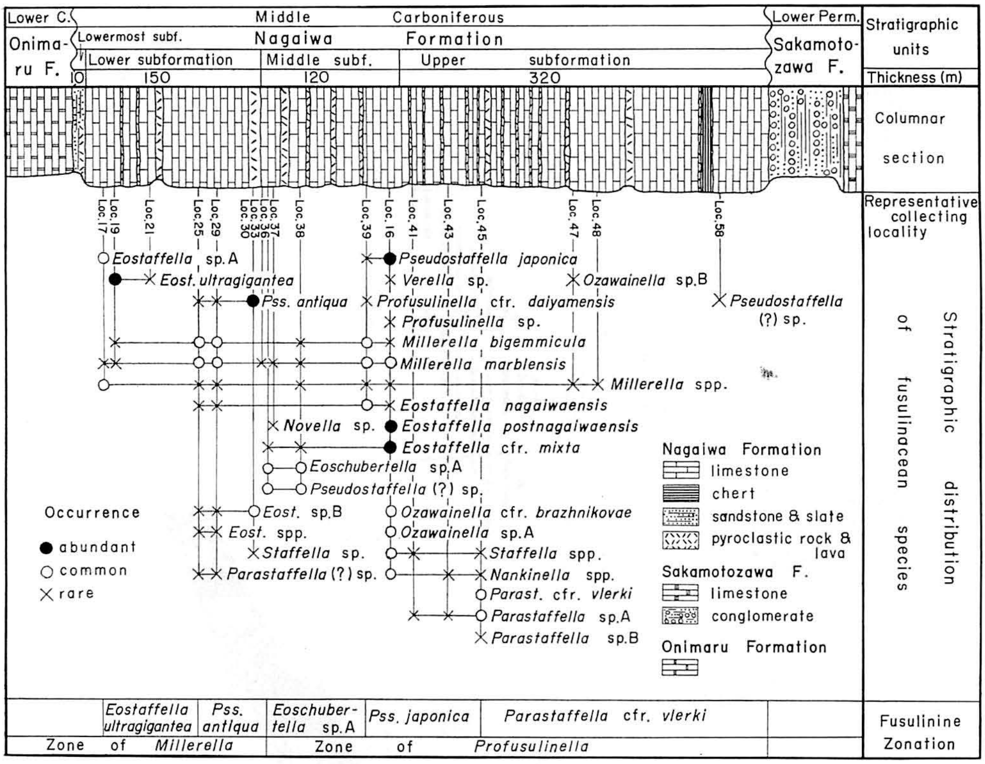


Text-fig. 1. Topographic and generalized geological map of Nagaiwa area showing the fossil localities.



Text-fig. 2. Generalized stratigraphic section of the Nagaiwa Formation showing the distribution of the fusulinacean species.

Tokyo Gakugei University for their encouragement and valuable advice during the course of this study.

All of the figured specimens are stored in the Institute of Geology and Astronomy, Tokyo Gakugei University.

Description of Species

Genus *Eostaffella* RAUSER-CERNOUSSOVA, 1948

Eostaffella ultragigantea KOBAYASHI, n. sp.

Plate 30, figs. 1–5

Shell very large for the genus, discoidal in shape and with straight lateral side. Polar regions flat or with shallow umbilical depressions. Periphery bluntly pointed to arched throughout the growth. Shell coiled involute throughout, but rarely evolute in the last coil. Mature shells with 4 to 5 volutions. Axial length 0.118 to 0.298 mm and median width 0.623 to 1.328 mm. Form ratio of mature specimens 1: 0.11 to 1: 0.22. Shell expands rapidly from the third volution. Proloculus minute, spherical and external diameter 0.023 to 0.070 mm. Spirotheca thin, composed of tectum, upper and lower tectoria, but the last volution seems to have a translucent layer between tectum and lower tectorium. Septa numerous, slightly arched anteriorly, unfluted throughout shell. Chomata weakly developed or lacking. Tunnel low and path rather irregularly.

Remarks:—The present new species somewhat resembles *Eostaffella gigantea* (KANMERA) and *E. japonica* (KANMERA), but the former is easily distinguished from the latter two species by its larger shell, smaller form ratio, and almost straight lateral side.

Occurrence:—Abundant to common in Loc. 19, rare in Loc. 21, associated with *Millerela marblensis* THOMPSON, *Millerella bigemmicula* IGO, and *M.* spp.

Measurements of *Eostaffella ultragigantea* KOBAYASHI, n. sp. in mm.

No. of sp.	L.	W.	R.	P.	Half length				
					1	2	3	4	5
1	0.145	0.648	0.22	0.053	.025	.025	.040	.073	—
2	0.298	1.328	0.22	0.070	.035	.060	.068	.118	.153
3	0.118	1.053	0.11	0.028	.025	.630	.063	.093	.115
4	0.143	0.770	0.19	0.023	.025	.033	.063	.073	—
5	0.130	0.798	0.16	0.033	.023	.023	.043	.063	—

Radius vector					Form ratio of vol.				
1	2	3	4	5	1	2	3	4	5
.068	.103	.170	.323	—	.37	.24	.24	.23	—
.078	.175	.270	.485	.733	.45	.34	.25	.24	.21
.053	.098	.188	.348	.548	.47	.31	.34	.27	.21
.063	.118	.218	.453	—	.40	.28	.29	.16	—
.078	.150	.243	.400	—	.30	.17	.18	.16	—

Reg. Nos.:—2141-1 (Holotype), 2141-2—2141-5 (Paratypes).

Eostaffella nagaiwaensis KOBAYASHI, n. sp.

Plate 30, figs. 9-13

Shell minute, subspherical to lenticular in shape with convex lateral side and with pointed to bluntly pointed periphery. Polar regions with shallow umbilical depressions. Shell involute throughout the growth and almost planispirally coiled. Mature shells have 4 to 5 volutions, 0.148 to 0.225 mm in axial length and 0.270 to 0.368 mm in median width. Form ratios of mature specimens 1: 0.44 to 1: 0.81, but about 1: 1 in inner volutions. Heights of volutions gradually increase. Proloculus minute, spherical, and external diameter 0.008 to 0.033 mm. Spirotheca thin, composed of tectum, lower and upper tectoria. Septa numerous, plane and unfluted. Chomata low, weakly developed or lacking. Tunnel low and path rather regular.

Remarks:—The present new species resembles closely *Eostaffella rhomboides*

Measurements of *Eostaffella nagaiwaensis* KOBAYASHI, n. sp. in mm.

No. of sp.	L.	W.	R.	P.	Half length				
					1	2	3	4	5
1	0.225	0.298	0.76	0.008	.020	.045	.095	.110	—
2	0.220	0.273	0.81	0.010	.015	.048	.090	.108	—
3	0.163	0.368	0.44	0.033	.018	.023	.045	.065	.078
4	0.148	0.270	0.55	0.028	—	.023	.053	.075	—

Radius vector					Form ratio of vol.					Tunnel angle (degrees)				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
.023	.050	.098	.153	—	.87	.90	.97	.72	—	25	25	—	—	—
.023	.063	.103	.150	—	.65	.76	.87	.72	—	—	31	—	—	—
.018	.040	.093	.103	.170	1.00	.58	.48	.63	.46	—	—	—	—	—
—	.038	.075	.113	—	—	.61	.71	.66	—	—	—	25	—	—

RAUSER-CERNOUSSOVA in many respects, such as form ratio, size of shell, and shape of periphery. However, it differs from the latter in poor development of chomata, thin spirotheca, and large form ratio of inner volutions of the present new species. It is also similar to *Eostaffella postnagaiwaensis* KOBAYASHI, n. sp., but the latter has larger and smaller form ratio than the former. *E. nagaiwaensis* also resembles *Millerella bigemmicula* IGO, but it differs in its involute last volution and more inflated shell.

Occurrence:—Common in Loc. 39, rare in Locs. 25, 29, and 16; upper part of the Zone of *Millerella* and lower part of the Zone of *Profusulinella*.

Reg. nos.:—2095-2 (Holotype), 2095-1, 2095-3—2095-5 (Paratypes).

Eostaffella postnagaiwaensis KOBAYASHI, n. sp.

Plate 30, figs. 17-20

Shell small, subdiscoidal to lenticular in shape with convex or rarely concave lateral side and broadly rounded periphery. Polar regions with umbilical depressions or flat. Shell involute throughout the growth and coiled almost planispirally. Mature shells have 4 to 5 volutions and 0.193 to 0.258 mm in axial length and 0.358 to 0.550 mm in median width. Form ratios of mature specimens 1: 0.45 to 1: 0.71. Proloculus minute, spherical and external diameter 0.018 to 0.043 mm. Spirotheca thin, composed of tectum, lower and upper tectoria. Translucent layer between tectum and lower tectorium recognized in the last volution of some specimens. Septa numerous, slightly arched anteriorly, unfluted throught shell. Chomata low and poorly developed. Tunnel path rather regular.

Remarks:—Most of the present specimens are deformed. Therefore detailed comparison is almost difficult. It resembles *Eostaffella ampla* (THOMPSON), but the former has more broadly rounded periphery and less dense chomata. It also resembles *Eostaffella inflecta* (THOMPSON) and *E. circuli* (THOMPSON) in many respects, but the former has larger form ratio, thinner and slightly undulated spirotheca.

Occurrence:—Abundant in Loc. 16; Zone of *Profusulinella*, *Pseudostaffella japonica* subzone.

Reg. nos.:—2056-21 (Holotype), 2056-22—2056-24 (Paratypes).

Measurements of *Eostaffella postnagaiwaensis* KOBAYASHI, n. sp. in mm.

No. of sp.	L.	W.	R.	P.	Half length				
					1	2	3	4	5
1	0.253	0.358	0.71	0.018	.018	.043	.085	.138	—
2	0.258	0.550	0.47	0.043	.025	.038	.063	.103	.138
3	0.193	0.398	0.49	0.020	.015	.038	.060	.075	.098
4	0.193	0.428	0.45	—	.025	.040	.063	.098	—

Radius vector					Form ratio of vol.					Tunnel angle (degrees)				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
.040	.063	.120	.198	—	.45	.68	.71	.72	—	—	27	34	—	—
.025	.053	.088	.160	.268	1.00	.72	.72	.64	.52	—	25	19	20	—
.025	0.48	.090	.150	.203	.60	.71	.67	.50	.48	—	—	25	—	—
.043	0.75	.138	.213	—	.58	.53	.46	.46	—	—	23	24	—	—

Eostaffella cfr. *mixta* RAUSER-CERNOUSSOVA

Plate 30, figs. 8, 14-16

Cfr. 1951. *Eostaffella mixta* RAUSER-CERNOUSSOVA, *Acad. Nauk. Inst. Geol. Sci. Minist. Prosp.*, p. 59-60, pl. 1, figs. 34, 35.

Shell rather large for the genus, subdiscoidal in shape with straight to slightly convex lateral side, shallowly umbilicated polar regions, and arched to pointed periphery. Shell involute throughout the growth and coiled planispirally. Mature shells have 4 to 5 volutions and 0.138 to 0.118 mm in axial length, and 0.488 to 0.613 mm in median width. Form ratio of mature specimens 1: 0.23 to 1: 0.31. Proloculus minute, spherical and external diameter 0.018 to 0.025 mm. Spirotheca thin, composed of three layers. Septa numerous, slightly arched anteriorly. Chomata massive, low and indistinct in inner volutions. Tunnel low and path rather regular.

Remarks:—The present specimens differ from the Russian ones in form ratio, shape of periphery and other characters. However, the secondary deformation possibly caused the above mentioned differences. Thus, the writer reserved the identification until more well-preserved specimens accumulate.

Occurrence:—Abundant in Loc. 16 and rare in Locs. 36 and 38; lower part of the Zone of *Profusulinella*.

Reg. nos.:—2056-17—2056-20

Eostaffella sp. A

Plate 30, fig. 31

Measurements of *Eostaffella* cfr. *mixta* RAUSER-CERNOUSSOVA in mm.

No. of sp.	L.	W.	R.	P.	Half length 1	2	3	4	5	Radius vector 1	2	3	4	5
1	0.138	0.598	0.23	0.023	.010	.013	.028	.050	.075	.038	.065	.103	.175	.295
2	0.148	0.488	0.30	0.025	.013	.023	.048	.050	.075	.033	.068	.100	.168	.265
3	—	0.518	—	0.018	—	—	—	—	—	.038	.078	.155	.258	—
4	0.188	0.613	0.31	0.023	.013	.025	.050	.075	.093	.038	.073	.123	.203	.303
5	0.138	0.513	0.27	0.025	.013	.030	.030	.070	—	.048	.095	.168	.278	—

Form ratio of vol. 1	2	3	4	5	Tunnel angle (degs.) 1	2	3	4	5	Septal count 1	2	3	4
.26	.20	.27	.29	.25	—	—	15	19	—	—	—	—	—
.39	.34	.48	.30	.28	—	—	—	14	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	6?	10	11	15
.34	.34	.41	.37	.31	—	—	13	15	—	—	—	—	—
.27	.32	.18	.25	—	—	14	16	—	—	—	—	—	—

Remarks:—The present specimens are very poorly preserved. Thus, the detailed comparison with other species is almost impossible, but it is slightly similar to *Eostaffella cooperi* (ZELLER) in shape of shell, number of volutions and arched periphery. *E. cooperi* is originally described from the Kinkaid Limestone, uppermost Chesterian of U. S. A. However, this American species differs from *E.* sp. A in larger proloculus and highly arched periphery.

Occurrence:—Rare in Loc. 17, enclosed within the nucleus of oölite, lowermost fossil bed of the Nagaiwa Formation.

Reg. no.:—2179-1

Eostaffella sp. B

Plate 30, figs. 6-7

Shell large for the genus, inflated discoidal in shape with straight to convex lateral sides; polar regions slightly depressed or sometimes flat umbilically; periphery arched to highly arched. Shell involute throughout the growth, and coiled planispirally. Mature shells have 5 volutions and 0.253 to 0.280 mm in axial length, 0.625 to 0.750 mm in median width. Form ratios of mature specimens 1: 0.37 to 1: 0.41. Shell expands gradually. Proloculus minute, spherical, and external diameter 0.025 to 0.045 mm. Spirotheca thin, composed of tectum, lower and upper tectoria. Septa numerous, slightly arched anteriorly, unfluted and plane throughout shell. Chomata massive, poorly developed. Tunnel low and path rather regular.

Remarks:—The present species is slightly similar to *Eostaffella gigantea* (KANMERA), but highly arched periphery and large size of shell of the former distinguish this species from the latter. It also resembles *Eostaffella ultragigantea* KOBAYASHI, n. sp., but shape of periphery, expansion and size of shell are different.

Occurrence:—Common in Loc. 30, rare in Locs. 25 and 29: upper part of the Zone of *Millerella, Pseudostaffella antiqua* subzone.

Reg. nos.:—2254-9—2254-10

Measurements of *Eostaffella* sp. B in mm.

No. of sp.	L.	W.	R.	P.	Half length 1	2	3	4	5
1	0.280	0.750	0.37	0.045	.023	.035	.053	.088	.143
2	0.253	0.625	0.41	0.025	.015	.038	.060	.083	.130

Radius vector 1	2	3	4	5	Form ratio of vol. 1	2	3	4	5	Tunnel angle (degs.) 1	2	3	4	5
.048	.088	.153	.275	.423	.48	.40	.35	.32	.34	—	10	13	20	—
.026	.085	.143	.233	.363	.60	.45	.42	.36	.36	—	13	13	—	—

Genus *Millerella* THOMPSON, 1942

Millerella marblensis THOMPSON

Plate 30, figs. 23, 24

1948. *Millerella marblensis* THOMPSON, *Kansas Univ. Paleont. Contr., Protozoa* Art 1, p. 76, pl. 23, figs. 1-12, pl. 24, figs. 1-9.
1957. *Millerella* cfr. *marblensis* THOMPSON: IGO, *Sci. Rep. Tokyo Kyoiku Daigaku*, Sec. C, Vol. 5, Nos. 47, 48, p. 26, 27, pl. 1, figs. 13, 14, 18, 19.
1964. *Millerella marblensis* THOMPSON: MOORE, *Jour. Pal.*, Vol. 38, No. 2, p. 294-305, pl. 47, figs. 1-24, pl. 48, figs. 1-23.

Shell small, discoidal in shape, with straight or convex lateral sides and shallowly depressed polar regions. Periphery arched to pointed. Mature shells have 4 volutions, 0.078 to 0.103 mm in axial length, and 0.488 to 0.623 mm in median width. Form ratios of the mature specimens 1: 0.15 to 1: 0.17. Shell expands rapidly. The first to third volutions tend to involute with shallow umbilical depressions, but the last one is evolute with umbilical depressions. Proloculus minute, spherical and external diameter 0.028 to 0.040 mm. Spirotheca thin, smooth and detailed structures can not observed. Chomata poorly developed.

Measurements of *Millerella marblensis* THOMPSON in mm.

No. of sp.	L.	W.	R.	P.	Half length 1	2	3	4	Radius vector 1	2	3	4	Form ratio of vol. 1	2	3	4
1	0.103	0.623	0.17	0.028	.013	.025	.048	.048	.053	.103	.183	.338	.25	.24	.26	.14
2	0.078	0.488	0.16	0.040	.023	.025	.048	.048	.050	.113	.188	.273	.46	.22	.26	.18
3	0.083	0.550	0.15	0.028	.015	.025	.040	.040	.048	.088	.168	.298	.31	.28	.24	.13

Remarks:—The present species closely resembles THOMPSON's typical specimens from the Marble Falls Limestone, Texas. Compared with MOORE's one from the Big Saline Formation, Texas, the present specimens have not so evolute shell.

Occurrence:—Common to rare throughout the Nagaiwa Formation.

Reg. nos.:—2195-1, 2056-25

Millerella bigemmicula IGO

Plate 30, figs. 21, 22

1957. *Millerella bigemmicula* IGO, *Sci. Rep. Tokyo Kyoiku Daigaku*, Sec. C, Vol. 5, Nos. 47-48, p. 172-174, pl. 1, figs. 1-9, 15-17, 27.

1964. *Millerella bigemmicula* IGO: SADA, *Jour. Sci. Hiroshima Univ.*, Sec. C, Vol. 4, No. 3, p. 228-229, pl. 21, figs. 5, 6, 10-13.

Shell small, discoidal in shape, with convex lateral sides, narrowly rounded or acutely pointed periphery and somewhat deeply umbilical depressions. Mature shells have 4 to 4.5 volutions, 0.098 to 0.178 mm in axial length, and 0.263 to 0.450 mm in median width. Form ratios of mature specimens 1: 0.24 to 1: 0.57. Shell coiled planispirally throughout the growth. Inner volutions involute with slight umbilical depressions, but the outer ones evolute or partly evolute. Proloculus minute, spherical and external diameter 0.018 to 0.048 mm. Spirotheca thin, composed of tectum, lower and upper tectoria. Chomata massive, asymmetrical and weakly developed.

Measurements of *Millerella bigemmicula* IGO in mm.

No. of sp.	L.	W.	R.	P.	Half length				
					1	2	3	4	4.5
1	0.178	0.413	0.42	0.025	.018	.023	.038	.073	.075
2	0.098	0.273	0.34	0.020	.010	.025	.040	.050	—
3	0.108	0.450	0.24	0.048	.025	.038	.055	.055	—
4	0.150	0.263	0.57	0.018	.030	.050	.075	.075	—

Radius vector					Form ratio of vol.					Tunnel angle (degs.)				
1	2	3	4	4.5	1	2	3	4	4.5	1	2	3	4	4.5
.023	.048	.075	.143	.218	.78	.48	.51	.51	.35	—	—	22	—	—
.023	.053	.103	.150	—	.44	.47	.39	.33	—	—	—	—	—	—
.048	.083	.148	.255	—	.52	.46	.38	.22	—	—	17	—	—	—
.033	.058	.113	.148	—	.91	.86	.66	.51	—	—	—	—	—	—

Remarks:—It differs slightly from the typical species from the Ichinotani Formation in expansion of shell, diameter of proloculus, development of chomata and form ratio.

Occurrence:—Common to rare throughout the Zone of *Millerella* and the lower part of the Zone of *Profusulinella*.

Reg. nos.:—2111-1, 2096-6.

Genus *Ozawainella* THOMPSON, 1935

Ozawainella cfr. *brazhnikovae* GINKEL

Plate 30, figs. 25, 26

Cfr. 1965. *Ozawainella brazhnikovae* GINKEL, *Leidse Geol. Med.*, Deel. 34, p. 62, 63, pl. 15, figs. 61, 62.

Shell small, rhomboidal to lenticular in shape, with convex lateral sides. Polar regions flat or with broad and shallow umbilical depressions; periphery arched in the first to second volutions, angular to bluntly angular in outer ones. Axial length 0.213 to 0.298 mm, median width 0.843 to 0.963 mm, and form ratio 1: 0.25 to 1: 0.31. Mature shells have 4.5 to 5 volutions. Proloculus spherical and external diameter 0.043 to 0.048 mm. Spirotheca composed of dense tectum and thin lower and upper tectoria in outer volutions. This differentiation of spirotheca in inner volutions obscure. Chomata weakly developed, or extends to the poles in some specimens, and path straight.

Measurements of *Ozawainella* cfr. *brazhnikovae* GINKEL in mm.

No. of sp.	L.	W.	R.	P.	Half length				
					1	2	3	4	5
1	0.213	0.843	0.25	0.043	.025	.050	.063	.078	.108
2	0.298	0.963	0.31	0.048	.023	.023	.058	.098	.163

Radius vector					Form ratio of vol.					Tunnel angle (degs.)				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
.083	.115	.153	.273	.430	.30	.44	.41	.29	.25	9	9	14	—	—
.073	.123	.198	.308	.478	.32	.19	.29	.32	.34	—	10	10	—	—

Remarks:—The present species are identified with GINKEL's one with some reservation. Detailed specific identification is postponed until more well-preserved specimens accumulate.

Occurrence:—Rather common in Loc. 16; Zone of *Profusulinella*, *Pseudostaffella japonica* subzone.

Reg. nos.:—2056-26, 2056-27.

Ozawainella sp. A

Plate 30, fig. 27

Shell small, lenticular to rhomboidal in shape. Polar regions flat or with slight umbilical depressions; periphery arched in 1-1.5 volutions, but bluntly angular in outer ones. Mature shells have 4 to 4.5 volutions. Axial length 0.431 mm, median width 1.963 mm, and form ratio 1: 0.21. Half length of the first to fourth volutions 0.038, 0.058, 0.103, and 0.138mm, respectively: radius vector 0.075, 0.133, 0.253 and 0.458 mm, respectively. Proloculus small, spherical and external diameter 0.075 mm. Spirotheca composed of tectum, lower and upper thick layers, but secondary mineralization obliterates most of their original structure. Chomata indistinct, and weakly developed.

Remarks:—This species is distinguished from *Ozawainella* cfr. *brazhni-*

kovae from Nagaiwa, in larger shell, weakly developed chomata, and spirothecal structure.

Occurrence:—Common in Loc. 16; Zone of *Profusulinella*, *Pseudostaffella japonica* subzone.

Reg. no.:—2056-28.

Ozawainella sp. B

Plate 30, fig. 39

Remarks:—Only one poorly preserved specimen was obtained. It has 0.263 mm in axial length and 0.775 mm in median width, giving form ratio 1 : 0.34. Detailed observation is difficult, but the occurrence of this unidentified species is noteworthy, because this species seems to be the uppermost representative of the Zone of *Profusulinella* of the Nagaiwa Formation.

Occurrence:—Very rare in Loc. 47; Zone of *Profusulinella*, *Parastaffella* cfr. *vlerki* subzone.

Reg. no.:—2238-1.

Genus *Pseudostaffella* THOMPSON, 1942

Pseudostaffella antiqua (DUTKEVICH)

Measurements of *Pseudostaffella antiqua* (DUTKEVICH) in mm.

No. of sp.	L.	W.	R.	P.	Half length					Radius vector				
					1	2	3	4	5	1	2	3	4	5
1	0.488	0.825	0.59	0.035	.013	—	.103	.163	.223	.035	.105	.165	.260	.395
2	0.500	0.625	0.80	0.055	.025	.053	.100	.160	.255	.060	.085	.133	.205	.338
3	0.563	0.900	0.63	0.030	—	.075	.113	.175	.275	.060	.105	.195	.310	.475
4	0.575	0.900	0.64	0.038	.050	.080	.128	.190	.288	.060	.140	.238	.350	?
5	0.525	0.813	0.65	0.035	—	—	.138	.210	.295	.050	.113	.178	.303	.433
6	0.450	0.675	0.67	0.055	.040	.080	.150	.225	—	.065	.103	.190	.260	?
7	0.450	0.700	0.64	0.063	.015	.075	.108	.150	—	.065	.095	.143	.248	.385
8	0.613	0.498	1.23	0.050	.023	.028	.070	.198	.263	.050	.093	.145	.185	.200
9	—	0.525	—	0.048	—	—	—	—	—	.050	.085	.170	.208	—
10	—	0.500	—	0.060	—	—	—	—	—	.045	.113	.200	—	—

Form ratio of vol.					Tunnel angle (degs.)					Septal count				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
.37	—	.62	.63	.57	—	13	20	25	—	—	6	—	—	—
.42	.62	.75	.78	.75	—	18	25	—	—	—	—	—	—	—
—	.71	.58	.57	.58	—	22	27	35	—	5	—	—	—	—
.83	.57	.54	.54	—	—	22	20	—	—	—	—	—	—	—
—	—	.78	.69	.68	—	—	26	26	—	?	10	—	—	—
.62	.78	.79	.87	—	—	18	—	—	—	—	—	—	—	—
.23	.79	.76	.61	—	—	—	21	27	—	—	—	—	—	—
.46	.30	.48	1.07	1.32	—	—	69	55	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	8	11	11	14	—
—	—	—	—	—	—	—	—	—	—	3?	12	16	?	—

Plate 31, figs. 1-6

1951. *Pseudostaffella antiqua* (DUTKEVICH): RAUSER-CERNOUSSOVA, *Acad. Nauk. Inst. Geol. Sci. Minist. Petrol. Prosp.*, p. 97, 98, pl. 5, figs. 6-8.
1965. *Pseudostaffella antiqua* (DUTKEVICH): GINKEL, *Leidse Geol. Med.*, Deel. 34, p. 69, 70, pl. 16, figs. 22-25.

Shell small, spherical to subspherical in shape. Mature shells have 4 to 5 volutions. Axial length 0.450 to 0.613 mm, median width 0.498 to 0.900 mm, and form ratio 1: 0.59 to 1: 1.23. Inner first or second volution closely coiled and commonly at right angle to the axis. Spirotheca thin, composed of three layered structures. Proloculus spherical and external diameter 0.030 to 0.063 mm. Septa plane and unfluted. Chomata low and massive. Tunnel low and path rather regular.

Remarks:—This species is reported from the Russian Platform, Donetz Basin, Cantabrian Mountains, Omi and Akiyoshi Limestones of Japan. The present specimens from Nagaiwa are slightly larger than the specimens from the above mentioned localities, but other characters are closely similar to these specimens.

Occurrence:—Abundant in Loc. 30 and rare in Locs. 25 and 29; Zone of *Millerella*, *Pseudostaffella antiqua* subzone.

Reg. nos.:—2254-1—2254-6

Pseudostaffella japonica KOBAYASHI, n. sp.

Plate 31, figs. 7-16

Shell spherical to subspherical in shape. Mature shells have 5.5 to 6, rarely 7, volutions. Axial length 0.703 to 1.038 mm, median width 0.733 to 1.365mm, and form ratio 1: 0.51 to 1: 1.19. Inner first to second, occassionally third, volutions with short axis of coiling, and coiled commonly at right angle or very irregularly to the axis. Spirotheca thin, composed of three layered profusulinellid wall. Proloculus spherical and external diameter 0.045 to 0.075 mm. Septa numerous, plane and unfluted. Chomata low and massive. Tunnel path rather irregular.

Remarks:—Although the present specimens are deformed, this resembles *Pseudostaffella gorskyi* (DUTKEVICH) and *P. nibelensis* RAUSER-CERNOUSSOVA in many respects, except the weaker development of chomata in the former. Also this species resembles *Pseudostaffella kanumai* IGO, but the former has larger shell and more irregular coiling of the inner volutions than the latter.

Occurrence:—Abundant in Loc. 16 and rare in Loc. 39; Zone of *Profusulinella*, *Pseudostaffella japonica* subzone.

Reg. nos.:—2056-1 (Holotype), 2056-2—2056-10 (Paratypes).

Pseudostaffella (?) sp.

Plate 30, figs. 28-30

Shell spherical to subspherical in shape, with slightly shallow umbilical depressions. Mature shells have 4 volutions. Axial length 0.168 to 0.413 mm, median width 0.208 to 0.425 mm, and form ratio 1: 0.40 to 1: 1.99. Inner first to second volutions coiled very irregularly or at right angle to the axis. Spirotheca very thin, composed of dense layer and thin less dense layer. Proloculus minute, spherical and external diameter 0.025 to 0.038 mm. Chomata low and weakly developed or lacking.

Measurements of *Pseudostaffella japonica* KOBAYASHI, n. sp. in mm.

No. of sp.	L.	W.	R.	P.	Half length							Radius vector						
					1	2	3	4	5	6	7	1	2	3	4	5	6	7
1	0.703	1.063	0.66	0.045	.045	.065	.118	.188	.275	.365	—	.073	.130	.198	.300	.423	.568	—
2	0.988	1.243	0.80	0.050	.025	.050	.108	.198	.310	.428	.493	.063	.100	.143	.213	.340	.475	.642
3	0.878	1.258	0.70	0.070	.035	.063	.160	.263	.393	.428	—	.075	.123	.175	.290	.500	.673	—
4	1.038	1.025	1.03	—	—	.093	.150	.275	.390	.513	—	—	.088	.163	.238	.350	.520	—
5	0.703	1.365	0.51	0.073	—	.050	.108	.188	.253	.350	—	.088	.150	.248	.380	.625	.728	—
6	0.873	0.733	1.19	0.055	.038	.068	.108	.193	.325	.443	—	.053	.098	.125	.173	.273	.398	—
7	0.880	0.803	1.10	0.053	.030	.050	.098	.198	.340	.438	—	.048	.063	.110	.178	.303	.423	—
8	0.825	0.938	0.88	0.053	.030	—	.123	.208	.315	.393	—	.050	.080	.140	.218	.347	.503	—
9	—	1.053	—	0.075	—	—	—	—	—	—	—	.095	.160	.263	.408	.575	—	—
10	—	1.118	—	—	—	—	—	—	—	—	—	.060	.115	.175	.278	.420	.593	—

Form ratio of vol.							Tunnel angle (degrees)							Septal count						
1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
.62	.50	.60	.63	.65	.64	—	—	15	16	28	38	—	—	—	—	—	—	—	—	—
.40	.50	.76	.93	.91	.90	.77	—	15	22	23	45	—	—	9?	—	—	—	—	—	—
.47	.51	.91	.91	.79	.64	—	13	12	14	30	—	—	—	—	—	—	—	—	—	—
—	1.06	.92	1.16	1.11	.99	—	—	25	28	31	—	—	—	—	—	—	—	—	—	—
—	.33	.44	.50	.48	.48	—	—	9	9	16	27	—	—	8	—	—	—	—	—	—
.72	.69	.86	1.12	1.19	1.11	—	—	—	10	24	28	—	—	—	—	—	—	—	—	—
.63	.79	.89	1.11	1.12	1.04	—	—	17	21	23	37	—	—	—	—	—	—	—	—	—
.60	—	.88	.95	.91	.78	—	—	15	26	39	55	—	—	—	10	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	12	13	20	24	3+	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	12	15	17	20	15+	—

Tunnel low and path rather irregular.

Remarks:—The present specimens are so deformed that the original shape of shell is obscure. Several important bio-characters are somewhat related to *Eoschubertella*. Generic designation is tentative.

Occurrence:—Common in Locs. 36 and 38; Zone of *Profusulinella*, *Eoschubertella* sp. A subzone.

Reg. nos.:—2088-5—2088-6, 2093-1

Measurements of *Pseudostaffella* (?) sp. in mm.

No. of sp.	L.	W.	R.	P.	Half length			
					1	2	3	4
1	0.190	0.423	0.45	0.030	.030	.063	.075	.098
2	0.413	0.208	1.99	0.038	.018	.088	.148	.198
3	0.168	0.425	0.40	—	—	.038	.058	.088
4	0.173	0.343	0.50	0.025	—	.048	.070	.103

Radius vector				Form ratio of vol.				Septal count			
1	2	3	4	1	2	3	4	1	2	3	4
.053	.100	.158	.235	.51	.63	.48	.41	—	—	—	—
.063	.038	.073	.108	.29	2.32	2.03	1.83	—	—	—	—
.050	.090	.148	.225	—	.42	.39	.39	—	—	—	—
.063	.088	.148	.203	—	.55	.47	.51	9	—	—	—

Genus *Profusulinella* Rauser-Cernoussova and Beljaew, 1934

Profusulinella cfr. *daiyamensis* Hasegawa

Plate 31, fig. 17

Cfr. 1967. *Profusulinella daiyamensis* Hasegawa, *Sci. Rep. Niigata Univ.* Ser. E, No. 1, p. 9–15, pl. 1–3.

Shell small, slightly inflated fusiform in shape. Mature shells have 5 volutions. Axial length 1.033mm and median width 0.413 mm. Inner structures can not be clarified by ill-preservation and poorly oriented sections.

Remarks:—Slightly inflated fusiform shell, concave lateral sides and other features of the present specimens may be comparable with Hasegawa's species from the Akiyoshi Limestone, but the conclusion is kept open.

Occurrence:—Common to rare in Loc. 39; Zone of *Profusulinella*, lower part of *Pseudostaffella japonica* subzone.

Reg. no.:—2095-7.

Profusulinella sp.

Plate 31, figs. 18–19

Two well-oriented specimens obtained. Shell inflated fusiform to elongate fusiform in shape. Mature shells have 5 volutions. Axial length 2.275mm, median width 1.275 mm, and form ratio 1: 1.78. Half length of the first to fifth volutions 0.103, 0.230, 0.450, 0.838 and 1.175 mm, respectively. Radius vector 0.053, 0.105, 0.220, 0.465 and 0.740 mm, respectively. Inner 2 or 3 volutions closely coiled and the subsequent ones gradually increase in height and width. Proloculus minute and external diameter 0.055 mm. Spirotheca composed of tectum, lower and upper tectoria. Chomata low and massive. Tunnel angle of the second to fourth volutions 17, 28, and 47 in degrees, respectively. Tunnel path irregular.

Remarks:—The previous students listed *Profusulinella* sp. from the Nagaiwa Formation. *Profusulinella* sp. described herein seems to differ from the species by other authors, because the writer's specimens are rare in occurrence, and some of the deformed specimens of *Pseudostaffella japonica* resembles *Profusulinella*. Furthermore, the writer's *Pseudostaffella japonica* is particularly abundant. Therefore, *Profusulinella* sp. listed by the previous authors seems to be the writer's *Pseudostaffella japonica.*

Occurrence:—Very rare in Loc. 16; Zone of *Profusulinella*, *Pseudostaffella japonica* subzone.

Reg. nos.:—2056-29, 2056-30

Genus *Verella* DALMATSKAYA, 1952

Verella sp.

Plate 31, figs. 20-25

Shell elongate fusiform in shape, composed of 3.5 to 4 volutions in mature specimens. Axial length 1.293 to 2.450 mm, median width 0.353 to 0.558 mm, and form ratio 1: 3.40 to 1: 4.39. Heights of volutions increase gradually. The first to second volutions elongate rhomboidal and subsequent ones elongate fusiform or elongate subcylindrical. Proloculus spherical and external diameter 0.075 to 0.150 mm. Septa weakly fluted in polar regions. Chomata poorly developed or

Measurements of *Verella* sp. in mm.

No. of sp.	L.	W.	R.	P.	Half length			
					1	2	3	4
1	1.788	0.488	3.66	0.080	.130	.320	.575	—
2	1.293	0.365	3.40	0.095	.148	.313	.598	—
3	2.450	0.558	4.39	0.075	.100	.200	.403	.738
4	1.558	0.405	3.85	0.103	.100	.303	.623	—
5	1.300	0.353	3.68	0.105	.125	.288	.638	—
6	1.775	0.428	4.15	0.150	.205	.378	.750	—

Radius vector				Form ratio of vol.				Tunnel angle (degs)			
1	2	3	4	1	2	3	4	1	2	3	4
.050	.098	.153	.275	2.60	3.27	3.76	—	17	40	—	—
.063	.125	.208	—	2.35	2.50	2.88	—	—	—	—	—
.050	.080	.125	.238	2.00	2.50	3.22	3.10	—	—	—	—
.050	.088	.150	.238	2.00	3.44	4.17	—	—	—	—	—
.060	.115	.195	—	2.08	2.50	3.27	—	—	—	—	—
.058	.125	.228	—	3.53	3.02	3.29	—	—	—	—	—

lacking. Dense secondary filling observed in axial regions. Spirotheca thin, probably composed of three layers.

Remarks:—This is the first record of the occurrence of this genus in Japan. Comparing with the Russian species and *Verella* sp. from the Cantabrian Mountains, Spain, the present species is characterized by less number of volutions, smaller size of shell and weaker septal fluting. Based on the mentioned differences, the Nagaiwa species may be biologically more primitive than the mentioned foreign materials.

Occurrence:—Rare in Loc. 16; associated with *Profusulinella* sp., *Pseudostaffella japonica*, *Eostaffella postnagaiwaensis* and others; Zone of *Profusulinella*, *Pseudostaffella japonica* subzone.

Reg. nos.:—2056-11~2056-16

Genus *Eoschubertella* THOMPSON, 1937

Eoschubertella sp. A

Plate 31, figs. 28-31

Shell minute, subspherical in shape with straight axis of coiling. Mature shells have 4 volutions. Axial length 0.358 to 0.523 mm, median width 0.203 to 0.300 mm, and form ratio 1: 1.74 to 1: 1.76. Inner one to one and half volutions irregularly coiled to the axis, subsequent ones regularly coiled. Proloculus spherical, rather large for size of shell and external diameter 0.038 to 0.050 mm. Spirotheca thin, composed of tectum and a lower dense layer. Chomata massive, and rather symmetrical. Septa not fluted and plane.

Remarks:—This species resembles closely *Eoschubertella obscura* (LEE and CHEN) in many respects, such as shape and coiling of shell and rather large proloculus, but this can be distinguished from the latter in number of volutions and development of chomata. Also this species resembles *Eoschubertella lata* (LEE and CHEN) and *E. elliptica* (SHENG), but differing from the latters in having subspherical shape and irregular coiling of the inner volutions.

Occurrence:—Common in Locs. 36 and 38; lower part of the Zone of *Profusu-*

Measurements of *Eoschubertella* sp. A in mm.

No. of sp.	L.	W.	R.	P.	Half length				Radius vector			
					1	2	3	4	1	2	3	4
1	0.448	0.258	1.74	0.048	.070	.090	.130	.213	.030	.063	.098	.163
2	0.523	0.300	1.74	0.043	.075	.125	.175	.253	.048	.075	.113	.175
3	0.358	0.203	1.76	0.050	.053	.108	.175	—	.048	.075	.105	—
4	—	0.298	—	0.038	—	—	—	—	.050	.093	.158	—

Form ratio of vol.				Tunnel angle (degs.)				Septal count			
1	2	3	4	1	2	3	4	1	2	3	4
2.33	1.43	1.33	1.31	—	42	44	—	—	—	—	—
1.56	1.67	1.55	1.45	—	32	60	—	—	—	—	—
1.10	1.44	1.67	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	7?	14	16	2+

linella, *Eoschubertella* sp. A subzone.
Reg. nos. :—2088-2∼2088-4, 2093-2

Genus *Parastaffella* RAUSER-CERNOUSSOVA, 1948

Parastaffella cfr. *vlerki* GINKEL

Plate 30, figs. 34-38

Cfr. 1965. *Parastaffella vlerki* GINKEL, *Leidse Geol. Med.*, Deel. 34, p. 19, 20, pl. 9, figs. 7-18, pl. 10, figs. 1-35.

Shell lenticular with convex lateral sides; polar regions having flat or shallow umbilical depressions; periphery bluntly pointed to arched in inner volutions, broadly rounded in outer ones. Shell involute in inner one to three and half volutions, evolute or occasionally involute in subsequnt ones. Mature shells have 4.5 to 5 volutions. Axial length 0.203 to 0.345 mm, median width 0.833 to 0.925 mm and form ratio 1: 0.22 to 1: 0.41. Chomata massive, low and sometimes extends to poles. Septa unfluted, numerous and inclined anteriorly.

Explanation of Plate 30

Figs. 1-5. *Eostaffella ultragigantea* KOBAYASHI, n. sp.
1. Axial section of the holotype; 2-4. Axial sections of paratypes; 5. Sagittal section of paratype, ×60; Loc. 20.

Figs. 6-7. *Eostaffella* sp. B
6-7. Axial sections, ×60; Loc. 13.

Figs. 9-13. *Eostaffella nagaiwaensis* KOBAYASHI, n. sp.
10. Axial section of the holotype; 9, 11-13. Axial sections of paratypes, ×60; Loc. 39.

Figs. 8, 14-16. *Eostaffella* cfr. *mixta* RAUSER-CERNOUSSOVA
8, 14-15. Axial sections; 16. Sagittal section, ×60; Loc. 16.

Figs. 17-20. *Eostaffella postnagaiwaensis* KOBAYASHI, n. sp.
17. Axial section of the holotype; 18-20. Axial sections of paratypes, ×60; Loc. 16.

Figs. 21-22. *Millerella bigemmicula* IGO
21-22. Axial sections, ×60; Locs. 2 and 39.

Figs. 23-24. *Millerella marblensis* THOMPSON
23-24. Axial sections, ×60; Locs. 16 and 28.

Figs. 25-26. *Ozawainella* cfr. *brazhnikovae* GINKEL
25-26. Axial sections, ×40; Loc. 16.

Fig. 27. *Ozawainella* sp. A
Axial section, ×40; Loc. 16.

Figs. 28-30. *Pseudostaffella* (?) sp.
28-30. Axial sections, ×40; Locs. 36 and 38.

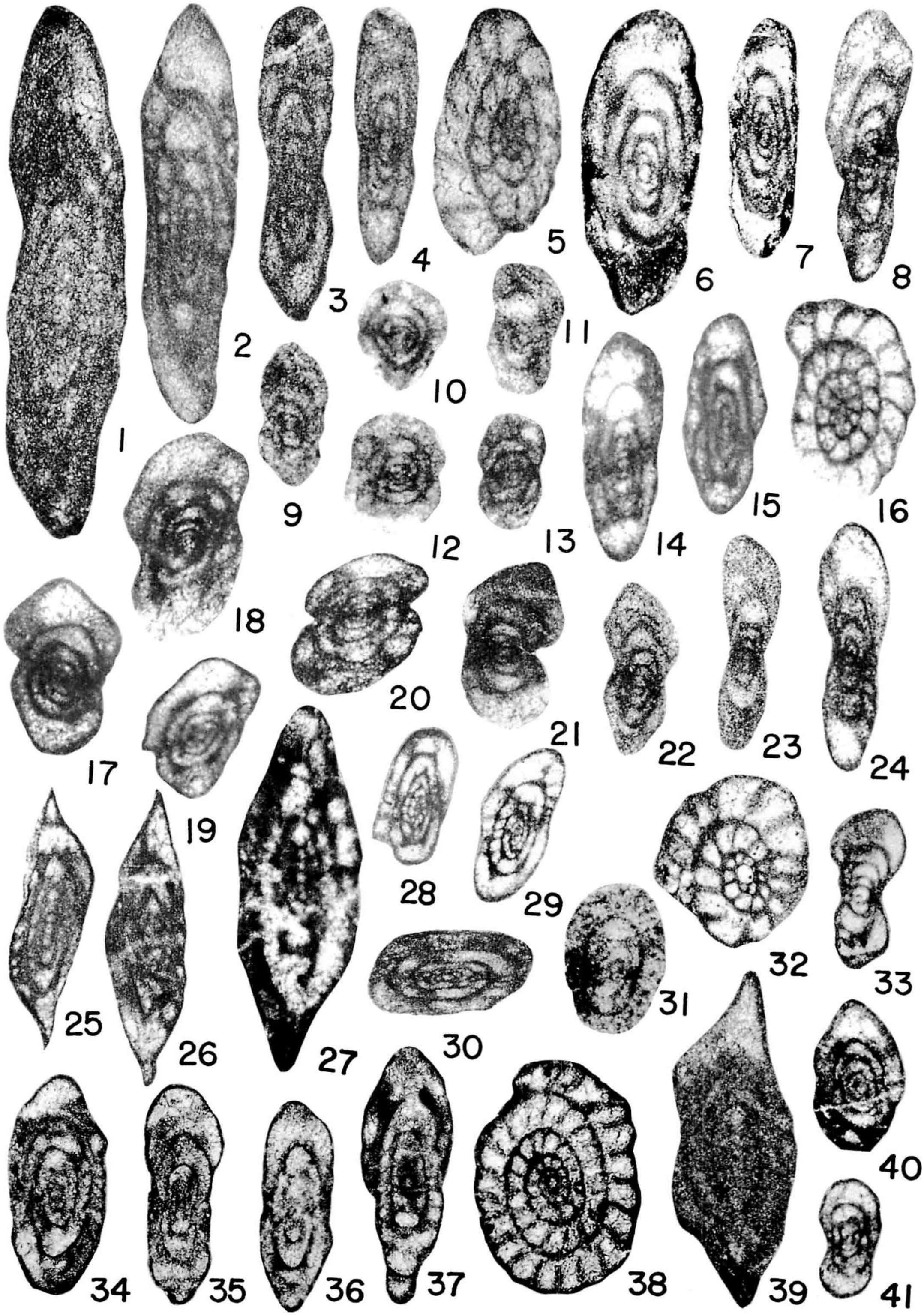
Fig. 31. *Eostaffella* sp. A
Tangential section, ×60; Loc. 18.

Figs. 32-33. *Parastaffella* sp. B
32. Sagittal section; 33. Axial section, ×60; Loc. 45.

Figs. 34-38. *Parastaffella* cfr. *vlerki* GINKEL
34-35. Axial sections; 36-37. Tangential sections; 38. Sagittal section, ×40; Loc. 45.

Fig. 39. *Ozawainella* sp. B
Axial section, ×60; Loc. 47.

Figs. 40-41. *Parastaffella* sp. A
40. Axial section, ×40; Loc. 45. 41. Tangential section, ×60; Loc. 40.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Spirotheca composed of very distinct dense layer and lower and upper less dense layers. Diaphanotheca indistinct.

Remarks:—GINKEL recognized broad variations in this species, such as measurements of radius vector, form ratio, angularity of periphery and height of chomata. The present material is very similar to the original ones from the Cantabrian Mountains and falls within the limits of variation of the type species, except the spirothecal structure.

Occurrence:—Common in Loc. 45; Upper part of the Zone of *Profusulinella*, *Parastaffella* cfr. *vlerki* subzone.

Reg. nos.:—2232-1—2232-5

Measurements of *Parastaffella* cfr. *vlerki* GINKEL in mm.

No. of sp.	L.	W.	R.	P.	Half length 1	2	3	4	5	Radius vector 1	2	3	4	5
1	—	0.918	—	0.043	—	—	—	—	—	.055	.123	.220	.363	.460
2	0.345	0.833	0.41	0.045	.025	.050	.090	.133	.193	.045	.093	.175	.298	.450
3	0.203	0.925	0.22	0.028	.018	.033	.048	.103	.103	.050	.098	.158	.278	.450

Form ratio of vol. 1	2	3	4	5	Tunnel angle (degs.) 1	2	3	4	5	Septal count 1	2	3	4	5
—	—	—	—	—	—	—	—	—	—	8	11	13	17	20
.56	.54	.51	.45	.43	—	16	20	—	—	—	—	—	—	—
.36	.34	.30	.37	.23	16	12	12	—	—	—	—	—	—	—

Parastaffella sp. A

Plate 30, figs. 40, 41

Remarks:—Small and involute shells have 3 to 3.5 volutions; axial length 0.148 to 0.163 mm, median width 0.328 to 0.383 mm and form ratio 1 : 0.43 to 1 : 0.45. Because of ill preservation and lack of well oriented specimens, specific identification was impossible.

Occurrnce:—Common in Loc. 45, rare in Locs. 41 and 43, associated with *Parastaffella* cfr. *vlerki*, *Parastaffella* sp. B and others; upper part of the Zone of *Profusulinella*, *Parastaffella* cfr. *vlerki* subzone.

Reg. nos.:—2232-6, 2096-7.

Parastaffella sp. B

Plate 30, figs. 32, 33

Remarks:—Owing to rare occurrence, detailed paleontological work was impossible. Further specimens are necessary to identify.

Occurrence:—Rare in Loc. 45; upper part of the Zone of *Profusulinella*, *Parastaffella* cfr. *vlerki* subzone.

Reg. nos.:—2096-7, 2096-8

Genus *Staffella* OZAWA, 1925

Staffella sp.

Plate 31, figs. 26, 27

Shell spherical to subspherical in shape with umbilical depressions. Mature shells have 5 to 5.5 volutions. Axial length 0.488 to 0.713 mm, median width

0.500 to 0.675 mm and form ratio 1:0.78 to 1: 1.20. Proloculus rather large, spherical and external diameter 0.035 to 0.075 mm. Volutions involute throughout the growth. Spirotheca thin, and composed of indistinct tectum, outer thin layer and inner thick layers which sometimes bear diaphanotheca-like layer. Chomata low, massive and rather symmetrical. Tunnel low and path rather irregular.

Remarks:—The present species resembles *Staffella breimerai* GINKEL in many respects, but chomata of the former is not so strong and seldom extends to the poles.

Occurrence:—Rather common in Loc. 30; Zone of *Millerella*, upper part of *Pseudostaffella antiqua* subzone.

Reg. nos.:—2254-7—2254-8

Measurements of *Staffella* sp. in mm.

No. of sp.	L.	W.	R.	P.	Half length 1	2	3	4	5	Radius vector 1	2	3	4	5
1	0.713	0.673	1.06	0.045	.038	.095	.153	.230	.363	.035	.063	.150	.240	.353
2	0.488	0.630	0.78	0.035	.048	.075	.103	.153	.245	.050	.088	.138	.195	.360
3	0.600	0.500	1.20	0.045	.050	.088	.135	.218	.300	.068	.113	.155	.203	.273
4	—	0.675	—	0.075	—	—	—	—	—	.050	.080	.135	.203	.305

Form ratio of vol. 1	2	3	4	5	Tunnel angle (degs.) 1	2	3	4	5	Septal count 1	2	3	4	5
1.09	1.51	1.02	.96	1.03	—	25	33	—	—	—	—	—	—	—
.96	.85	.75	.79	.68	—	—	23	17	20	—	—	—	—	—
.74	.78	.87	1.07	1.10	—	—	60	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	9	12	14	18	?

Explanation of Plate 31

Figs. 1–6. *Pseudostaffella antiqua* (DUTKEVITCH)
1–5. Axial sections; 6. Sagittal section, ×40; Loc. 13.

Figs. 7–16. *Pseudostaffella japonica* KOBAYASHI, n. sp.
7. Axial section of the holotype; 8–15. Axial sections of paratypes; 16. Sagittal section of paratype, ×30; Loc. 16.

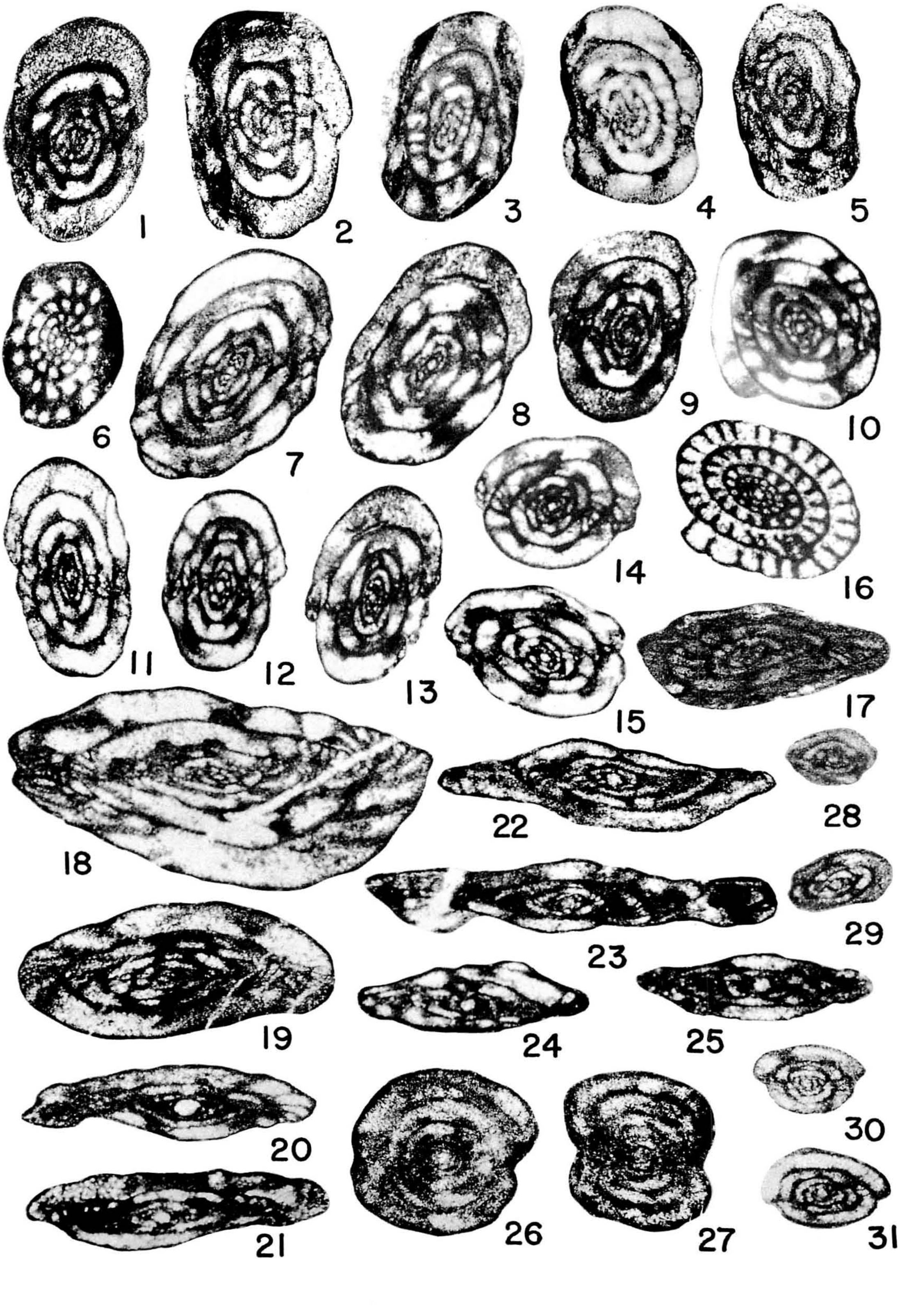
Fig. 17. *Profusulinella* cfr. *daiyamensis* HASEGAWA
Oblique section, ×40; Loc. 39.

Figs. 18–19. *Profusulinella* sp.
18. Axial section; 19. Tangential section, ×30; Loc. 16.

Figs. 20–25. *Verella* sp.
20–25. Axial sections, ×30; Loc. 16.

Figs. 26–27. *Staffella* sp.
26–27. Axial sections, ×40; Loc. 13.

Figs. 28–31. *Eoschubertella* sp. A
28–31. Axial sections, ×40; Locs. 36 and 38.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Nagaiwa	長 岩	Ichinotani	一ノ谷
Kitakami	北 上	Akiyoshi	秋 吉

Palaeontological Society of Japan Special Papers No. 17-Revision of Matajiro YOKOYAMA's Type Mollusca from the Tertiary and Quaternary of the Kanto Area

By Katura OYAMA. Issued November 30, 1973, 148 pp., 57 plates.

Price (postage and handling included)..U. S. $ 20. 00

The paper presents entirely revised systematics and illustrations of the type specimens of Mollusca from the Tertiary and Quaternary of the Kanto area (Tokyo and vicinities) which were originally described by the late Professor Matajiro YOKOYAMA (1920-1927). Locality records are examined and the ecological conditions of the species are considered. This would be an indispensable reference for the late Cenozoic biostratigraphy as well as the molluscan palaeontology.

The special papers are on sale at the Society. Orders must be accompanied by remittance, made payable to Dr. Totsuro MATSUMOTO, Editor of the Special Papers, Palaeontological Society of Japan, c/o Department of Geology, Faculty of Science, Kyushu University, Fukuoka (Hakata) 812, Japan.

The following backnumbers are on sale at the Society and also purchasable through the University of Tokyo Press, Hongo, Tokyo 113, Japan.

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PROCEEDINGS OF THE PALAEONTONLOGICAL SOCIETY OF JAPAN

日本古生物学会112回例会は1973年10月20日(土)に東京大学理学部において開催された(参加者57名)。

個 人 講 演

Late Lower Cretaceous flora newly found from the upper beds of the Tetori Group, Fukui Prefecture, Japan ....KIMURA, T.

Cryptomeria and *Sciadopitys* from the Late Miocene of Akita Prefecture, Japan .. ..HUZIOKA, K. & UEMURA, K.

Fossil pollen group *Triprojectacites* from the Late Cretaceous in northern Japan ....MIKI, A.

Fusulinacean fossils from the Okutama district (No. 2, Fusulinacean fossils in the intraformational conglomerate. Part 1, *Paleofusulina-Reichelina* Fauna) ....KOBAYASHI, F.

中華民国台湾省,南投県粗坑層産 *Discocyclina* について...............橋本 亘・栗原謙二

フィリピン・ミンダナオ島東部の大型有孔虫動物群............................松丸国照

"OST"と海綿の sterraster の類似について ....井上雅夫・岩崎泰頴

上部成田層産のウズマキゴカイ (*Spirorbis foraminosus* MOORE et BUSH) について ....福田芳生

Discovery of Late Permian *Araxoceras* from the Toyoma Formation in the Kitakami Massif, Northeast Japan ....MURATA, M. & BANDO, Y.

Khumerspira, a new genus of bellerophontid, and some Middle Permian gastropods from Cambodia ....MURATA, M. & ISHII, K.

Marine fossils from the Moniwa Formation along the Natori River, Sendai, Northeast Honshu, Japan. Part 2, Problematica from the Moniwa Formation ....HATAI, K., MASUDA, K. & NODA, H.

台湾省北部海岸地区の五指山層および木山層産貝化石群について..................菅野三郎

酸素同位体比からみた成田層群産貝化石の古水温について.....................増田富士雄

日本のシルル紀三葉虫について ....小林貞一・浜田隆士

Neohibolites に穿孔する Acrothoracica ....花井哲郎

Spatial pattern of deposit feeding starfish, *Astropecten latespinosus*..MATSUKUMA, A.

Pliocene gobiid fish from Sankago Diatomite Member, Kagoshima Prefecture, Japan ....UYENO, T. & IWAO, Y.

北海道日高累層群から産する三畳紀 conodont について...............猪郷久義・小池敏夫

総 会・例 会 等 の 通 知

	開催地	開催日	講演申込締切日
1974年 総会・年会	九州大学	1974年1月11-12日	1973年11月10日
113回 例 会	大阪市立 自然科学博物館	1974年6月下旬	1973年4月10日

◎ 1974年総会・年会(九州大学)では「古無脊椎動物の系統分類に関する最近の進歩」(世話人 高柳洋吉・速水 格)が予定されている。

お 知 ら せ

各種学術奨励金の学会推薦について　従来本学会以外の各種学術賞・奨励金については，すべて予め賞の委員会が審議して候補者を選び，その後本人と連絡して推薦するという形式がとられてきた。しかし，下記の例のような学術奨励金・研究助成金は，元来個人またはグループが直接応募申請するもので，学会（長）の推薦は必ずしも必要ではない。そこで，昭和49年度からは，以下のように年度末発行の本誌に翌年度中に予想される奨励金類の応募要項をのせることにし，本会からの推薦の御希望の申出があったものについて賞の委員会で審議の上，推薦を決めることとする。会員各位には，古生物学発展のため，これらの奨励金にふるって御応募されたい。

昭和49年度の下記のような各種奨励金に本会の推薦を希望される場合は，昭和49年1月20日までに，① 研究者および協力者氏名所属　② 希望される奨励金の名称　③ 課題名と大略の内容を記して，本会事務局気付賞の委員会あて申込まれたい。

○朝日学術奨励金　金額に制限なし，研究は進行中またはこれから始めるもの，学界関係者の推薦を要する。〆切は3月1日。

○三菱財団自然科学研究助成金　1件3000万円以内（300～1000万円程度），重点対象分野の指定あり，推薦は不要，助成期間は原則として1年間，〆切5月末頃。

○毎日学術奨励金　1件30～50万円程度，完成の近い研究が対象（主として出版経費の助成），〆切6月頃。

○偕成学術奨励金　1件50万円程度，研究は進行中かこれから始めるもの，学界関係者の推薦を要する。〆切6月頃。

以上の他に，学会長の推薦を必要とするものとして，次のようなものがある。

○東レ科学技術研究助成金　1件1000万円程度，基礎または応用科学，特に環境科学，〆切11月頃。

○山地自然科学振興財団研究助成金　1件100～200万円程度，基礎科学，〆切6月頃。

（賞の委員会）

◎ 昭和49年11月に，**日本学術会議第10期会員選挙**が行なわれます。有資格者で未登録の方は登録を，住所・勤務先等に変更のあった有権者は異動届を行なって下さい。問合せ，届出は，106 東京都港区六本木7-22-34. 日本学術会議中央選挙管理会あて。

◎ **日本古生物学会特別号 No. 17,** "Revision of Matajiro YOKOYAMA's Type Mollusca from the Tertiary and Quaternary of the Kanto Area"（大山桂著，148ページ，57図版，1973年11月30日発行）が，文部省刊行助成金の補助を得て，刊行されました。定価は1部3,800円（郵送・梱包料300円加算），$20.—（郵送・梱包料を含む）です。
註文は 〒812 福岡市東区箱崎　九州大学理学部地質学教室内，日本古生物学会特別号編集委員会へ。

日本古生物学会報告・紀事 編集出版規約

(1973年1月16日)

I 出版・編集

I A 発 行

—1 日本古生物学会報告・紀事(以下報告・紀事と略称)は，年4回発行される。

I B 記 載

—1 報告・紀事には，本会の会則第2条の目的にかなう原著論文，短報および学会紀事，古生物学界ニュース等を掲載する。

—2 投稿された論文は，原則として受理順に掲載される。

I C 配 布

—1 報告・紀事は，本会のすべての会員ならびに評議員会の認める若干の機関に配布され，会員外の者はこれを購読することができる。

I D 編集委員会

—1 報告・紀事の編集は，会の編集出版規約にもとづき，編集委員会がこれを行なう。

—2 編集委員会は，評議員である編集長1名および常務委員会で認められる若干の委員から構成され，編集会議は編集長の召集により開かれる。

—3 編集長は，必要に応じて受付原稿のコピーを編集委員以外の適切な人に示し，その意見を徴することができる。

—4 原稿の採否は，編集会議において編集委員会の責任で決定し，編集長はその結果を常務委員会に報告する。

—5 不採用原稿は，その理由を付して著者に返却する。

—6 編集委員会の決定に不服の著者は，評議員会に対して異議申立を行なうことができる。編集委員会および著者は，評議員会の裁定にしたがう。

I E 校 正

—1 校正は，原則として編集委員会がこれを行なう。ただし，著者は初校について1回限り著者校正をとることができる。このとき正規の原稿は著者に返送されない。

II 投 稿

II A 資 格

—1 本会の会員は，報告・紀事に投稿する権利を有する。ただし，常務委員会で認める特例については，非会員でも投稿できる。

—2 投稿論文は欧文(英・仏・独のいずれかが望ましい)で書かれたもので，本学会の年会・例会等で講演されたものとする。

II B 執筆制限

—1 原稿はタイプスクリプトとする。原著論文では，挿図，表などを含めて24印刷頁，および図版2葉を限度とする。ただし，4印刷頁以内の論文については，とくに認められた場合を除いて図版を付さない。短報類は1印刷頁以内とし，かつ図版を用いないものとする。

—2 挿図は，1論文につき10図，あるいは印刷延面積で600 cm^2 を限度とする。ただし，4印刷頁以内の論文では2図，あるいは合計面積200 cm^2 までとする。挿図は印刷時に，1つの図の幅が本文の1段幅(6.4 cm)か2段幅(=1頁幅，13.4 cm)のいずれかの大きさに縮小されるので，原図はそれに適した大きさと鮮明さを備えたもので，原稿本文とは別紙に画かれたものとする。

—3 上に示されたそれぞれの執筆制限をこえる場合には，超過分の印刷出版に要する実費を著者自身が負担する。

II C 原稿の体裁

—1 属種名などの学名や特殊な語についての字体の指定は，原稿中に著者自身が行なう。

—2 挿図・表等の挿入希望箇所を，原稿の欄外に指定する。

—3 挿図・表の題および説明，ならびに図版説明等は，本文とは別紙にまとめる。

—4　引用文献は本文の最後の部分にまとめ，著者名の姓のアルファベット順および発表年代順に配列し，原則として下記の要領にしたがう。

著者名，年，論文表題，雑誌名（斜体指定のため下線をほどこす），巻，号，頁数，図版数，その他。

—5　日本など漢字でかく地名を含む論文については，ローマ字表現と漢字とを対照した表を本文の末尾に付すことが望ましい。

—6　著者の現所属機関名とその所在地，あるいはそれらに代わる住所を，タイトル頁の著者名の下に完記する。

—7　短報類以外の論文には，邦題，著者名を含めて800字以内にまとめた邦文要旨を別紙として付ける。(日本語を常用しない著者の論文については，英文要旨を付しておけば，それにもとづいて編集委員会が邦文要旨を作成する。)

II D　**著者の責務**

—1　著者は，編集上の諸事項に関して可能な限り編集委員会の指示にしたがわなければならない。

—2　原稿の受付後に，著者が大幅改訂を希望する場合は，原稿は返却されるが，改訂した原稿は新規の投稿とみなされる。

—3　投稿に際しては，正規の論文原稿の他に，図，表，図版等を含む完全なコピー1組を付して下記へ送付する。

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日本学会事務センター気付
日本古生物学会　　編集長

—4　投稿に際しては，別に定める投稿カードに必要事項を記入し，原稿類とは別便で上記事務局宛に送付する。

II E　**別　刷**

—1　別刷は，無表紙120部までを無償で著者（複数の場合は分配）に供与する。それ以上の部数または表紙等に要する費用は，著者自身の負担とし，直接印刷所に支払うものとする。

付　則

i)　本規約の発効・改訂・廃止に関しては，評議員会の議を経て，総会の承認を得なければならない。

ii)　本規約の発効により，従来の「日本古生物学会報告・紀事出版規定」は失効する。

POLICY PROVISIONS OF THE TRANSACTIONS AND PROCEEDINGS OF THE PALAEONTOGICAL SOCIETY OF JAPAN

(January 16, 1973)

I　Publishment and Editing

IA　Issue

—1　The "Transactions and Proceedings of the Palaeontological Society of Japan" (TPPSJ) will be published quarterly.

IB　Contents

—1　TPPSJ will include original papers and notes that comply with Article 2 of the Constitution of the Society as well as the proceedings of the Society meetings and news concerning any aspect of palaeontology.

—2　Contributions will be published in the order of the acceptance by the Editorial Board.

IC　Circulation

—1　All members of the Society and some organizations specified by the Council will generally receive TPPSJ free of charge. Non-members and institutions are invited to become subscribers.

ID Editorial Board

—1 The Editorial Board will be responsible for editing TPPSJ according to the policy provisions of the Society.

—2 The Editorial Board will be composed of the Editor in Chief, who must be a member of the Council, and several members designated by the Executive Committee. All editorial meetings will be called by the Editor in Chief.

—3 The Editor in Chief will have the authority to submit a copy of the manuscript under consideration to an appropriate person for reviewing.

—4 The final decision on the acceptance or rejection of submitted manuscript will be made by the Editorial Board at an editorial meeting. The Editor in Chief will report the results of the meeting to the Executive Committee.

—5 Rejected manuscript will be returned to the author with an explanation of the reason for its rejection.

—6 An author who disagrees with the decision of the Editorial Board may take his complaint to the Council. Both the Editorial Board and the author must abide by the final judgement of the Council.

IE Proof Reading

—1 Proofs will be read, as a rule, by the Editorial Board. A set of page proofs without the original manuscript will be sent to the author.

II Contribution

IIA Eligibility

—1 All members of the Society may submit contributions to TPPSJ. Contributions from non-members will be accepted for publication if they are approved by the Executive Committee.

—2 Manuscript should be written, as far as possible, in English, French or German, and should have been read at an annual meeting or ordinary meeting of the Society.

IIB Limitation of Manuscript

—1 Manuscript should be typewritten, and should be limited to 24 printed pages including tables and text-figures. Two plates may also be added to it. Plates may not be attached to the articles of up to 4 printed pages only without the approval of the Editorial Board. Notes may not exceed one printed page, and no plate may be used for it.

—2 Ten figures or 600 cm^2 of the total printed area will be permitted for a single article. Two figures or 200 cm^2 of the total for article of less than 4 printed pages. The original illustrations should be neat and legible to permit reduction to either the width of one printed page (13.4 cm) or one column (6.4 cm). Figures should be kept separate from the text of the manuscript.

—3 Excess printing charges for articles exceeding the stated limit must be borne by the author.

IIC Style of Manuscript

—1 Generic and specific names and special words should be indicated in the manuscript.

—2 Suggested positions of tables and text-figures should be indicated in the margin of the text.

—3 Captions and explanations of text-figures, tables and plates should be submitted on separate sheets of paper numbered independently from the text.

—4 References cited should be listed in a bibliography at the end of the text in alphabetical order under the author's name, and in chronological order, as follows:

Author's name, year, title of article, name of journal (underlined), vol., no., pages, plates, etc.

—5 It is recommended that an alphabetical list of romanized geographical names be included with Kanji (Chinese ideograph), if any. The annotated list will be placed at the end of the text.

—6 Name(s) and professional or private present address of the author(s) should appear below the title of the manuscript.

—7 All manuscripts with the exception of notes should be accompanied by an abstract in Japanese of 800-words or less on separate sheet(s) of paper. The abstract should include the title in Japanese and the author's name. Abstracts of papers by non-Japanese speaking authors will be prepared by the Editorial Board if an English abstract be submitted with the manuscript.

IID Obligation of Author

—1 Authors are expected to follow the directions of the Editorial Board regarding editorial matters.

—2 Manuscripts will be returned to an author if he wishes to make large-scale revisions. The revised manuscript must be submitted as a new contribution.

—3 Manuscript should be accompanied by a complete copy including text-figures, tables and plates. Manuscript should be sent to

Editor in Chief
Palaeontological Society of Japan
c/o Business Center for Academic Societies
4-16, Yayoi 2 chome, Bunkyo-ku, 113 Tokyo, JAPAN

—4 The author should fill out the register card for contributions and send it to the Society office under separate cover.

IIE Reprints

—1 120 reprints without covers will be furnished free of charge. Excess charges for printed covers, additional reprint copies, etc. will be borne by the author who must pay the amount directly to the publisher.

Proviso

i) Effecting, amending or rescinding of policy provisions will be considered by the Council, and must be approved by the general meeting of the Society.

ii) The approved policy provisions will nullify and replace existing "Regulations for Publication in Transactions and Proceedings of the Palaeontological Society of Japan".

◎ 本会誌の出版費の一部は文部省研究成果刊行費による。

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