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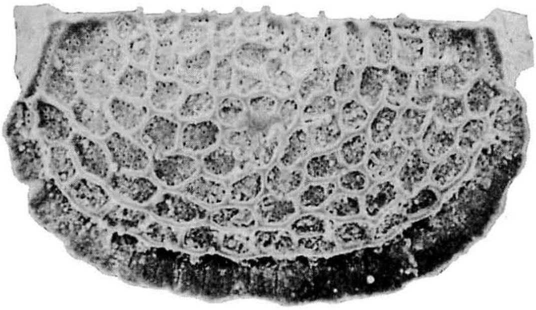

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The ostracod carapace on the cover is an adult specimen of *Manawa konishii* NOHARA (Suborder Palaeocopina, Family Punciidae) from the East China Sea. (photo by K. ABE, x190)

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760. PALEOENVIRONMENT OF THE PLIO-PLEISTOCENE DAISHAKA FORMATION, TSUGARU BASIN, NORTHEAST JAPAN*

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Abstract. This paper presents a brief discussion on the relationship between the molluscan assemblages and the sediments of the Daishaka Formation, and the inferred sedimentary environment. The stratigraphy and the lithological change in time and space were studied in detail through the correlation using several tuff and pumice conglomerate layers as key beds. The molluscan assemblages of the Daishaka Formation, which belong to the "Omma-Manganjian fauna", are grouped into seven categories, judging from the molluscan fossils regarded as actually or nearly autochthonous. These autochthonous assemblages seem to be very consistent with the sediments representing both the substratum and the water depth at that time. Almost all the sediments were deposited in the sublittoral zone. Generally speaking, the finer sediments, prevailing in the lower parts of the lower and upper units of this formation, were deposited in the lower sublittoral zone, and the remaining coarser sediments in the upper sublittoral zone.

Introduction

The Plio-Pleistocene Daishaka Formation, distributed in the northeastern part of the Tsugaru Basin, Aomori Prefecture, contains many well-preserved marine fossil invertebrates. Paleontological studies were published on molluscs (Nomura and Hatai, 1935; Iwai, 1962, 1965), brachiopods (Kotoh, 1957) and bryozoa (Kataoka, 1957). Molluscan fossils of the Daishaka Formation are characterized by cold and shallow water species and have been assigned to the "Omma-Manganjian fauna" by Otuka (1939), which is known mainly from the Plio-Pleistocene sediments distributed on the Japan Sea side of Honshu and Hokkaido.

In this paper, the writer intends to give brief description on the molluscan fauna which occurs in various kinds of sediments at many horizons of the Daishaka Formation, and to discuss the sedimentary environment at that time. This work is completed by going through the following steps of study.

1. (1) Exact correlation by using several tuff layers as key beds.
2. (2) Analysis of depositional environment based on the nature of the sediments.
3. (3) Representation of distribution of molluscan assemblages in terms of species association.

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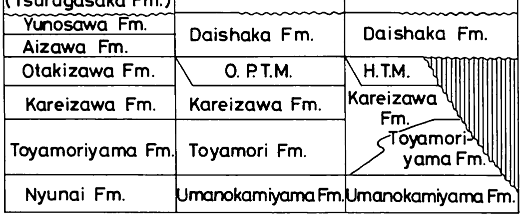
Outline of geology of the area studied

The Late Cenozoic deposits are extensively distributed in the marginal area of the Tsugaru Basin. The surveyed area occupies the northeastern part of this basin and can be divided into two areas, northern and eastern areas (Text-fig. 1). Stratigraphic successions proposed by previous authors are shown in Table 1 in comparison with the writer's view.

Foldings and faultings trending approximately N-S direction prevail over the entire area. Elongate dome structure with an axis plunging south is known in the northern area. The Late Cenozoic deposits in this area are divided into the Umanokamiyama, Toyamoriyama, Kareizawa, Daishaka, Tsurugasaka, Maedanome Formations, Towada-Hakkoda volcanic ejecta and terrace deposits in upward sequence.

Table 1. Stratigraphy of the study area: a comparison with previous works.



I. KATO et al. (1959)	T. IWAI (1965)	R. TABUKI this paper
Hongo Fm. (Tsurugasaka Fm.)	Tsurugasaka Fm.	Tsurugasaka Fm.
Yunosawa Fm.	Daishaka Fm.	Daishaka Fm.
Aizawa Fm.		
Otakizawa Fm.	O. P.T.M.	H.T.M.
Kareizawa Fm.	Kareizawa Fm.	Kareizawa Fm.
Toyamoriyama Fm.	Toyamori Fm.	Toyamoriyama Fm.
Nyunai Fm.	Umanokamiyama Fm.	Umanokamiyama Fm.

O. P.T.M. : Otakizawa Pumice Tuff Mbr.
H.T.M. : Hitotsumori Tuff Mbr.

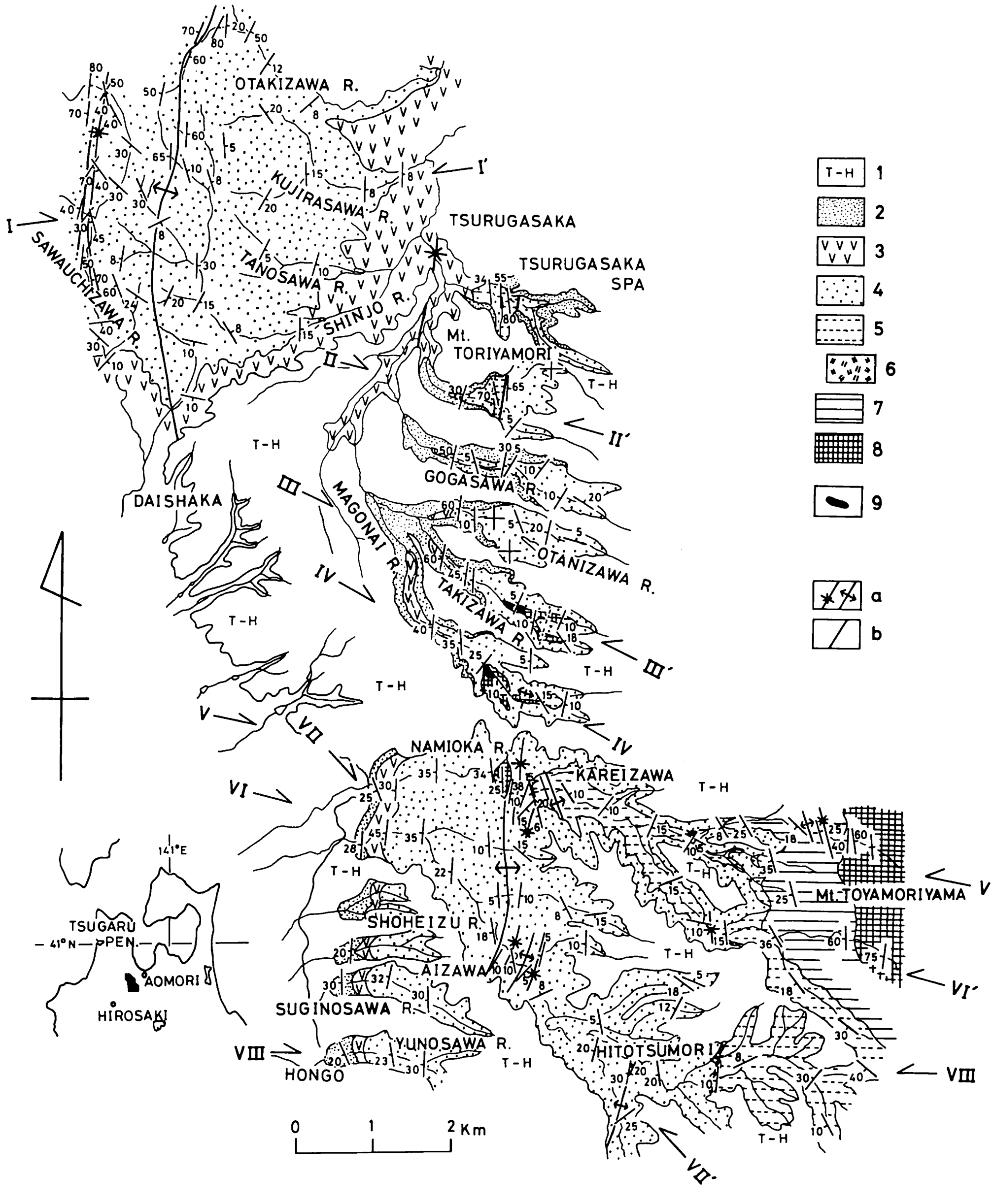
The Umanokamiyama Formation: This formation is the lowest strata in this area and consists of andesitic volcanic breccia, pale-green to grayish white tuff and grayish to black siliceous shale. The thickness is more than 300 meters.

The Toyamoriyama Formation: This formation conformably overlies the Umanokamiyama Formation and consists of well-stratified hard siltstone. The thickness is approximately 380 meters.

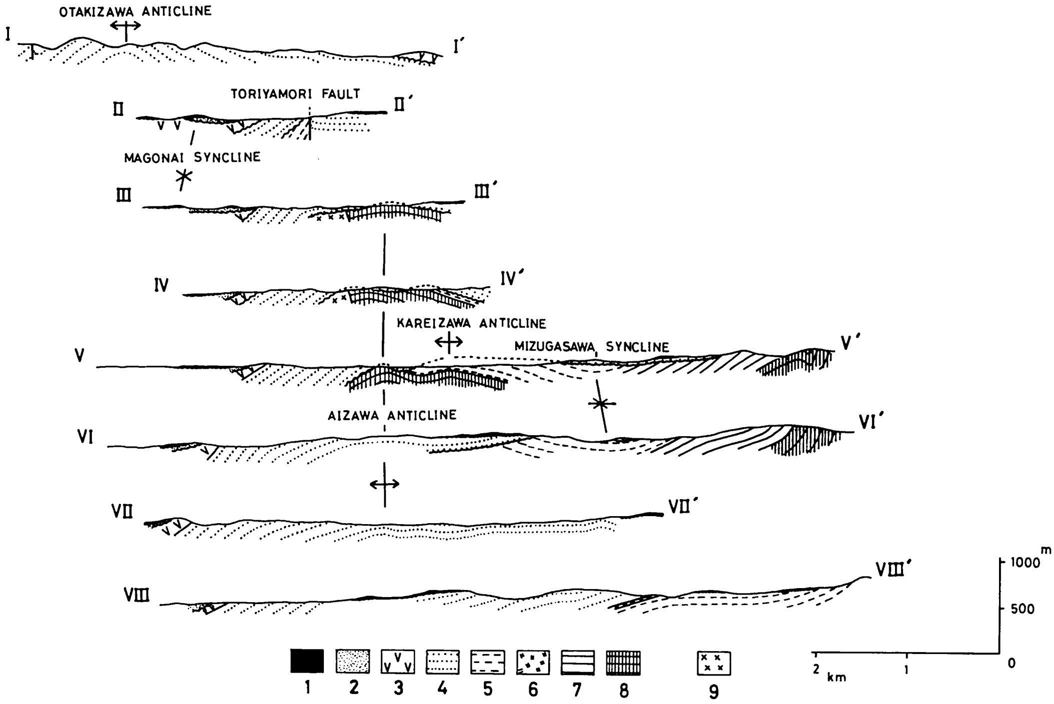
The Kareizawa Formation: This formation is composed of grayish massive diatomaceous siltstone. The uppermost white fine tuff with approximately 10 meters in maximum thickness is separable from the main part of this formation and is here designated as the Hitotsumori Tuff Member. Iwai (1965) regarded it as belonging to the Otakizawa Pumice Tuff Member, but as the result of the writer's field survey, the member at Otakizawa (type locality) should be included in the lower unit of the Daishaka Formation. The Kareizawa Formation conformably overlies the Toyamoriyama Formation on the east flank of the Mizugasawa Syncline. On the west flank, however, the Kareizawa Formation conformably overlies the Umanokamiyama Formation with the lack of the Toyamoriyama Formation. The Toyamoriyama Formation on the east flank and the lower part of the Kareizawa Formation on the west flank, both of which are composed of siltstone, are stratigraphically lateral equivalents, because these overlie the Umanokamiyama Formation composed of siliceous shale and pyroclastics. The thickness attains a maximum of 500 meters.

In general, fossils are very rare from the Kareizawa and the underlying formations, but *Makiyama chitanii* is found commonly from shale and siltstone of the above-mentioned three formations. Diatoms occur from siltstone of the Kareizawa Formation and molluscan fossils are found rarely from siltstone of the Toyamoriyama and Kareizawa Formations.

The Daishaka Formation: This formation is mostly composed of medium to coarse-grained sandstone, with intercalations of siltstone, fine



Text-fig. 1. Index map and geological map.
1: Towada-Hakkoda volcanic ejecta, 2: Maedanome Formation, 3: Tsurugasaka Formation, 4: Daishaka Formation, 5: Kareizawa Formation, 6: Hitotsumori Tuff Member, 7: Toyamoriyama Formation, 8: Umanokamiyama Formation, 9: extrusive rock (andesite).
a: fold, b: fault.



Text-fig. 2. Cross sections.
1: Towada-Hakkoda volcanic ejecta, 2: Maedanome Formation, 3: Tsurugasaka Formation, 4: Daishaka Formation, 5: Kareizawa Formation, 6: Hitotsumori Tuff Member, 7: Toyamoriyama Formation, 8: Umanokamiyama Formation, 9: extrusive rock (adesite).
The positions of cross sections are indicated in Fig. 1.

to medium-grained sandstone and conglomerate layers. Its lower unit consists mainly of sandstone, in which fossils are rare. Its upper unit shows remarkable lateral and vertical changes in lithology. Marine invertebrates are especially abundant. In the southern part of the eastern area, this formation conformably overlies the Hitotsumori Tuff Member. However, this formation unconformably overlies the underlying formations in the northern part of the eastern area. The thickness attains a maximum of 730 meters.

The Tsurugasaka Formation: This formation is composed of grayish white pumice tuff containing subangular andesitic rock fragments. It overlies conformably the Daishaka Formation in the area around the Namioka River and south of the river, whereas an unconformity is observable in the area north of the river. The thickness attains a maximum of 150 meters in the area just between the eastern and northern areas.

These formations are covered with, in upward sequence, the Maedanome Formation (mud, sand and gravel, occasionally intercalating peat and peaty mud, 60 meters thick) and the Towada-Hakkoda volcanic ejecta (grayish white pumic tuff containing subangular andesitic rock fragments).

Extrusive andesite is found in the upper stream of the Magonai River and the upper stream of the Takizawa River, though small in scale. The extrusion is inferred to have taken place after the deposition of the Umanokamiyama Formation and before the deposition of the Daishaka Formation.

Stratigraphy and lithology of the Daishaka Formation

The exposures of the Daishaka Formation are separated into the eastern and northern areas by the Tsurugasaka Formation which lies between the two areas. The Daishaka Formation is stratigraphically divided into two units. The lower unit mainly consists of sandstone, and the upper unit mainly consists of sandstone, conglomerate and siltstone. The boundary between the lower and upper is somewhat arbitrary but can be drawn along the lower limit of the key bed DT-3, which can be traced widely both in the eastern and northern areas. In addition, the upper part of the lower unit and the entire upper unit of the Daishaka Formation are interbedded with tuff layers and pumice conglomerate, which consists of pumices of pebble and cobble size, cemented by the matrix of sand or sandy silt. Some of them (DT-1 to DT-7 (D=Daishaka, T=Tuff)) are of practical use for correlation.

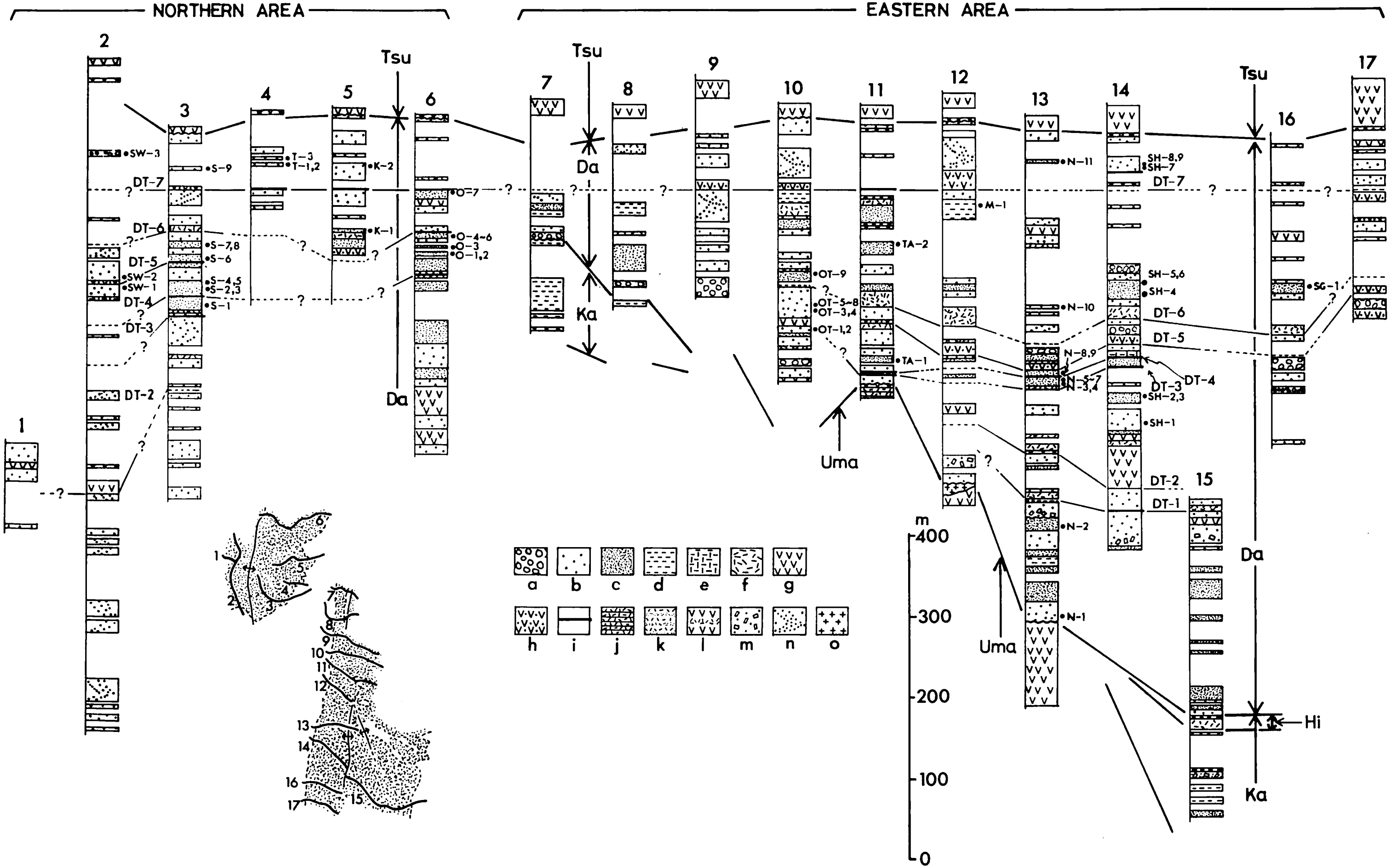
In the eastern area, the formation attains a maximum thickness of 730 meters along the route of the Shoheizu River, but becomes thinner toward the north to 110 meters thick in the neighborhood of the Tsurugasaka Spa, the northern end of the eastern area. In the northern area, the thickness of this formation attains more than 720 meters.

Descriptions of the stratigraphy and lithology of this formation are given as follows.

The lower unit: In the eastern area, the lower unit of the Daishaka Formation conformably overlies the Hitotsumori Tuff Member of the Kareizawa Foramtion. The exposure showing the conformable relation between the two formations are found in the upper stream of the Shoehizu River and the upper stream of the Namioka River. Toward the north from these areas, successively the upper horizon of the Daishaka Formation abuts against the mass of the underlying formations, the Umanokamiyama Formation and the Kareizawa Formation, with low-angle clino-unconformity in both flanks of the Aizawa Anticline north of the Namioka River. Therefore, the northern extention of the distribution of the lower unit is confiend to the southern area, south of the route of a tributary of the Magonai River. Thickness of the lower unit attains 440 meters at the route of the Shoheizu River, and decreases to the north to become 30 meters along the upper stream of the Takizawa River. However, along the upper stream of the Otanizawa River and the upper stream of the Gogasawa River, north of the Takizawa River, the thickness of the lower unit again increases to attain more than 90 meters and, to the north, abruptly decreases to thin out.

The lower unit is subdivided into two, the lower and upper parts. The lower part of the lower unit is restricted in distribution to the area around the Namioka River and south of the river. The lower part is mainly composed of dark gray to gray fine to medium-grained sandstone containing abundant carbonaceous matter. Many silt-walled burrows exist densely in the fine to medium-grained sandstone exposed along the middle stream of the Namioka River. In the middle stream of the Namioka River, the granule to pebble-bearing coarse-grained sandstone of 30 meters thick is found in the basal part of the Daishaka Formation just above the unconformity. The sandstone contains sporadically cobbles and boulders of grayish white tuff of about 10 to 200 centimeters in diameter which are probably originated from the underlying Umanokamiyama Formation.

The upper part of the lower unit of the Daishaka Formation is distributed extensively in both flanks of the Aizawa Anticline along the Gogasawa River and south of the river. The upper part lies over the lower part conformably in the area south of the Namioka River but unconformably in the middle stream of the river, and finally, to the north, it lies directly over the underlying formations without intercalation of the lower part of the lower unit. The upper part is mainly composed of pumice-bearing conglomeratic medium to coarse-grained sandstone and frequently exhibits cross lamination and cross stratification of large scale. It is


NORTHERN AREA
EASTERN AREA
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Ka
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DT-2
DT-3
DT-4
DT-5
DT-6
DT-7
SW-1
SW-2
SW-3
S-1
S-2,3
S-4,5
S-6
S-7,8
S-9
T-1,2
T-3
K-1
K-2
O-1,2
O-3
O-4-6
O-7
OT-1,2
OT-3,4
OT-5-8
OT-9
TA-1
TA-2
M-1
N-1
N-2
N-3,4
N-5-7
N-8,9
N-10
N-11
SH-1
SH-2,3
SH-4
SH-5,6
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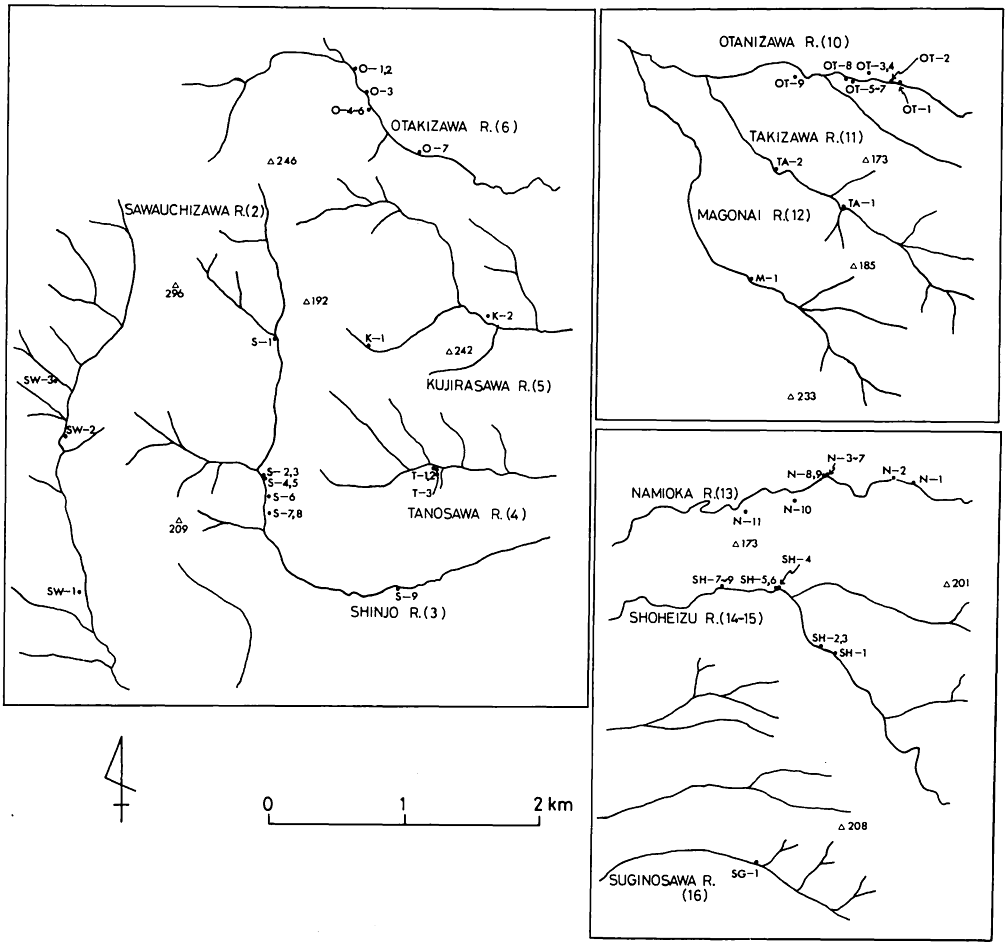

Text-fig. 4. Map showing fossil localities.
The route numbers in parentheses correspond to those shown in Fig. 3.

Text-fig. 3. Columnar sections of the Daishaka Formation with the stratigraphic positions of fossil localities.

1-17 indicate the routes along which columnar sections are obtained, and which are shown in the map where the dotted area indicates the distribution of the Daishaka Formation.

1: a tributary of Sawauchizawa River, 2: Sawauchizawa River, 3: Shinjo River, 4: Tanosawa River, 5: Kujirasawa River, 6: Otakizawa River, 7: the neighborhood of Tsurugasaka Spa, 8: a tributary of Magonai River, 9: Gogasawa River, 10: Otanizawa River, 11: Takizawa River, 12: Magonai River. 13: Namioka River, 14: lower stream of Shoheizu River, 15: upper stream of Shoheizu River, 16: Suginosawa River, 17: Yunosawa River. Uma: Umanokamiyama Formation, Ka: Kareizawa Formation, Hi: Hitotsumori Tuff Member, Da: Daishaka Formation, Tsu: Tsurugasaka Formation. a: conglomerate, b: medium to coarse-grained standstone, c: fine to medium-grained sandstone, d: massive siltstone, e: stratified siltstone, f: fine tuff, g: pumice tuff, h: "pumice conglomerate", i: thin tuff key bed, j: alternation of siliceous shale and fine tuff, k: alternation of sandstone and fine tuff, l: alternation of pumice tuff and fine tuff, m: extrusive rock, n: slumping deposits, o: cross lamination.

interbedded with many layers of tuff and pumice conglomerate. Among them, two sets of pyroclastics are useful for key beds, DT-1 and DT-2. DT-1 is restricted in distribution to the eastern area and DT-2 is traceable over the whole area studied. DT-1 is situated at the lower horizon of the upper part and has variable thickness ranging from 4 to 17 meters. It consists of white to light gray fine tuff with intercalations of conglomeratic medium to coarse-grained sandstone and sandy pumiceous tuff. DT-2 stratigraphically occupies the middle portion of the upper part and attains a maximum thickness of 73 meters at the route of the Shoheizu River. It is mainly composed of white to gray pumiceous tuff, accompanying pumiceous sandstone and white to gray fine tuff of several meters in thickness. The lowest portion of the upper part in the area south of the Magonai River is characterized by the slumping deposits containing "torn off" beds of sandstone and siltstone with abundant carbonaceous matter. These clastic rocks with abundant carbonaceous matter are characteristic of the lower part of the lower unit, and these "torn off" beds are probably derived from the lower part. Pebbles and cobbles of fine tuff and andesite are also abundant in this portion. The slumping deposits conformably overlie the fine-grained sandstone of the lower part in the middle stream of the Shoheizu River. The deposits rest upon the eroded surface of the lower part in the middle stream of the Namioka River. In the upper stream of the Magonai River, north of the Namioka River, the slumping deposits are also observed at almost the same horizon as in the above two routes, lying over the basal conglomerate which unconformably overlies the extrusive andesite without intercalation of the lower part. However, they are mainly composed of the angular cobbles and boulders of fine tuff, accompanying the pebbles and cobbles of andesite with sandy matrix, and lack in the clastics containing carbonaceous matter. In the area north of the Magonai River, the slumping deposits are absent.

In the northern area, the lower unit of the Daishaka Formation is distributed in the central part of the Otakizawa Anticline which actually shows dome structure. The lowest part of the formation is hidden under the anticlinal dome. The inferred thickness is more than 220 meters at the route of the Shinjo River and more than 440 meters at the route of the Sawauchizawa River. The lower unit is mainly composed of medium to coarse-grained sandstone, bearing granules and pebbles of fine tuff, andesite and pumice, and exhibits cross lamination.

The lower unit is poor in the occurrence of molluscan fossils except for the uppermost part. Most of molluscan fossils are discovered as molds and casts. The molluscan fossils occur sporadically in fine to medium-grained sandstone and bivalves are often articulated, whereas molluscan fossils found densely in the conglomeratic medium to coarse-grained sandstone are fragmental, suggesting allochthonous mode of occurrence.

The upper unit: In the eastern area, the upper unit is distributed in the west flank of the Aizawa Anticline, forming a monocline dipping to the west. The upper unit conformably overlies the lower unit in the Gogasawa River and in the area south of the river. In the area north of the river, the upper unit lies directly over the underlying Kareizawa Formation without intercalation of the lower unit. The thickness attains a maximum of 330 meters along the route of the Namioka River, and a minimum of 110 meters in the neighborhood of the Tsurugasaka Spa. The upper unit is mainly composed of conglomeratic medium to coarse-grained sandstone. Tuff and pumice conglomerate are frequently found in the lower part of the upper unit, of which five sets of tuff and pumice conglomerate, DT-3 to DT-7, are characteristic to recognize and are traceable over the whole area studied. The lower limit of DT-3 is defined to be the boundary between the lower unit and the upper as mentioned above. DT-3 is composed of the lower pumice conglomerate of 1 to more than 2 meters thick and the upper pale brown fine tuff with considerably variable thickness of 0.02 to 3 meters. Both parts are separated by pumiceous medium to coarse-grained sandstone of 1.5 to 4 meters thick, except at the route of the Namioka River where the intervening sandstone is absent. The total thickness of DT-3 ranges from 2.5 to 8 meters. DT-4 is the set composed of the white fine pumice layer of 0 to 15 centimeters thick and the overlying volcanic breccia of 30 to 80 centimeters thick, composed of andesite, scoria and pumice. The total thickness decreases to the north from 95 centimeters at the route of the Shoheizu River to 30 centimeters at the route of the Otakizawa River where the pumice layer is absent. DT-5 consists of the pumice conglomerate composed of pumice and scoria of granule to cobble size with the matrix of medium to coarse-grained sand, frequently intercalating the laminae of pumiceous medium to coarse-grained sand. At some routes, light brown fine tuff lies over, or below this pumice conglomerate. The overlying fine tuff ranges from 15 to 450 centimeters thick and the underlying tuff from 30 to more than 600 centimeters thick. The thickness of the conglomerate attains a maximum of 8 meters at the route of the Shoheizu River and a minimum of 3 meters at the route of the Shinjo River. DT-6 is assigned to the light brown fine tuff which consists of the alternation of coarser-grained and finer-grained layers of 3 to 20 centimeters thick, and intercalates the laminae of pumice. At the two routes of the Shoheizu River and the Magonai River, pumice conglomerate of 70 to 200 centimeters thick is interbedded in the fine tuff. The total thickness attains a maximum of 24 meters at the route of the Magonai River and decreases to the north and to the south and attains a minimum of 3 meters at the route of the Otakizawa River. DT-7 consists of the pumice conglomerate composed of pumice of 1 to 10 centimeters in diameter, containing the granules and pebbles of andesite and siltstone, with the matrix of medium to coarse-grained sand, and intercalates several beds of pumiceous medium to coarse-grained sandstone.

The total thickness attains a maximum of 20 meters at the route of the Magonai River. In the lower part of the upper unit, dark gray to gray fine to medium-grained sandstone and siltstone predominate in several horizons, but generally change laterally into medium to coarse-grained sandstone. In the area south of the Takizawa River, the conglomerate is found around the boundary between the lower and upper units, and it becomes thick toward the south. The conglomerate contains many subangular granules and pebbles of andesite of 0.2 to 3.0 centimeters in diameter, accompanying granules and pebbles of pumice, scoria and tuffaceous siltstone, cemented by relatively small amount of sand. To the north of the Magonai River, the conglomerate changes laterally into medium to coarse-grained sandstone. The upper part of the upper unit is mainly composed of pumice-bearing conglomeratic medium to coarse-grained sandstone with cross lamination. In the upper part of some localities, molluscan shells occur abundantly, and bivalves are commonly disarticulated. The uppermost part of the upper unit is occasionally interbedded with several beds of peat and peaty mud.

In the northern area, the upper unit is distributed so as to surround the lower unit. The sequence attains 280 meters along the route of the Sawauchizawa River and 230 meters along the route of the Shinjo River. The lithology of the lower part of the upper unit is different between in the west flank of the Otakizawa Anticline and in the east flank. In the west flank, conglomeratic medium to coarse-grained sandstone with cross lamination predominates. Thick coquina beds containing molluscan shells, mostly fragmental, are present in the middle portion of the lower part. In the east flank, on the contrary, fine to medium-grained sandstone predominates in several horizons, as is seen in the eastern area. Similar lithology to the lower part of the west flank is found in the upper part of the upper unit throughout the northern area. At some places, however, the upper part is interbedded with thin beds of pumice and silt, and contains abundant molluscan and brachipod shells of allochthonous occurrence. Peat beds are occasionally found in the uppermost part of the upper unit.

In the upper unit, abundant marine invertebrate fossils are found in various kinds of sediments. The relationship between the sediments and the modes of occurrence of molluscan shells is generally similar to that recognized in the lower unit.

Analysis of molluscan fossils from the Daishaka Formation

The following six types of sediments which contain molluscan fossils are recognizable in the Daishaka Formation:

(A) Sandy silt
(B) Silty fine-grained sand
(C) Granule to pebble-bearing ill-sorted fine to medium-grained sand
(D) Granule to pebble-bearing calcareous sandy silt or silty sand
(E) Conglomeratic medium to coarse-grained sand
(F) Gravel

In the sediments (A) and (B), molluscan shells occur at some places. The majorithy of bivalves are disarticulated. They occur sporadically, densely in lenticular beds or lying parallel to the bedding plane along the laminae of relatively coarse-grained sand. A few articulated bivalves are also found. In the sediments (C), molluscan shells occur relatively densely and form shell beds at some places. The sediments (D) is characterized by the grayish white colour, reflecting their sediment grain dominated by shell fragments. Molluscan shells occur densely to form shell beds. Most of bivalves are disarticulated, lying parallel to the bedding plane. In the sediments (A) to (D), shells are found in various modes of occurrence, but as a whole, shells do not suffer from destruction or abrasion. In the sediments (E), however, shells show an allochthonous occurrence and form shell beds at some places. Shells are generally ill-preserved, fragmental and remarkably abraded, suggesting the effect of transportation over much distance. In some cases, however, well-preserved shells are found abundantly, and some of them are found even in living position. In Loc. OT-4, the individuals of *Panomya arctica* occur at upright position and apart from one another with a relatively constant distance. Shells in gravel (F) are very rare. In general, shells are ill-preserved and at some places most of them are fragmental and abraded.

Theoretically, reconstruction of paleoenvironment should be based only on the ecological data of the molluscs which are proved to be autochthonous in occurrence. The term, assemblage here used, do not necessarily mean to have relationship among the constituent species. Two species occurring together may be a result of transportation, accidental in terms of the ecology. However, the shells with scarce destruction and abrasion may suggest that they were not transported for long distance, thus are taken into account as one of the informative data at the time of discussion to reconstruct paleoenvironment. Under such a precondition, seven assemblages of fossil molluscs, whose constituents are mostly autochthonous (or if not strictly autochthonous, their habitats are expected near the present localities), are recognized. Each assemblage is named after the dominant species in the number of individuals. The mode of life and the feeding type of the constituent species of these assemblages are to considerable extent related to the nature of the sediments in which these fossils are embedded. The importance of bottom character as controlling factor on the distribution of molluscs is recognized in many recent faunal studies of molluscs. Thus it is natural that these assemblages of species have a certain relation with the lithology. Most of the constituents of the above-mentioned assemblages in sandy silt and silty fine-grained sand are composed of infaunal species and are deposit or suspension feeders. However, the constituents of other assemblages in coarser sediments are commonly composed of both of infauna and epifauna, and are mostly suspension feeders. In general, it may be said that as the sediments containing molluscs get coarser, infaunal species become fewer both in the numbers of species and individuals.

Various neontological informations on the ecology of living molluscs are used to estimate the paleoenvironments. These informations are mainly derived from Yamamoto and Habe (1958, 1959, 1962), Habe and Ito (1965), Oyama (1973) and Habe (1975a, 1975b, 1977).

The seven assemblages are briefly described as follows:

A. *Acila nakazimai-Macoma calcarea* assemblage

This assemblage is found in sandy silt (A) and silty fine-grained sand (B) of the lower part of the upper unit in the eastern area (Loc. M-1 and TA-2). Articulated individuals of *Acila nakazimai* overwhelm those of other species. The assemblage is characterized by the inhabitants of muddy and sandy bottom of the lower sublittoral zone, probably ranging from approximately 50 meters to more than 100 meters in depth.

B. *Portlandia japonica-Yoldia notabilis-Macoma calcarea* assemblage

This assemblage is confined to silty fine-grained sand (B) of the lower part of the upper unit in the northern area (Loc. S-1, S-2, S-3, S-4, S-5, S-6, S-7, O-1, O-2 and O-7). In most cases, *Portlandia japonica* or *Yoldia notabilis* dominates. But, one of these two species dominates with the rare occurrence or the absence of the another in the same locality, probably reflecting delicate difference of ecological requirements of these species. *Cryptonatica janthostomoides*, *Nuculana ikebei* and *Robaia robai* are commonly found in this assemblage. The assemblage is characterized by the inhabitants of muddy and sandy bottom of the lower sublittoral zone.

C. *Nuculana pernula sadoensis-Portlandia japonica-Limopsis tokaiensis* assemblage

This assemblage is found in silty fine-grained sand (B) of the lower part of the upper unit in the northern and eastern areas (Loc. S-8, N-3, N-4 and N-5). This assemblage is similar to the above-mentioned B assemblage, but is different in the occurrence of *Nuculana pernula sadoensis* and the absence of *Yoldia notabilis*, *Nuculana ikebei* and *Robaia robai*. The constituent species of this assemblage are mostly the inhabitants of muddy and sandy bottom of the lower sublittoral zone.

D. *Astarte borealis-Venericardia ferruginea-Nuculana pernula sadoensis-Polynemamussium alaskense* assemblage

This assemblage is found in granule to pebble-bearing ill-sorted fine to medium-grained sand (C) of the uppermost part of the lower unit in the eastern area, and of the lower part of the upper unit in the northern and eastern areas (Loc. K-1, O-3, O-4, O-5, OT-9, TA-1, N-6, N-7, N-8, N-9, SH-2 and SH-3). A species questionably assigned to the Veneridae and *Limopsis tokaiensis* are other common constituents. Particularly, at all localities in the northern area (Loc. K-1, O-3, O-4 and O-5), Veneridae? species are found abundantly. The occurrence of *Polynemamussium alaskense* is limited only to this assemblage, and *Turritella fortilirata* is also characteristic species of this assemblage, though the individuals of the species are relatively few. The assemblage includes muddy and sandy bottom dwellers of the lower sublittoral zone.

E. *Acesta goliath-Ezocallista brevisiphonata-Astarte borealis* assemblage

This assemblage is confined to granule to pebble-bearing sandy silt or silty sand (D) of the uppermost part of the lower unit and the lower part of the upper unit in the eastern area (Loc. OT-2, OT-5, OT-8, N-10, SH-4, SH-5, SH-6 and SG-1). Besides the above-mentioned three species, *Nuculana pernula sadoensis*, *Chlamys cosibensis* and *Monia macroschisma* are commonly found. The assemblage contains epifaunal species abundantly. Here, the epifauna is mainly composed of sessile molluscs, lacking in such scallops as *Mizuhopecten*. The living forms of the constituent species of this assemblage are mostly known from the upper sublittoral zone, ranging approximately from 0 to 50 meters in depth, although *Acesta goliath* is living below 100 meters deep.

F. *Ezocallista brevisiphonata-Glycymeris yessoensis-Chlamys cosibensis* assemblage

This assemblage is found in conglomeratic medium to coarse-grained sand (E) of the upper unit in the eastern area (Loc. OT-3, OT-7, SH-8 and SH-9). *Mizuhopecten yessoensis yokoyamae* is commonly found in conglomeratic sand.

Table 2. List of representative molluscan fossils from the Daishaka Formation.
○ rare to common, ◎ abundant

Lithology	Sandy silt		Silty fine sand													
Assemblage	Acila-Macoma		Portlandia-Yoldia-Macoma										Nuculana-Portlandia-			
Species / Locality	M-1	TA-2	S-1	S-2	S-3	S-4	S-5	S-6	S-7	O-1	O-2	O-7	S-8	N-3	N-4	N-5
Acila nakazimai OTUKA	◎	◎										○				
A. vigilia SCHENCK							○				◎					
Ennucula tenuis (MONTAGU)				○	○		○		○	○					○	
Nuculana pernula sadoensis (YOKOYAMA)													○	○	◎	◎
N. yokoyamai (KURODA)	○	○					○	○					○			
N. ikebei (SUZUKI & KANEHARA)					○	○	○		○	○						
Robaia robai (KURODA)		○								○	○	◎				
Yoldia notabilis YOKOYAMA					◎	◎	○			◎	○	◎				
Portlandia japonica (A.ADAMS & REEVE)			◎	○	○	○	◎	◎	○	○	◎	○	◎	◎	○	
Arca boucardi JOUSSEAUME																
Glycymeris yessoensis (SOWERBY)																
Limopsis tokaiensis YOKOYAMA					○					○				○	○	○
Mytilus crassitestus LISChKE																
Modiolus margaritaceus (NOMURA & HATAI)										○			○			
Solamen spectabilis (A.ADAMS)									○	○			◎			
Polynemamussium alaskense (DALL)																
Chlamys cosibensis (YOKOYAMA)																
C. daishakaensis (MASUDA & SAWADA)																
C. swiftii (BERNARDI)																
Mizuhopecten yessoensis yokoyamae (MASUDA)																
Monia macroschisma (DESHAYES)																
Acesta goliath (SOWERBY)																
Limaria hakodatensis (TOKUNAGA)																
Limatula vladivostokensis SCARLATO										○			○			
Lucinoma annulata (REEVE)																
Thyasira tokunagai KURODA & HABE		○			○			○	○	○	○		○		○	
Venericardia ferruginea (CLESSIN)																
Miodontiscus nakamurai (YOKOYAMA)												○				
Astarte borealis (SCHUMACHER)																
A. alaskensis DALL												○				
Clinocardium chikagawaense KOTAKA																
Serripes groenlandica (BRUGUIÈRE)										○	○					
Spisula voyi alaskana DALL																
Cadella lubrica (GOULD)	○															
Macoma calcarea (GMELIN)	○	○	○		○	○	○		○	◎	○	◎		○		○
Macoma contabulata (DESHAYES)																
Mercenaria stimpsoni (GOULD)																
Callithaca adamsi (REEVE)																
Ezocallista brevisiphonata (CARPENTER)																
Mya japonica JAY																
Caryocorbula venusta (GOULD)																
Panomya beringiana DALL												○				
P. arctica (LAMARCK)																
Pholadidea penita CONRAD																
Puncturella nobilis (A.ADAMS)																
Homalopoma amussitatum (GOULD)																
Cocculina japonica DALL				○												
Turritella fortilirata SOWERBY																
Bittium yokoyamai OTUKA																
Neverita reiniana (DUNKER)																
Cryptonatica janthostomoides (KURODA & HABE)			○	○	○	○	○	○		◎	○		○			
Neptunea arthritica hirosakiensis IWAI																
Mohnia yanamii (YOKOYAMA)						○				○	○					
Fusitriton oregonensis (REDFIELD)																
Crepidula turugasakana NOMURA & HATAI																
Cancellaria kobayashii (YOKOYAMA)																
Antiplanes contraria (YOKOYAMA)																
Turbonilla shigeyasui YOKOYAMA																
Cadulus opportunus (KURODA & HABE)				◎			○		◎	○	○		○			
Dentalium rhabdotum (PILSBRY)								○					○			

Gra.-bearing fine to medium sand												Gra.-bearing sandy silt or silty sand								Medium to coarse sand				Gravel																
Astarte-Venericardia-Nuculana-Polynemamussium												Acesta-Ezocallista-Astarte								Ezocallista-Glycymeris-				Chlamys-	"other assemblages"															
																									type 1													type 2		
K-1	O-3	O-4	O-5	OT-9	TA-1	N-6	N-7	N-8	N-9	SH-2	SH-3	OT-2	OT-5	OT-8	N-10	SH-4	SH-5	SH-6	SG-1	OT-3	OT-7	SH-8	SH-9	SW-3	SW-1	SW-2	S-9	T-1	T-2	T-3	K-2	O-6	OT-1	OT-6	N-11	SH-1	SH-7	N-1	N-2	OT-4
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◎		O										O		O				O		O							◎					◎	O							
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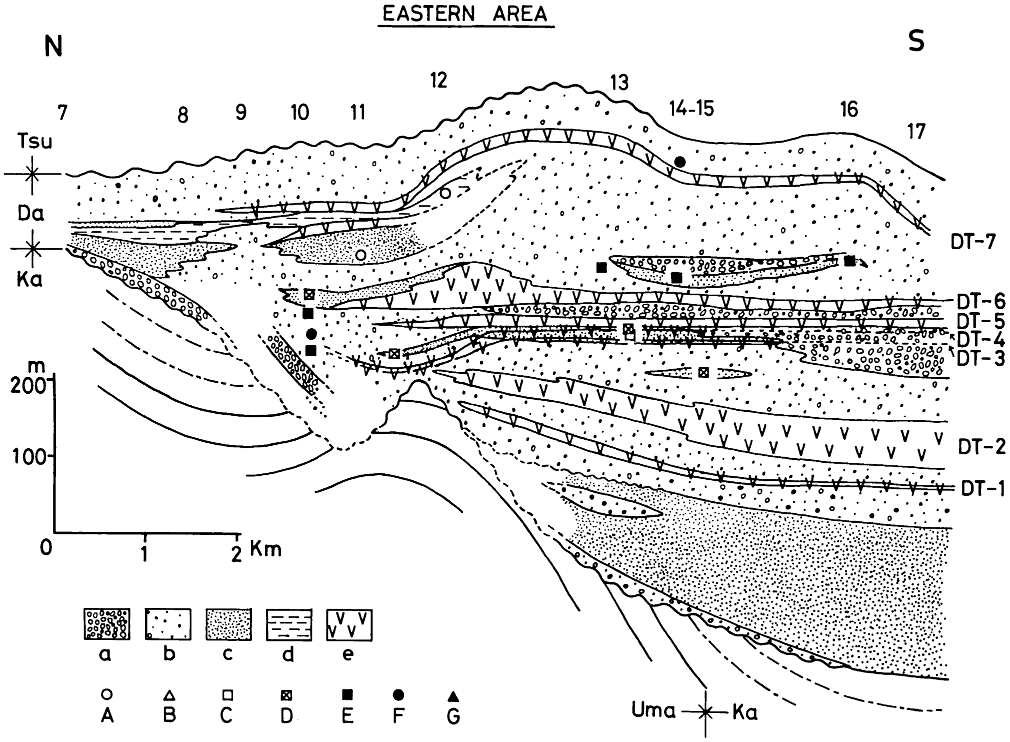


Text-fig. 5. Schematic stratigraphic section, including the distribution of the molluscan assemblages. (Fig. 5-1: eastern area, Fig. 5-2: northern area)
The route numbers and the abbreviations of formations correspond to those shown in Fig. 3. a: conglomerate, b: medium to coarse-grained sandstone, c: fine to medium-grained sandstone, d: siltstone, e: pyroclastic rock. A: *Acila nakazimai-Macoma calcarea* assemblage, B: *Portlandia japonica-Yoldia notabilis-Macoma calcarea* ass., C: *Nuculana pernula sadoensis-Portlandia japonica-Limopsis tokaiensis* ass., D: *Astarte borealis-Venericardia ferruginea-Nuculana pernula sadoensis-Polynemamussium alaskense* ass., E: *Acesta goliath-Ezocallista brevisiphonata-Astarte borealis* ass., F: *Ezocallista brevisiphonata-Glycymeris yessoensis-Chlamys cosibensis* ass., G: *Chlamys cosibensis-Chlamys swiftii* ass.

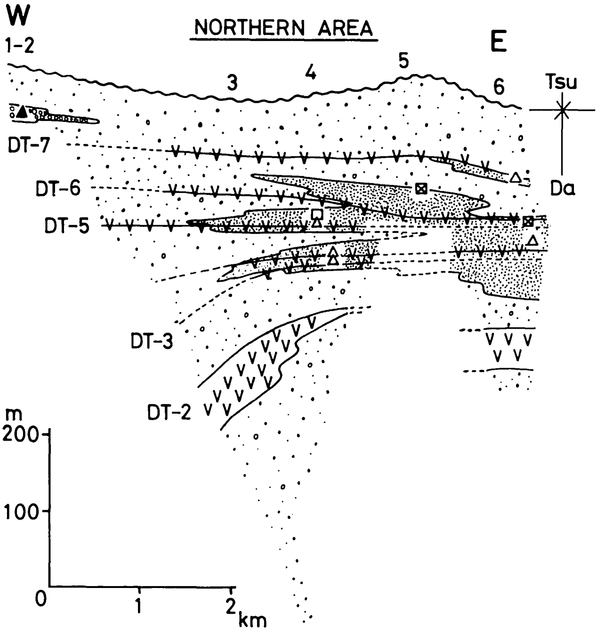
Nuculana pernula sadoensis occurs where sand gets muddy. The constituents are the inhabitants living on sandy and gravely bottom of the upper sublittoral zone.

G. *Chlamys cosibensis-Chlamys swiftii* assemblage

This assemblage is found in gravel (F). It is so far found from only one locality, Loc. SW-3 which is situated near the uppermost horizon of the upper unit in the northern area. The assemblage is dominated by pectinids shells. The members of this assemblage seem to be the inhabitants of gravely bottom of the upper sublittoral zone.

H. Other assemblages

Various assemblages not assignable to any one of the above seven assemblages are included in this category. A type of assemblage assignable to this category may be composed exclusively of allochthonous molluscs which are mostly contained in conglomeratic medium to coarse-grained sand and are suffered remarkably from



destruction and abrasion (Loc. SW-1, SW-2, S-9, T-1, T-2, T-3, K-2, O-6, OT-1, OT-6, N-11, SH-1 and SH-7). These assemblages are usually characterized by the molluscs derived from various environments of upper sublittoral zone. Another type of assemblage of this category may be characterized by the small number of individuals (Loc. N-1, N-2 and OT-4). Two species, *Arca boucardi* and *Macoma* sp., occur from coarse-grained sand of Loc. N-1, and three species, *Macoma calcarea*, *Crenella columbiana* and *Nuculana yokoyamai* from fine to medium-grained sand of Loc. N-2. Molluscs from both localities occur sporadically and, particularly, those from Loc. N-2 are relatively well-preserved, indicating nearly autochthonous mode of occurrence. Molluscan fossils from Loc. OT-4 are characteristic in the occurrence of three articulated individuals of *Panomya arctica*, standing upright in the silty medium-grained sand. In this type, rareness does not necessarily correspond with the poorness in informative source for environment at that time.

Paleoenvironment of the Daishaka Formation

On the basis of the analysis on the stratigraphy, lithology and molluscan assemblages, the writer attempts to infer synthetically the paleoenvironment at the time of the deposition of the Daishaka Formation.

The lower unit: The lower unit of the Daishaka Formation is poor in molluscan fossils, and therefore, only a few data are actually available for analysis on the sea level change at the time of deposition. In fact, no fossils allowing species identification have so far been found from the northern area.

In the eastern area, the lower unit overlies conformably the Kareizawa Formation in the southeastern part and, to the north, successively abuts the underlying Umanokamiyama and Kareizawa Formations, and is absent in the northernmost part. It indicates that at the beginning of the deposition of the Daishaka Formation, the depositional area was confined only to the southeastern part, and, thereafter, was extended to the north, except the northernmost part which was subjected to subaerial erosion and remained to be land area throughout the time of deposition of the lower unit.

In the middle stream of the Namioka River of the eastern area, the coarse-grained sandstone at the lowermost part of the lower unit contains two species of molluscs, *Arca boucardi* and *Macoma* sp. (Loc. N-1), indicating a relatively shallow upper sublittoral water at the beginning of the deposition of the Daishaka Formation in the area around the middle stream of the river. Along the same river, the fine to medium-grained sandstone overlying the coarse-grained sandstone mentioned above contains sporadically three species of molluscs, *Macoma calcarea*, *Crenella columbiana* and *Nuculana yokoyamai* (Loc. N-2). The occurrence of three species may indicate that the sea at the time was under lower sublittoral environment.

The fine to medium-grained sandstone of the lower part of the lower unit abruptly changes upward into the conglomeratic medium to

Table 3. Recent ecological data of some molluscan species.
1: Oyama (1973), 2: Habe and Ito (1965), Habe (1975a, 1975b, 1977).

Species		Geographical distribution	Bathymetric range	Bottom character
Acila vigilia	2	Choshi to Kuril Is., Japan Sea	100 to 500m	sand, mud
Ennucula tenuis	2	northward from Choshi, Japan Sea	intertidal to 250m	sand
Nuculana pernula sadoensis	2	northward from Sagami Bay, Japan Sea	100 to 200m	sand, mud
N. yokoyamai	1	P 33-40, J 32-41	N3-4B2-4	cS
	2	Kyushu to southwestern Hokkaido	50 to 450m	sand, mud
N. ikebei	2	Sagami Bay to Hokkaido	100 to 1030m	mud
Robaia robai	2	western Hokkaido, Japan Sea	100 to 250m	sand, mud
Yoldia notabilis	1	P 37-45, J 32-46	N1	S
	2	Tohoku to Okhotsk Sea	20 to 200m	sand, mud
Portlandia japonica	2	Kyushu to Honshu, Japan Sea, East China Sea	10 to 300m	sand
Arca boucardi	2	Taiwan to Hokkaido	intertidal to 20m	rock, gravel
Glycymeris yessoensis	1	P 34-44, J 34?-46	N1	S
	2	Tohoku to Kuril Is., Japan Sea	5 to 30m	sand
Limopsis tokaiensis	1	P 35-40, J 32-41		
Mytilus crassitestus	1	P 31-42, J -42	N0-1	R
	2	Kyushu to southern Hokkaido	intertidal to 20m	rock
Modiolus margaritaceus	2	Kyushu to Hokkaido, Japan Sea	30 to 450m	gravel, shell, sand
Solamen spectabilis	1	P 32-36, J 33-41	N2	sM
	2	Kyushu to Tohoku, Japan Sea, East China Sea	30 to 300m	sand, mud
Polynemamussium alaskense	2	northward from Tohoku, Japan Sea	50 to 560m	sand, mud
Chlamys swiftii	2	northward from Tohoku	intertidal to 20m	rock, gravel
Monia macroschisma	2	northward from Tohoku	shallow sea	rock, gravel
Acesta goliath	1	P 34-41, J 35-42	N4B	R, S
	2	Shikoku to southern Hokkaido, Japan Sea	100 to 1390m	sand, mud
Limaria hakodatensis	1	P 25-42	N1-2	gS, S, M
	2	Kyushu to southern Hokkaido	5 to 100m	sand
Limatula vladivostokensis	2	northward from Sagami Bay, Japan Sea	50 to 350m	sand, mud
Lucinoma annulata	1	P 31-42, J -41		
	2	northward from Kyushu	10 to 150m	mud
Thyasira tokunagai	1	P 31-64, J 32-41		
	2	Kyushu to Hokkaido, Japan Sea	5 to 50m	mud
Venericardia ferruginea	1	P 33-42, J 32-42	[N3]	[S]
	2	Kyushu to southern Hokkaido	50 to 400m	sand, mud
Miodontiscus nakamurai	2	Nemuro(Hokkaido)		
Astarte borealis	1	P 37-50, J 35-46		
	2	northward from Tohoku	10 to 360m	sand, mud
A. alaskensis	2	northward from Hokkaido, Japan Sea	100 to 200m	sand, mud
Serripes groenlandica	2	northward from Hokkaido, Japan Sea	10 to 80m	sand, mud
Spisula voyi alaskana	2	northward from Choshi	intertidal to 120m	sand, mud
Cadella lubrica	2	Tohoku to Hokkaido	subtidal to 50m	sand
Macoma calcarea	2	northward from Shikoku	intertidal to 1000m	sand, mud
M. contabulata	2	Kyushu to Hokkaido	intertidal	mud
Mercenaria stimpsoni	1	P 37-45, J 34-46	N1	S
	2	Tohoku to Kuril Is.	subtidal to 20m	sand
Callithaca adamsi	1	P 38-45, J 35-46	N1-3	mS, sM
	2	Tohoku to Kuril Is.	subtidal to 20m	sand, mud
Ezocallista brevisiphonata	1	P 36-45, J 38-46	N1-2	S
	2	Tohoku to Kuril Is.	subtidal to 30m	gravel, sand
Mya japonica	2	northward from Tohoku	subtidal	sand, mud
Caryocorbula venusta	1	P 31-42, J -43	N0-4B2	S, mS
	2	Kyushu to Hokkaido	intertidal to 200m	sand
Panomya beringiana	2	northward from Hokkaido, Japan Sea	50 to 200m	mud
P. arctica	2	northward from Hokkaido		
Puncturella nobilis	1	P 39-46, J 36-46	N1	
	2	northward from Tohoku	intertidal to 50m	gravel, sand
Homalopoma amussitatum	1	P 38-51, J 36-46		
	2	Choshi to Sakhalin	subtidal to 20m	gravel, sand
Cocculina japonica	2	northward from Tohoku, Japan Sea	50 to 200m	wood fragment etc.
Turritella fortilirata	2	Tohoku to Kuril Is., Japan Sea	50 to 200m	sand, mud
Neverita reiniana	1	P 26-35, J -37	N1-3	sM
	2	southward from Boso Pen.	10 to 30m	sand, mud
Cryptonatica janthostomoides	1	P 31-42, J -43	N1-2	S, mS
	2	Kyushu to Hokkaido	10 to 50m	sand, mud
Mohnia yanamii	2	Japan Sea(200m)		
Fusitriton oregonensis	2	northward from Sagami Bay, Japan Sea	30 to 300m	mud
Antiplanes contraria	2	Boso Pen. to Okhotsk Sea	50 to 200m	
Turbonilla shigeyasui	1	P 34-35, J 33-34	[N0-1]	[mS]
Cadulus opportunus	2	Sagami Bay to Sea of Kashima	100 to 700m	sand, mud
Dentalium rhabdotum	2	Kyushu to Honshu, Japan Sea, East China Sea	50 to 620m	mud

coarse-grained sandstone of the upper part, and the slumping deposits are characteristically found at the lowermost horizon of the upper part. In the upper stream of the Otanizawa River of the eastern area, molluscan fossils occur abundantly in the conglomeratic medium to coarse-grained sandstone of the uppermost part of the lower unit. The molluscs thought to be nearly autochthonous belong to the members of E assemblage (Loc. OT-2) and are mostly the inhabitants on sandy and gravely bottom of upper sublittoral zone. Molluscs occurring in the fine to medium-grained sandstone at almost the same horizon in the middle stream of the Shoheizu River are mostly the species of D assemblage, suggesting that the sea became deeper in the area around the Shoheizu River.

The upper unit: In the west flank of the Otakizawa Anticline of the northern area and in the area south of the Shoheizu River of the eastern area, the lower part of the upper unit of the Daishaka Formation is dominated by coarse sediments (medium to coarse-grained sand and gravel). On the contrary, in the east flank of the Otakizawa Anticline of the northern area and in the area around the Shoheizu River and north of the river of the eastern area, fine sediments (silt and fine to medium-grained sand) are sometimes found in the lower part of this unit.

In the area around the Magonai River and north of the river of the eastern area, fine sediments are dominant stratigraphically between the key beds DT-6 and DT-7, and coarse sediments predominate between DT-3 and DT-6; and *vice versa* in the area south of this river. The molluscs in the coarse sediments are dominated by the species belonging to the upper sublittoral E and F assemblages. On the other hand, the fine sediments are deposited in relatively deep lower sublittoral sea. This is indicated by the occurrence of the A, C and D molluscan assemblages in such fine sediments. This indicates that, before the deposition of DT-6, the area south of the Magonai River was covered with the relatively deep sea, and thereafter turned into the area where upper sublittoral environment predominated, and that, on the contrary, in the area around the Magonai River and north of the river, before the deposition of DT-6, the relatively shallow sea existed, and the Tsurugasaka Spa and its environs, where the sediments corresponding to DT-6 and the lower horizon are absent, might have been an area of denudation at that time, but after the deposition of DT-6, as depositional area spreaded to the north, the sea became deeper.

In the northern area, in the east flank of the Otakizawa Anticline, during the period between the deposition of DT-3 and DT-7, fine sediments were accumulated, alternating with coarse sediments, in relatively deep lower sublittoral sea represented by the B, C and D assemblages. In the west flank of the anticline, all the molluscan fossils were found as allochthonous shell beds. These molluscs are the inhabitants of the intertidal and upper sublittoral zones (ex. *Mytilus crassitestus* and *Ezocallista brevisiphonata*) (Loc. SW-1). The sediments are coarse and gravely, also indicative of very shallow environmet. Therefore, as a whole, at that time, the sea which covered the northern area became deeper from the west to the east.

The upper part of the upper unit overlying DT-7 is composed of the medium ot coarse-grained sandstone both in the eastern and northern areas. The molluscan fossils contained are allochthonous in many cases, but are mostly a mixture of upper sublittoral molluscs such as *Glycymeris yessoensis* and *Arca boucardi*, indicating that the sea became shallower after the deposition of DT-7. Coarseness of the sediments in this part also supports the conclusion. In the uppermost part of the formation, peat and peaty mud are found at many places both in the eastern and northern areas. It suggests that the sea at that time became much shallower, and even the change of depositional environment, from marine to brackish or freshwater, might have occurred.

Thereafter, in the area around the Namioka River and south of the river, deposition of the Daishaka Formation was succeeded conformably by the pyroclastic sediments of the Tsurugasaka

Formation. However, the area north of the Namioka River turned into the erosional area and the Tsurugasaka Formation unconformably overlies the Daishaka Formation.

References

Habe, T. (1975a): *Mollusca I, chiefly from Japan.* 301 pp., 74 pls. Gakken Co., Ltd. Tokyo. (in Japanese)

——(1975b): *Mollusca II, Chiefly from Japan.* 294 pp., 80 pls. Gakken Co., Ltd. Tokyo. (in Japanese)

——(1977): *Systematics of Mollusca in Japan.* Bivalvia and Scaphopoda. 372 pp., 72 pls. Hokuryukan Tokyo. (in Japanese)

——and Ito, K. (1965): *Shells of the world in colour.* Vol. 1, The northern Pacific. 164 pp., 56 pls. Hoikusha Osaka. (in Japanese)

Iwai, T. (1962): The Pliocene deposits and molluscan fossils from the northeast margin of the Tsugaru Basin, Aomori Prefecture, Japan. *Saito Ho-on Kai Mus., Res. Bull.*, no. 31, p. 35—46.

——(1965): The geological and paleontological studies in the marginal area of the Tsugaru Basin, Aomori Prefecture, Japan. *Bull. Educ. Fac., Hirosaki Univ.*, no. 15, p. 1—68, pls. 12—20.

Kataoka, J. (1957): Bryozoa from the Daishaka Formation (Pliocene), Minami-Tsugaru-Gun, Aomori Prefecture. *Trans. Proc. Palaeont. Soc. Japan*, N.S., no. 28, p. 143—153, pl. 22.

Kato, I. and Taguchi, K. (1959): *The Geology of the southwest part of Aomori City.* Publ. Aomori Pref. Govern. (in Japanese)

Koto, J. (1957): Brachiopoda from the Daishaka and Tsurugasaka fossil zones, Minami-Tsugaru-Gun, Aomori Prefecture. *Trans. Proc. Palaeont. Soc. Japan*, N.S., no. 25, p. 7—10.

Nomura, S. and Hatai, K. (1935): Pliocene Mollusca from the Daishaka shell-beds in the vicinity of Daishaka, Aomori-ken, Northeast Honsyu, Japan. *Saito Ho-on Kai Mus., Res. Bull.*, no. 6, p. 83—142, pls. 9—13.

Otuka, Y. (1939): Mollusca from the Cainozoic System of eastern Aomori Prefecture, Japan. *Jour. Geol. Soc. Japan*, vol. 46, no. 545, p. 23—31, pl. 2.

Oyama, K. (1973): Revision of Matajiro Yokoyama's Type-Mollusca from the Tertiary and Quaternary of the Kanto Area. *Palaeont. Soc. Japan, Spec. Pap.*, no. 17, p.1—147, pls. 1—57.

Tabuki, R. (1980): *The Ostracode Fauna from The Daishaka Formation.* 55 pp., (Master Thesis)

Yamamoto, G. and Habe, T. (1958): Fauna of shell-bearing molluscs in Mutsu Bay. Lamellibranchia (1). *Bull. Marine Biol. Sta. Asamushi, Tohoku Univ.*, vol. 9, no. 1, pls. 1—5.

——and —— (1959): Ditto. Lamellibranchia (2). *Ibid.*, vol. 9, no. 3, p. 85—118, pls. 6—14.

——and—— (1962): Ditto. Scaphopoda and Gastropoda (1). *Ibid.*, vol. 11, no. 1, p. 1—20.

津軽盆地の大釈迦層（鮮新—更新統）の古環境：大釈迦層に含まれる貝化石群の群集構成および堆積環境を論じた。いわゆる“大桑万願寺型動物群”の自生又は自生に近い群集として，下部浅海帯の比較的細粒な底質に生息していたと思われる4つの群集と上部浅海帯の比較的粗粒な底質に生息していたと思われる3つの群集を認めた。本層下半部については貝化石のデータは乏しいものの，下部に卓越する細粒堆積物は下部浅海帯に，上部の斜交葉理の発達した粗粒堆積物は上部浅海帯に堆積したと考えられる。上半部の下部には，海進期の堆積物で，下部浅海帯に堆積したと考えられる細粒堆積物が発達する。東部地域では，この細粒堆積物の堆積した比較的深い海域が，この時期のうちに，中央部から北部へ移動した。一方，北部地域では，東部で下部浅海帯の細粒堆積物が卓越し，西部では潮間帯，上部浅海帯の貝類を含む粗粒堆積物が発達する。すなわち，北部地域では海が西から東に向かって次第に深くなっていたその後，本層分布域全体が浅海化して終る。

田吹亮一

Trans. Proc. Palaeont. Soc. Japan, N. S., No. 130, pp. 79—84, pl. 15, July 15, 1983

761. SOME BIVALVES FROM THE LOWER JURASSIC KURUMA GROUP OF CENTRAL JAPAN*

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Abstract. Several bivalve fossils were newly obtained from the Lower Jurassic Kuruma Group in the eastern part of Toyama Prefecture, north-central Japan. The following species are described in this article: *Nuculana (Dacryoma) konishii* Hayami, *Nuculana* (*Dacryomya*) cf. *konishii* Hayami, *Pteroperna kitadaniensis* Goto n. sp., *Bakevellia* (*Neobakevellia*) sp.

Introduction

The Kuruma Group is a thick series of clastic sediments consisting of sandstones and mudstones together with some layers of conglomerates, and covers an area of more than 180 square kilometers. It exceeds 6,000 m in thickness, and is divided, in ascending order, into the Jogodani, Kitamatadani, Negoya, Teradani, Shinatani, Otakidani and Mizukamidani Formations (Kobayashi *et al.*, 1957; etc.). In some cases the sediments are carbonaceous, and thin seams of coal are intercalated.

Among the fossils contained neomiodontids are ubiquitous, while the bakevelliids are locally abundant in argillaceous sediments. They show that the series of sediments was deposited generally under brackish water conditions. Fossils of land plants such as *Cladophlebis* and *Dictyophyllum* are also known at various horizons.

Important is the occurrence of the ammonites from the Teradani and Otakidani Formations. According to Sato (1955), *Amaltheus* sp. and *Canavaria* sp. from the Teradani Formation show a late Pliensbachian age, while *Grammoceras* sp. from the Otakidani Formation suggests a latest Toarcian age. The other formations are almost barren of index fossils, but their ages may be confined to Early Jurassic. The abundant bivalves of *Crenotrapezium* and *Eomiodon* are generally found from the Jurassic-Cretaceous sediments but not from the Triassic (Hayami, 1958).

There are lower Jurassic sediments in several scattered areas of the Inner Zone of Japan. They are, from the east to the west, the Iwamuro Formation in Gunma Prefecture, the Yamaoku Formation in Okayama Prefecture, the Higuchi Group in Shimane Prefecture and the Toyora Group in Yamaguchi Prefecture. Among them the Iwamuro Formation is found about 150 km to the east of the present area on the opposite side of the Fossa Magna, and is regarded as was deposited under similar sedimentary condition.

Nuculana konishii was originally described from a marine bed (Y_2 member) of the Yamaoku Formation (Konishi, 1954; Hayami, 1961). Therefore, the present discovery seems to indicate that not only brackish water but also marine bivalves are intimately related between the Kuruma Group and the Yamaoku Formation.

The Kuruma Group, as noticed above, is brackish water sediments in general, but the upper part, at least, the Teradani Formation is thought to be neritic, as indicated by the occurrence of ammonites and such purely marine bivalves as *Plagiostoma* and *Nuculana.*

Doctor Itaru Hayami of the University of

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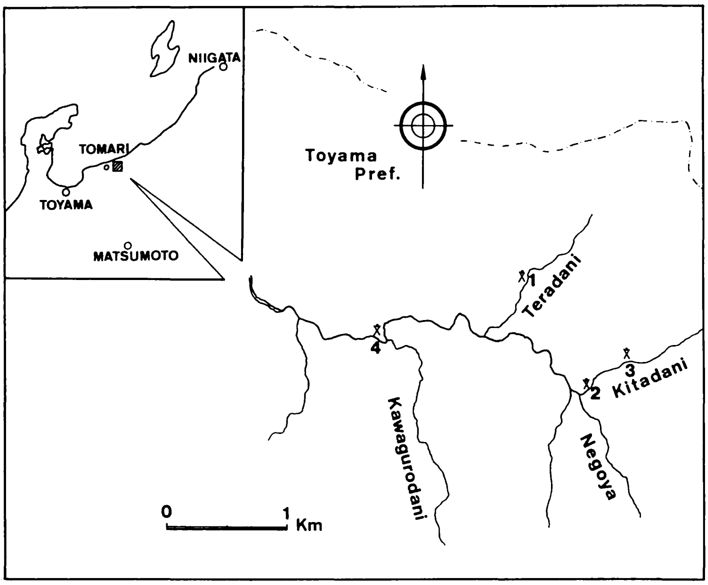
*Received June 18, 1982



Text-fig. 1. Index map of the localities of Early Jurassic bivalve fossils in northeast Toyama Prefecture

Tokyo instructed the author in the identification of specimens and read through the manuscript. Professor Noboru Yamashita of the Shinshu University supervised the field survey of the author and read through the manuscript of this introduction. Mr. Takashi Fujita of the same University prepared the photographs of the fossils here described. The author expresses his sincere gratitude to them.

Description

Family Nuculanidae

Genus *Nuculana* Link, 1807

Subgenus *Dacryomya* Agassiz, 1840

Nuculana (*Dacryomya*) *konishii* Hayami

Plate 15, Figure 1

1961. *Nuculana* (*Dacryomya*) *konishii* Hayami, p. 116, pl. 16, fig. 1.

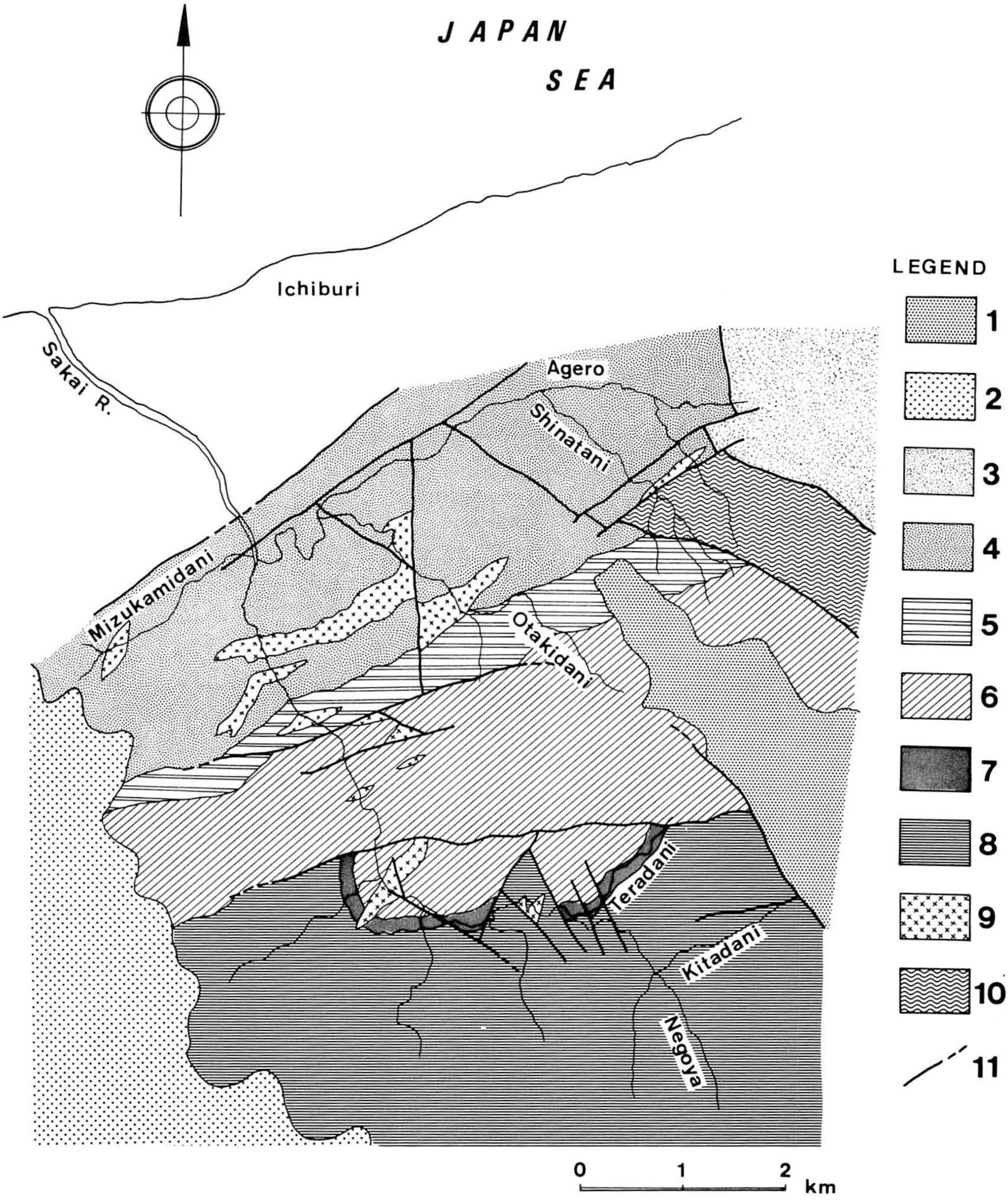
Shell spoon-shaped, highly rostrated, cuspidated backwards. Main body is subelliptical and moderately inflated; umbo is not very prominent, located at about one-third of length from front (P. 3114, 29.8 mm long, 11.5 mm high, 4.8 mm thick); anterior margin short and rounded, while postero-dorsal one is unusually long; posterior rostrum elongated, gently tapered backwards, scarcely bending upwards; surface marked with subvertical striae which are especially well marked on the anterior part of posterior rostrum. Main body marked with close striae; escutcheon narrow. Only a specimen is at hand. In the outline and characteristic surface ornaments, this is probably identical with *Nuculana konishii* from the Yamaoku Formation (Hayami, 1961).

Occurrence:—Mudstone of the upper part of the Teradani Formation at the Teradani, Asahi-machi, Shimoniikawa-gun, Toyama Prefecture.

Nuculana (*Dacryomya*) cf. *konishii* Hayami

Plate 15, Figure 2

An external mould is at hand. This is very similar to the preceding species in the surface ornamentation and outline (P. 1106, 40.8 mm + long, 15.8 mm + high, 6.0 mm thick), but the umbo is located more posteriorly. The shell size is somewhat larger in comparison with the type



Text-fig. 2. Geological map of northeast Toyama Prefecture

1. Shiratoriyama Formation, 2. Kurobishiyama F., 3. Shiritakayama F., 4. Mizukamidani F., 5. Otakidani F., 6. Shinatani F., 7. Teradani F., 8. Negoya F., 9. Porphyrite, 10. Green schist, 11. Fault

Table 1: Stratigraphic classification of the Kuruma Group

	Formation	Rock facies	Fossils
TETORI G?	Shiritakayama F. Shiratoriyama F. Kurobishiyama F.	conglomerate sandstone mudstone	
KURUMA G.	Mizukamidani F. 700 m +	sandstone mudstone conglomerate sandy mudstone	*Onychiopsis*
	Otakidani F. 450 m	mudstone sandy mudstone sandstone	*Grammoceras* *Hammatoceras* *Belemnites* *Geratrigonia*
	Shinatani F. 700 m +	sandstone mudstone	*Bakevellia* *Isognomon* *Protocardia* *Mytilus* *Crenotrapezium* *Eomiodon* *Pleuromya* *Equisetites*
	Teradani F. 250 m	sandy mudstone	*Amaltheus* *Canavaria*
	Negoya F. 1,000 m	sandstone mudstone	*Bakevellia* *Mytilus* *Eomiodon* *Crenotrapezium*
	Kitamatadani F. 2,000 m ?	sandstone mudstone	*Chlamys* *Bakevellia* *Crenotrapezium* *Cardinioides* *Eomiodon*
	Jogodani F. 700 m ?	conglomerate sandstone mudstone	
	? Renge metamorphics	green schist	

of Teradani specimens.

Occurrence:—Mudstone of the middle part of the Negoya Formation at the Kitadani, Asahi-machi, Shimoniikawa-gun, Toyama Prefecture.

Family Pteriidae

Genus *Pteroperna* Morris and Lycett, 1853

Pteroperna kitadaniensis Goto, new species

Plate 15, Figures 3-4

Description:—Shell is small, inequivalve, pteriform, left valve more strongly convex than right. Hinge-margin is straight, fairly long. Anterior wing is large, triangular in right valve, subtriangular with a rounded anterior extremity in left valve. Posterior wing with three longitudinal ridges is long, sharply pointed backwards, with remarkably sinuated posterior margin; umbo located at about a fifth of hinge-line from the anterior end, fairly protruded above hinge-margin in left valve, but not in right; surface marked with fluctuated concentric lamellae.

Observation and Comparison:—Two specimens, each of which is represented by internal and external moulds, are at hand. In the outline, these specimens are similar to some immature specimens of *Bakevellia.* Judging from the ligament structure, they are different from *Bakevellia* which is characterized by multivincular ligament pits. The development of longitudinal ridges on the posterior wing indicate that the present species belongs to *Pteroperna.*

Occurrence:—Black mudstone at the lower (?) Pliensbachian Negoya Formation of the Kitadani, Asahi-machi, Shimoniikawa-gun, Toyama Prefecture.

Family Bakevelliidae King, 1850

Genus *Bakevellia* King, 1848

Subgenus *Neobakevellia* Nakazawa, 1959

Bakevellia (*Neobakevellia*) sp.

Plate 15, Figure 5

An internal mould of left valve is at hand. Shell large (P. 0092, 77.2 mm long, 66.5 mm high, 13.2 mm thick, Obliquity 40), pteriform; anterior wing is relatively small; posterior one extends backwards; posterior margin remarkably sinuated below posterior wing; umbo located at about one-fifth of hinge-line from the anterior end, not protruded above hinge-margin in the left valve; anterior margin nearly straight; the left valve convex strongly; ligament area wide, with multivincular ligament pits numbering six or seven at least. This is different from hitherto described species of *Bakevellia* from the Kuruma Group (Hayami, 1957) in the shape, but it may be safely referable to the genus.

Occurrence:—Sandy mudstone of the Teradani Formation near the mouth of Kawagurodani, Asahi-machi, Shimoniikawa-gun, Toyama Pre-

Table 2. Measurements in mm, *Pteroperna kitadaniensis* Goto. n. sp.

Specimen	Length	Height	Thickness	Obliquity
Holotype left in. mould	23.6	13.1	4.4	45°
Holotype left ex. mould	23.6	13.1	4.4	45°
Paratype right in. mould	25.4+	13.2	3.4	45°
Paratype right ex. mould	23.1+	14.1	3.4	45°

References

Hayami, I. (1957): Liassic *Bakevellia* in Japan. *Japan. Jour. Geol. Geogr.*, vol. 28, no. 1-3, p. 47-59, pls. 2, 3.

——(1958): A review of the so-called Liassic cyrenoids in Japan. *Japan. Jour. Geol. Geogr.*, vol. 29, no. 1-3, p. 11-27, pl. 2, 3.

——(1961): Pelecypods from the Liassic Yamaoku Formation in west Japan. *Trans. Proc. Palaeont. Soc. Japan.* n.s., no. 43, p. 113-116, pl. 16.

Kobayashi, T., Konishi, K., Sato, T., Hayami, I. and Tokuyama, A. (1957): On the Lower Jurassic Kuruma Group. *Jour. Geol. Soc. Japan*, vol. 63, p. 182-194. [in Japanese with English abstract]

Konishi, K. (1954): Yamaoku Formation (a Jurassic deposit recently discovered in Okayama Prefecture). *Jour. Geol. Soc. Japan*, vol. 60, no. 707, p. 325-332. [in Japanese with English abstract]

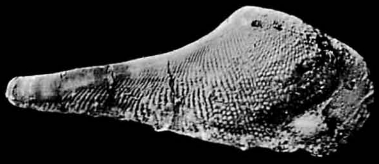
Sato, T. (1955): Les ammonites recueillies dans le groupe de Kuruma, nord du Japon central. *Trans. Proc. Palaeont. Soc. Japan*, n.s., no. 20, p.111-118, pl. 18.

Negoya 似虎谷， Teradani 寺谷， Kawagurodani 川黒谷， Shinatani 榀谷， Otakidani 大滝谷， Agero 上路， Ichiburi 市振， Tomari 泊， Asahi-machi 朝日町， Shimoniikawa-gun 下新川郡

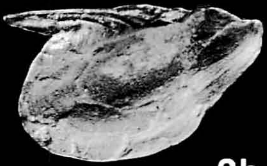
下部ジュラ系来馬層群産の二枚貝類：富山県北東部を中心として，新潟県，長野県の県境付近には下部ジュラ系来馬層群が分布し，植物化石をはじめ，瀕海棲二枚貝類が多産することは以前から知られていた。今回富山県下新川郡朝日町大平川上流の寺谷と北谷より純海棲を含む3種類の二枚貝が発見された。1新種を含むその3属3種を記載する。*Nuculana* (*Dacryomya*) *konishii*, *Nuculana* (*Dacryomya*) cf. *konishii*, *Pteroperna kitadaniensis* n. sp., *Bakevellia* (*Neobakevellia*) sp. この発見により，来馬層群からは瀕海棲二枚貝類だけではなく，純海棲二枚貝も産出することが明らかになった。さらに以前より岡山県の山奥層と来馬層群とは化石群の共通性より密接な関係があるとされて来たが，*Nuculana* (*Dacryoma*) *konishii* の発見はそれを裏付ける一つの証拠と言えるだろう。
後藤道治

Explanation of Plate 15

Nuculana (*Dacryomya*) *konishii* Hayami
  Fig. 1. Right valve (P. 3114), x1.2. Loc. 1
Nuculana (*Dacryomya*) cf. *konishii* Hayami
  Fig. 2. Left valve (P. 1106), x1.2
    2a: external mould, 2b: Rubber cast from the external mould. Loc. 3.
Pteroperna kitadaniensis Goto n. sp.
  Fig. 3. Left valve (P. 1102), holotype, x1.2
    3a: internal mould, 3b: external mould. Loc. 2
  Fig. 4. Right valve (P. 1102), paratype, x1.2
    4a: internal mould, 4b: external mould. Loc. 2.
Bakevellia (*Neobakevellia*) sp.
  Fig. 5. Left valve (P. 0092), x1.2. Loc. 4.


1


3a


3b


2a


4a


2b


4b


5

Trans. Proc. Palaeont. Soc. Japan, N. S., No. 130, pp. 85—95 pls. 16—20, July 15, 1983

762. CRETACEOUS NAUTILOIDS FROM HOKKAIDO — II
PART 2. THREE NAUTILOID SPECIES FROM THE SANTONIAN AND CAMPANIAN OF HOKKAIDO*

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Abstract. This is Part 2 of a monograph of the Cretaceous Nautiloids from Hokkaido being published in series. It contains the description of three species, of which the first is new and assigned to *Kummeloceras* (established in Part 1*), the second is identified with *Cymatoceras pseudoatlas* (Yabe et Shimizu), originally described on a specimen from Kyushu, and the last is a new species of *Cymatoceras* allied to and possibly evolved from *C. saussureanum* (Pictet) of an earlier age. The first two occur in the Lower Santonian Zone of *Inoceramus amakusensis* and the last in the Middle Campanian Zone of *Sphenoceramus schmidti* and seems to range down to the Lower Campanian Zone of *Sphenoceramus orientalis*. Some remarks are given on the Cymatoceratidae, proposing a new genus.

Introduction

As is well known, ammonoid cephalopods occur abundantly in the Santonian and the Campanian of Hokkaido. In contrast with this, nautiloids have been found rather rarely from the same sequences. This is probably due to collection failure and does not necessary mean the absolute scarceness. We hope that the descriptions of three species in this paper would become a start towards an intensive study of more material in the future.

One of the three species is referred to *Kummeloceras* but different from the two species of the same genus from the Turonian and the Coniacian of Hokkaido which were described in Part I. The second is identified with the species of *Cymatoceras* described years ago from Kyushu. These two occur in the Lower Santonian Zone of *Inoceramus amakusensis*. The last is a new species of *Cymatoceras* and of Lower (?) to Middle Campanian age.

In connexion with *Cymatoceras* one of us (T. M.) will give general remarks on the family Cymatoceratidae.

Palaeontological Description

Family Eutrephoceratidae Miller, 1951

Genus *Kummeloceras* Matsumoto, 1983

Remarks:—See Part I for the definition and

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* Part 1 is in T. Matsumoto (1983): Cretaceous Nautiloids from Hokkaido — I. *Trans. Proc. Palaeont. Soc. Japan*, n.s., no. 129, p. 9—25, pls. 4—9.

* Received July 2, 1982

the phylogenetic position of this genus.

Kummeloceras kamuy sp. nov.

Pl. 16, Fig. 1; Text-figs. 1, 2

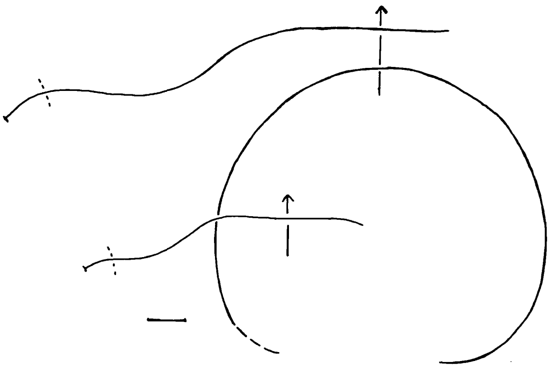
Material:—Holotype MC. Hbo-2015, consisting of the phragmocone and a part of the body-chamber. Another specimen, GK. H5925, is probably a secondarily distorted example of the present species.

Description:—The shell is fairly large. The holotype is about 132 mm in diameter, but it has only a part of the body-chamber for about 90°. Should the body-chamber assumed to be as long as 150°, the shell diameter would exceed 150 mm. Another specimen, GK. H5925, is 150 mm in diameter at the end of the phragmocone, although it is measured under distorted state.

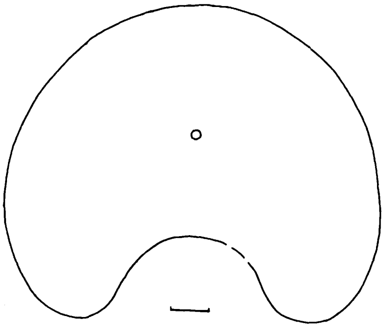
The whorl is rounded in cross-section, somewhat broader than high, with B/H=1.17 in the holotype. The maximum breadth is somewhat below the mid-height. The umbilicus is narrow, nearly 10 per cent of the diameter, surrounded by a steeply inclined, slightly incurved wall and a rounded shoulder.

The outer surface of the shell is smooth, except for fine growth-lines, which show a rather gentle ventral sinus.

The septa are widely spaced; 6 or 6.5 being counted in a half whorl. The suture is fairly sinuous. The last suture has almost imperceptible ventral lobe, being nearly straight on the venter, but the earlier ones (e.g. the last 5th or 6th) show a very shallow and broad ventral lobe. The lateral lobe, though shallow and broad, is more distinct in the latter. The saddle at the umbilical shoulder is indistinct or incipient and the suture-line runs nearly radially on the umbilical wall.



Text-fig. 1. *Kummeloceras kamuy* sp. nov. Diagrammatic whorl-section (body chamber); the last and the last 6th external sutures of the holotype. Bar = 10mm. (T. Matsumoto *delin.*)



Text-fig. 2. *Kummeloceras kamuy* sp. nov. Restored whorl-section of paratype, GK. H5925, showing the position of siphuncle. Bar = 10 mm. (T. Matsumoto *delin.*)

The siphuncle is subcentral, passing through a point slightly below the midst of the dorso-ventral median-line of a septum, as shown in GK. H5925.

Comparison:—The present species is similar to

Explanation of Plate 16

Fig. 1. *Kummeloceras kamuy* sp. nov. . . . . Page 86
Holotype, MC. Hbo-2015, ventral (a) and lateral (b) views, x1.
Photos (pls. 16—20) by courtesy of Dr. M. Noda.

1a

1b

Table 1. Measurement (in mm), *Kummeloceras kamuy* sp. nov.

Specimen	Diameter	Umbilicus	Height	Breadth	B/H
Holotype	131.5 (1)	13.0 (.098)	77.8 (.59)	91.0 (.69)	1.17
GK. H5925 (deformed)			84.0	95.0	1.13
E. kobayashii	140.0 (1)	13.4 (.095)	83.0 (.59)	90.0 (.64)	1.08

Eutrephoceras sublaevigatum (d'Orbigny, 1850) [=*Nautilus laevigatus* d'Orbigny (1840, p. 84, pl. 17, figs. 1-4)] in the broadly rounded whorl-section and the subcentral siphuncle but distinguished by its more sinuous and more distant sutures and opened instead of almost closed umbilicus.

With respect to its somewhat sinuous sutures, this species differs considerably from the typical species of *Eutrephoceras*, such as *E. dekayi* (Morton), *E. sublaevigatum* (d'Orbigny), *E. sloani* Reeside, 1924 (see Miller, 1947, text-fig. 6) and is closer to *Kummeloceras yamashitai* Matsumoto and *K. splendens* (Blanford) (see Part 1). Therefore we refer it to *Kummeloceras* rather than to *Eutrephoceras.*

Kummeloceras kamuy is distinguished from *K. yamashitai* Matsumoto and *K. yezoense* Matsumoto (both described in Part 1), from the Turonian and Coniacian of central Hokkaido respectively, by its more rounded, broader whorl and much more distant septa.

The holotype of the present species resembles that of *E. kobayashii* Matsumoto (1967, p. 164, pl. 3, fig. 1; text-figs. 1, 2), from an uncertain horizon of Urakawa (southern Hokkaido) in the general aspects, but the former has distinctly more sinuous and more distant septa (6.5 per half-whorl as compared with 11 or 12 in the latter) and the lower position of the siphuncle (somewhat below, instead of above, the midst of the dorso-ventral median-line). The whorl is somewhat broader in the former than in the latter, but the difference of B/H between the two (1.17 as compared with 1.08) is not great. Although the available specimens are few in both species, the sinuosity and the density of the septa and the position of the siphuncle at the corresponding growth-stage should be considerably reliable criteria. Therefore, this species is distinguished from *E. kobayashii.* For the same reasons, GK. H5925 is better regarded as a distorted example of the present species.

The present species is similar to *E. darupense* (Schlüter) (1876, p. 176, pl. 49, figs. 4, 5) (Wiedmann, 1960, p. 157, pl. 21, figs. C, D; pl. 23, figs. F, P; text-fig. 2), from the Upper Cretaceous of Germany, in the distant sutures, but is distinguished by its more sinuous sutures, subcentral (instead of ventral) position of the siphuncle, more rounded whorl-section and a narrowly opened (instead of closed) umbilicus. Incidentally, Wiedmann (1960) regarded the Schlüter's (1876, pl. 48, figs. 3-5) specimen of "*Nautilus neubergicus*" from the Emscher-Mergel as identical with *E. darupense.* This is, in our opinion, doubtful, because it has denser septa. It is more closely allied to, if not identical with, *E. kobayashii*, although it is smaller than the holotype of the latter. There is a similarly small specimen in the Collection of Mr. Y. Kawashita from the Coniacian of the Ikushumbets area, central Hoddaido, which can be provisionally called *E.* sp. aff. *E. kobayashii.* Anyhow, we agree with Wiedmann (1960) in regarding that Schlüter's *N. neubergicus* as distinct from *N. neubergicus* Redtenbacher (1873, p. 97, pl. 22, fig. 4) [=*N. sowerbianus* of Hauer (1858, p. 14, pl. 1, fig. 12) (non d'Orbigny)], from the Gosau Group of Austria, the latter of which should be assigned to *Angulithes.*

Occurrence:—The holotype was obtained by one of us (K. M.) from the Pisshiri-zawa, a branch of the Deto-futamata, a tributary to the River Haboro, northwestern Hokkaido. According to Ueda *et al.* (1962), the locality can be assigned to the Santonian. Ueda *et al.* listed *Eutrephoceras* sp. at their loc. CK. 63 of the

Deto-futamata, Unit A of their subdivision, which is Lower Santonian (Zone of *Inoceramus amakusensis*). Their specimen is unfortunately missing at present.

GK. H5925 was obtained by Mr. Hiroharu Kokubu in one of the floated nodules in the stream called Sanushibe, under the bridge of Sanushi at Inasato, Hobetsu area, central Hokkaido. The lithology (calcareous mudstone) of the nodule suggests the derivation from the Santonian part of the Upper Cretaceous in that area (see a geological map of fig. 1 in Matsumoto *et al.*, 1979). Mr. Kokubu kindly presented the specimen to one of us (T. M.), which is now kept in the Geological Collections of Kyushu University.

The specimen in Mr. Mitsutoshi Nihongi's Collection (MN. 201), donated to and exhibited at the City Hall of Sapporo, is possibly an example of this species. It is cut longitudianally, showing distant septa. It was obtained by M. Nihongi from the Santonian of the Obira area.

Etymology:—Kamuy means god in the Ainus.

Family Cymatoceratidae Spath, 1927

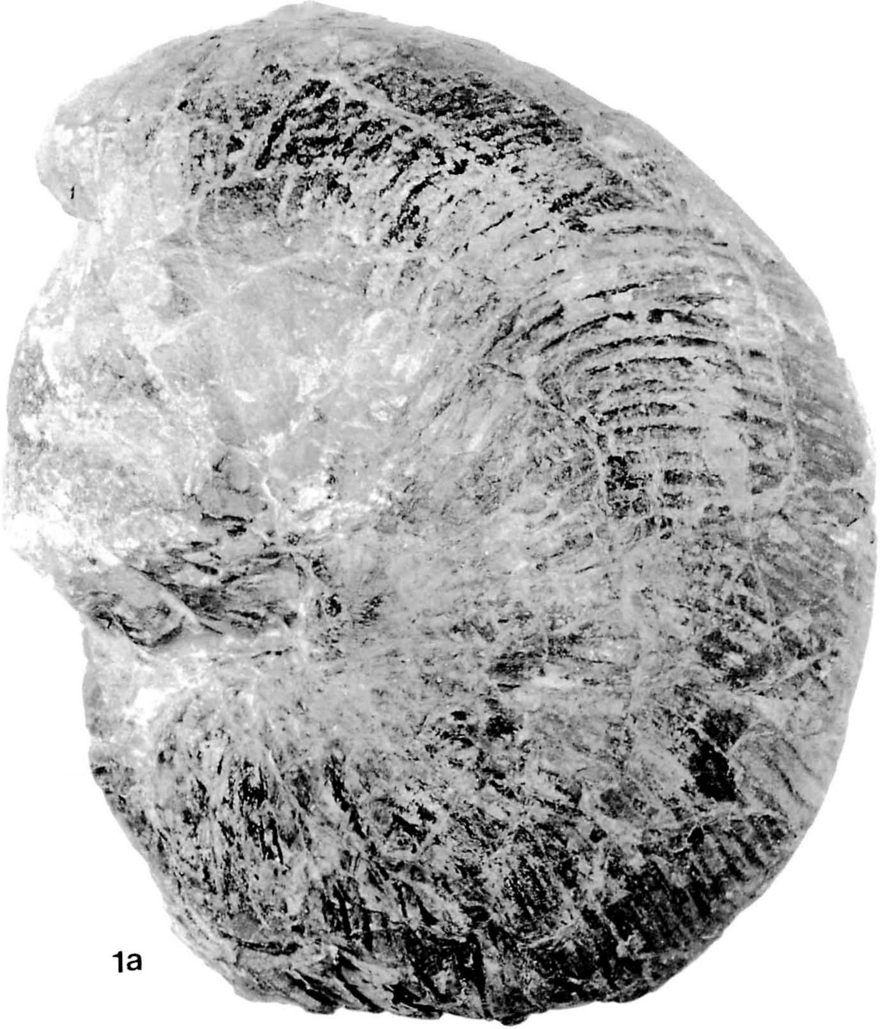
(Remarks down to p. 89 by T. Matsumoto)

Nautiloids of the Cymatoceratidae are characterized by their own particular ribs which appear in more or less late growth-stages. The ribs are distinct on the outer surface of the shell but weak or scarcely impressed on the internal mould. As far as the available material is concerned, the early immature shell of the cymatoceratids show a finely reticulate ornament just as those of *Nautilus*, *Kummeloceras* and *Eutrephoceras*.

The sutures of *Cymatoceras* vary considerably from a species to another. The type species, *Nautilus pseudoelegans* d'Orbigny (1840, p. 70, pl. 8, figs. 1-4; pl. 9, figs. 1, 2) (see also Kummel, 1956, pl. 16, figs. 1, 2; Miller and Harris, 1945, text-fig. 1), whose shell form is globose, has gently sinuous sutures which are similar to those of *Cenoceras* or early *Kummeloceras* (e.g. *K. turcicum* mentioned in Part I). The majority of the species of *Cymatoceras* shows somewhat more sinuous sutures, which are essentially similar to those of typical species of *Kummeloceras*. Examples are *C. atlas* (Whiteaves) (1876, p. 17) [=*N. elegans* of d'Orbigny, 1840, p. 87, pl. 19, figs. 1-4], *C. saussureanum* (Pictet) (1847, p. 273, pl. 1, figs. 3a-c), *C. tourtiae* (Schlüter) (1876, p. 170, pl. 46, figs. 1-4) (which has a *Procymatoceras*-like subtrapezoidal outer whorl), *C. pseudoneganum* (Spengler) (1910, p. 133, pl. 12, figs. la, b; 7d), *C. semilobatum* (Spengler) (1910, p. 133, pl. 11, figs. 4a, b), *C. patens* (Kner) (see Schlüter, 1876, p. 178, pl. 50, figs. 1-4), etc. The small dorsolateral saddle at the umbilical shoulder becomes more distinct in such species as *C. cenomanense* (Schlüter) (1876, p. 168, pl. 45, figs. 1, 2). In this connexion I should propose ***Eurocymatoceras*** gen. nov., designating *Nautilus deslongchampianus* d'Orbigny (1840, p. 90, pl. 20, figs. 1-4) [also Sharpe, p. 12, pl. 3, figs. 1, 2; p. 15, pl. 5, fig. 3 under *N. neocomiensis* (non d'Orbigny)], from the Cretaceous of Europe, as its type species. This species has been assigned to *Cymatoceras* (see Kummel, 1956, p. 424), but is distinct in the shell form with angular umbilical shoulder, the reticulate structure persisting to the shell of late growth-stage and the presence of a small but distinct saddle at about the umbilical shoulder. Its suture is somewhat similar to that of *C. cenomanense* and resembles more closely that of *Angulithes triangularis* (Montfort) (see Kummel, 1956, pl. 26, figs. 1, 2).

Explanation of Plate 17

Fig. 1. *Cymatoceras pseudoatlas* (Yabe et Shimizu) . . . . Page 90
Hypotype from loc. Ik1506r, lateral (a) and ventral (b) views, x0.6.



1a

1b

The almost linear suture as shown in *C. loeblichi* Miller et Harris (1945, p. 6, pl. 2, figs. 1-4; pl. 3, figs. 3, 4; text-fig. 2C) is exceptional for the genus and can be interpreted as a reduced rather than a primitive original character.

It should be noted that in the Cymatoceratidae the folded sutural pattern like that of *Nautilus* or *Cimomia* was developed already in the Jurassic to Cretaceous genus *Paracymatoceras* Spath, 1927, which is represented by the type species *Nautilus asper* (Oppel) Zittel, 1868 (p. 48, pl. 3, fig. 1) (also Miller and Harris, 1945, p. 9, pl. 4, figs. 1-3), *N. texanus* Shumard, 1860 (see Miller and Harris, 1945, p. 10, pl. 3, figs. 1, 2; pl. 5, figs. 1-3; text-figs. 3A, B) and *P. tunghaicum* Matsumoto et Amano (1964, p. 175, pl. 26, fig. 1; text-figs. 2, 3). *Heminautilus* Spath, 1927, represented by the type species *Nautilus saxbii* Morris (see Kummel, 1956, pl. 10, figs. 1, 2) and others, has likewise folded sutures and is characterized by a trapezoidal whorl with more or less sharpened ventrolateral shoulders.

Deltocymatoceras Spath, 1927, represented by the type species *Nautilus leiotropis* Schlüter (1876, p. 175, pl. 48, figs. 1, 2), is characterized by an *Angulithes* like subtrigonal whorl-shape, with a keel on the venter, and moderately sinuous sutures with a small but distinct saddle near the umbilical margin like those of *Angulithes triangularis.*

Procymatoceras Spath, 1927, with the type species *Nautilus subtruncatus* Morris et Lycett (1850, p. 10, pl. 1, fig. 2), from the Jurassic Great Oolite of England, is characterized by a thickly subtrapezoidal whorl-section and fine ribbing. As is better shown in *P. baberi* (Morris et Lycett) (1850, p. 10, pl. 1, fig. 1), another species from the Great Oolite, the suture is weakly sinuous, resembling that of *Cenoceras.*

Cymatonautilus Spath, 1927, established on *Nautilus julii* (Baugier MS) d'Orbigny, 1850 (see Kummel, 1956, p. 430, pl. 18, figs. 1-4), from the Jurassic of Europe, is characterized by a subquadrate whorl-section and a ventral and also lateral grooves. Its suture is similar to but somewhat more sinuous than that of *Cenoceras.*

Eucymatoceras Spath, 1927, represented by the type species *Nautilus plicatus* Fitton (see Kummel, 1956, pl. 21, figs. 1, 2), has a characteristic ribbing of multiple Vs. Its suture is also gently sinuous.

Epicymatoceras Kummel, 1956, represented by the type species *Nautilus vaelsensis* Binckhorst, 1861 (p. 15, pl. 5c, fig. 2) (see also Schlüter, 1876, p. 177, pl. 51, figs. 1, 2), from the Maastrichtian of Europe, is characterized by a compressed subrectangular whorl-section with a flattened venter and a compratively wider umbilicus. Its suture is as moderately sinuous as that of *Kummeloceras* but has a shallow ventral lobe.

Anglonautilus Spath, 1927, represented by the type species *Nautilus undulatus* Sowerby (see Kummel, 1956, pl. 26, figs. 1, 2) and several others, has a subquadrate body-chamber and fold-like major ribs in the adolescent stage. The suture of the type species is described as slightly sinuous but there is a species from Hokkaido which shows somewhat more sinuous sutures (see Part 4).

To sum up, *Cymatoceras* is interpreted to have been derived from some *Cenoceras* directly or by way of early *Kummeloceras* and have offshooted variously specialized genera of the Cymatoceratidae. The somewhat sinuous sutural pattern like that of *Kummeloceras* seems to have been the fundamental framework in the Cymatoceratidae and it may have been modified to a slightly sinuous or almost linear sutural pattern in some (but not many) species of *Cymatoceras*, kept with little or minor change in *Epicymatoceras*, *Eucymatoceras* and *Anglonautilus*, which are specialized in shell-form and ribbing respectively, and evolved to somewhat more sinuous pattern in *Deltocymatoceras* and *Eurocymatoceras* and to still more sinuous, folded patterns in *Paracymatoceras* and *Heminautilus*. *Deltocymatoceras* of the Cymatoceratidae is in parallel with *Angulithes* of the Nautilidae, whereas *Heminautilus* shows another specialization in shell-form.

In some species of *Paracymatoceras*, *Cymatoceras* and *Anglonautilus*, a shallow median groove is developed on the venter of the body-chamber. This is a character which must have been related to a particular mode of life. The ventral groove of *Cymatonautilus* is the most distinctive. Aside from this, a rather irregular groove may be seen occasionally on the venter. This can be interpreted as a kind of injury.

Genus *Cymatoceras* Hyatt, 1884

Type species:—*Nautilus pseudoelegans* d'-Orbigny, 1840.

Remarks:—The genus has been comprehensively redescribed by Kummel (1956, p. 418–427), and some additional remarks are given above. In addition to "*C.* " *deslongchampsianum* mentioned above (under *Eurocymatoceras* nov.), *C. tskaltsithelensis* (Rouchadzé) (1931) from the Aptian of Koutais (USSR), is peculiar in having a folded sutural pattern (see Kummel, 1956, text-fig. 24G) and a comparatively evolute shell. A new generic or subgeneric name may be required for it, but I would not propose it on this occasion.

Numerous species of *Cymatoceras* are mostly from the Cretaceous in various regions of the world. Kummel (1956, p. 426) listed an Upper Jurassic species, *C. perstriatus* (Steuer), from Argentina. I agree with Kummel in the assignment of *Neocymatoceras tsukushiense* Kobayashi (1954), from the Oligocene of Fukuoka (Kyushu), to *Cymatoceras*. I should add "*Entrephoceras*" *japonicum* (Shimizu), from the Eocene of Kyushu as another example of *Cymatoceras* who survived from Cretaceous species. Shimizu's (1929, p. 25, pl. 8, figs. 1, 2) holotype is an internal mould which show somewhat sinuous sutures like those of *Kummeloceras*. The specimens subsequently described by Kobayashi and Kamada (1959) (e.g., UMUT. CM 8497, CM 8498, CM 8500) have *Cymatoceras* type ribs on the body-chamber, although the ribs are weakened by erosion. It is interesting to see that a few species of *Cymatoceras* occur in the Lower Tertiary of Japan, representing the survival of the genus.

In this connection I notice another possible survivor from the Mesozoic nautiloid in Indonesia. That is *Nautilus butonensis* Martin (1933, p. 30, pl. 5, figs. 34, 34a), from the Oligocene of Buton island. It was referred to *Eutrephoceras* by Kummel (1956, p. 381), but its shell shows longitudinal lirae, especially distinctly on the outer surface of the shell. It resembles *Cenoceras* of the Jurassic period and could be either a derived fossil or a rare survivor.

Cymatoceras pseudoatlas (Yabe et Shimizu)

Pl. 18, Fig. 1

1924. *Nautilus (Cymatoceras) pseudo-atlas* Yabe et Shimizu, *Japan. Jour. Geol. Geogr.*, vol. 3, no. 2, p. 42, pl. 5.

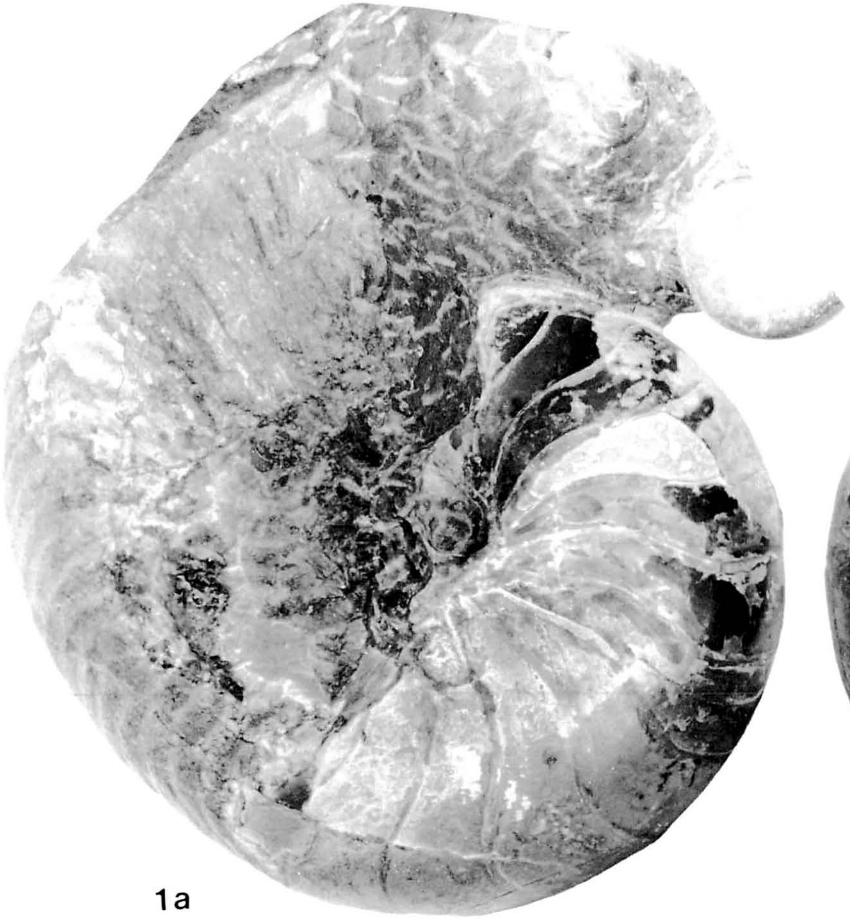
1956. *Cymatoceras pseudoatlas* Yabe et Shimizu; Kummel, *Bull. Mus. Comp. Zool. Harvard*, vol. 114, no. 7, p. 426.

Holotype:—A single specimen described by Yabe and Shimizu (1924, indicated above), IGPS. 8044, kept in the Palaeontological Collections, Tohoku University, Sendai. The type locality is a point 1 km north of Himenoura in Amakusa, Kumamoto Prefecture (western central Kyushu). It was collected by the late Dr. T. Nagao. The locality is assigned to the Santonian part of the Himenoura Group (Ueda, 1962).

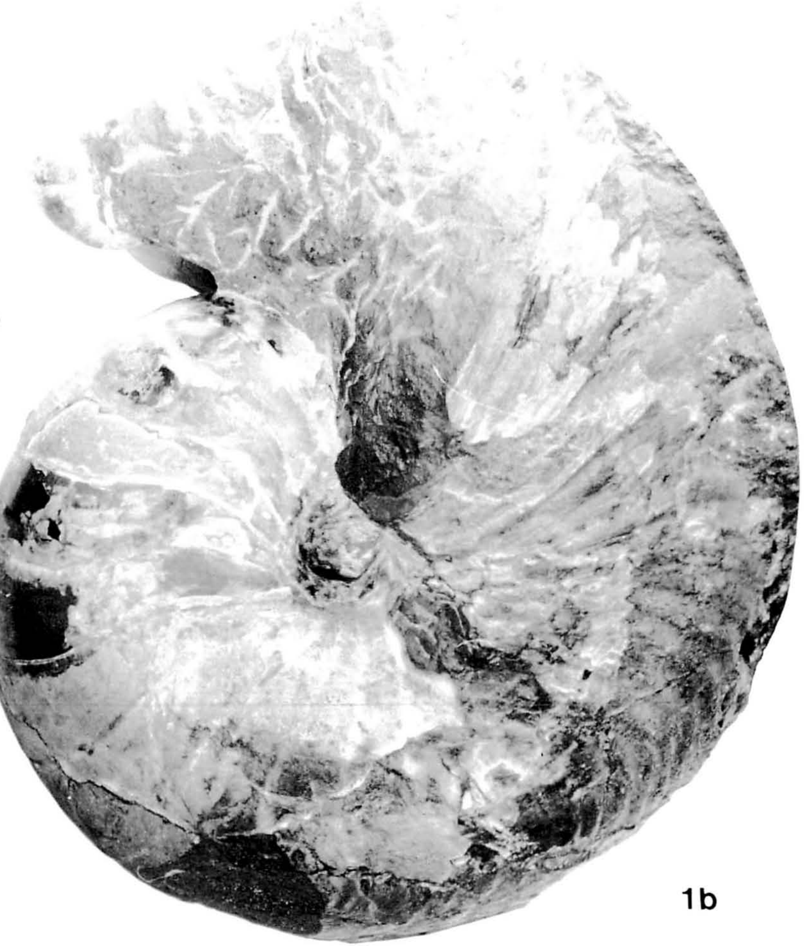
Material:—MC. Ik-1506r, probably an adult shell as large as the holotype; a still larger specimen in Satoru Yamaguchi's Collection, now displayed at the Museum of Mikasa (54719-2);

Explanation of Plate 18

Fig. 1. *Cymatoceras pacificum* sp. nov. . . . . Page 92
Holotype, MC. TS-3025, two lateral (a, b) views, x1.



1a



1b

GK. H5919, smaller, probably inner whorl.

Description:—The adult shell, represented by the holotype and MC. Ik 1506r, is fairly large, with a diameter over 200 mm. Another incompletely preserved specimen (S. Yamaguchi Coll.) is still larger, about 250 mm in diameter under a distorted condition.

The living chamber occupies about two thirds of the last whorl, as seen in MC. Ik 1506r, which has the last septum at about the diameter of 150 mm.

The whorl enlarges fairly "rapidly" (i.e., with a fairly large rate). It is subrounded reniform in section, a little broader than high in the adult stage, with the maximum breadth in the lower part at two fifths of the whorl-height. The venter is semicircular in the late stage but more narrowly arched in earlier stages. The umbilicus is very narrow, seemingly closed when it is covered by callus, as seen on the right side of MC. Ik 1506r (and on the holotype), but measured at about 7 per cent of the entire shell diameter, as seen on the left side of the same specimen (MC. Ik 1506r). It is deep and surrounded by a somewhat overhanging wall and a rounded shoulder.

The surface of the shell on the outer whorl is marked by numerous ribs of *Cymatoceras* type. They are dense, about 25 within the distance along the mid-venter as long as the whorl-height. Bifurcation of the ribs takes place at various distances from the umbilicus. It occurs more frequently on the lower part of the flank more or less near the umbilicus but sometimes seen on the ventrolateral part or even on the venter. On the well preserved part fine lirae run on the ribs in parallel to the latter. The ribs are slightly prorsiradiate on the inner (i.e. lower) part of the flank and gradually curved backward on the ventrolateral part, crossing the venter with a moderate backward curvature. On the venter in the last part of the adult body-chamber, the rib is about 5 mm in breadth, whereas the interspace (or furrow between the ribs) is much narrower, about 1.0 to 1.5 mm in breadth.

The surface of the immature shell on the inner whorl, as represented by GK. H5919, shows a fine lattice ornament which consists of radial and spiral lirae in combination. The curvature of the radial lirae is similar to that of the ribs on the outer whorl.

The septa are fairly frequent. The suture has a shallow and broad lateral lobe on the flank and a low and small saddle at the umbilical shoulder, showing a sinuosity. The siphuncle is not observable in MC. Ik 1506r. It is described to be subventral in the holotype.

Comparison:—We agree with Yabe and Shimizu (1924) in separating this species from *C. atlas* (Whiteaves) (1876, p. 17) [= *Nautilus elegans* of d'Orbigny, 1840, pl. 19, figs. 1—4] (*non* J. Sowerby). The ribs are bifurcated not only near the umbilical margin but also on the flanks and on the venter in the former, whereas they are not bifurcated on the outer part of the whorl in the latter. We notice, however, that the two species are closely allied to each other in view of the resemblance in shell-form, density and fineness of the ribs, rib curvature, frequency and sinuosity of the sutures and position of the siphuncle. It can be possibly presumed that

Table 2. Measurements (in mm), *Cymatoceras pseudoatlas*

Specimen	Diameter	Umbilicus	Height	Breadth	B/H
Holotype (Y. & S.)	211	—	157 (.74)	165 (.76)*[.78]	1.05
MC. Ik 1506r	215	16 (?) (.07)	130 (.60)	138 (.64)	1.06
GK. H5919	38.2	—	24.2 (.63)	29.2 (.76)	1.20

* There is discrepancy between the absolute value and the percentage in the measurements of Yabe and Shimizu (1924).

GK. H5919, smaller, probably inner whorl.

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The septa are fairly frequent. The suture has a shallow and broad lateral lobe on the flank and a low and small saddle at the umbilical shoulder, showing a sinuosity. The siphuncle is not observable in MC. Ik 1506r. It is described to be subventral in the holotype.

Comparison:—We agree with Yabe and Shimizu (1924) in separating this species from *C. atlas* (Whiteaves) (1876, p. 17) [= *Nautilus elegans* of d'Orbigny, 1840, pl. 19, figs. 1—4] (*non* J. Sowerby). The ribs are bifurcated not only near the umbilical margin but also on the flanks and on the venter in the former, whereas they are not bifurcated on the outer part of the whorl in the latter. We notice, however, that the two species are closely allied to each other in view of the resemblance in shell-form, density and fineness of the ribs, rib curvature, frequency and sinuosity of the sutures and position of the siphuncle. It can be possibly presumed that

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GK. H5919	38.2	—	24.2 (.63)	29.2 (.76)	1.20

* There is discrepancy between the absolute value and the percentage in the measurements of Yabe and Shimizu (1924).

C. pseudoatlas may have been derived from *C. atlas*, acquiring multiple bifurcation of the ribs.

Occurrence:—MC. Ik1506r was obtained by Mr. Tatsuo Muramoto with Matsumoto's field work. It was from the mudstone of loc. Ik1506r (indicated by a solid circle to the right of letter *Ia* at the left center of text-fig. 4 in Matsumoto *et al.*, 1981) which was exposed when the road on the left side of the River Ikushumbets was under construction. The mudstone contains *Inoceramus (Platyceramus) amakusensis* Nagao et Matsumoto and *Anapachydiscus deccanensis yezoensis* Matsumoto, among others. It is referred to the Zone of *Inoceramus amakusensis*, approximately Lower Santonian in terms of the international scale.

GK. H5919 was obtained by Mr. Ohmi, a student of Mikasa High School in 1955, at the confluence of the Yoshiyachi-zawa with the main stream of the Ikushumbets. This is again in the Zone of *Inoceramus amakusensis*.

Cymatoceras pacificum sp. nov.

Pl 18, Fig. 1; Pl. 19, Fig. 1; Pl. 20,
Figs. 1, 2; Text-fig. 3

Material:—Holotype, MC. TS-3025, probably adult specimen, in which shell layers are preserved on the body-chamber but the visible part of the phragmocone is devoid of the outer shell-layer or partly the internal mould. Paratype, MC. TS-3010, smaller, probably immature shell. There is another paratype, GK. H5918 of moderate size, collected by S. Nagaoka over 40 years ago from South Sakhalin.

Description:—The holotype is about 130 mm in diameter at the preserved end. The preserved body-chamber is slightly less than a half whorl, about 160°.

The whorl is broadly rounded in section, with a well rounded venter and inflated flanks. It is broader than high, broadest somewhat below the middle of the whorl-height, with the proportion of B/H about 1.2 to 1.3. The umbilicus is narrow, about 9 per cent of the entire shell diameter in the adult holotype and GK. H5918, but almost closed in the smaller paratype. The umbilical shoulder is rather abruptly rounded.

On the late part of the phragmocone and the body-chamber there are numerous ribs of *Cymatoceras* type, which are scarecely impressed on the internal mould. Shorter ribs are sometimes branched or intercalated at about the umbilical shoulder, on the flank and at about the ventrolateral shoulder. As a result the ribs number about 10 to 12 in a distance on the median part of the venter as long as the whorl-height. They can be described as fairly coarse or of moderate density compared with the cases in other species of *Cymatoceras*. On the well preserved part the ribs and the interspaces are covered with fine lirae which are nearly parallel to the ribs. They are somewhat prorsiradiate on the main part of the flank and curved backward at about the ventrolateral shoulder, forming a moderate backward curvature on crossing the venter.

The immature shell shows at first a characteristic lattice ornament by the combination of radial and spiral lirae and then, at the diameter of about 30 mm, weak radial ribs begin to appear at first on the inner half of the flank and then wholly. In GK. H5918 the *Cymatoceras* type band like ribs separated by groove-like narrow interspaces begin to appear at the diameter of about 50 mm, i.e. at about the last quarter of the phragmocone.

The suture, which is well exposed on the holotype (Text-fig. 3) and on a part of GK. H5918, shows some sinuosity. The ventral lobe

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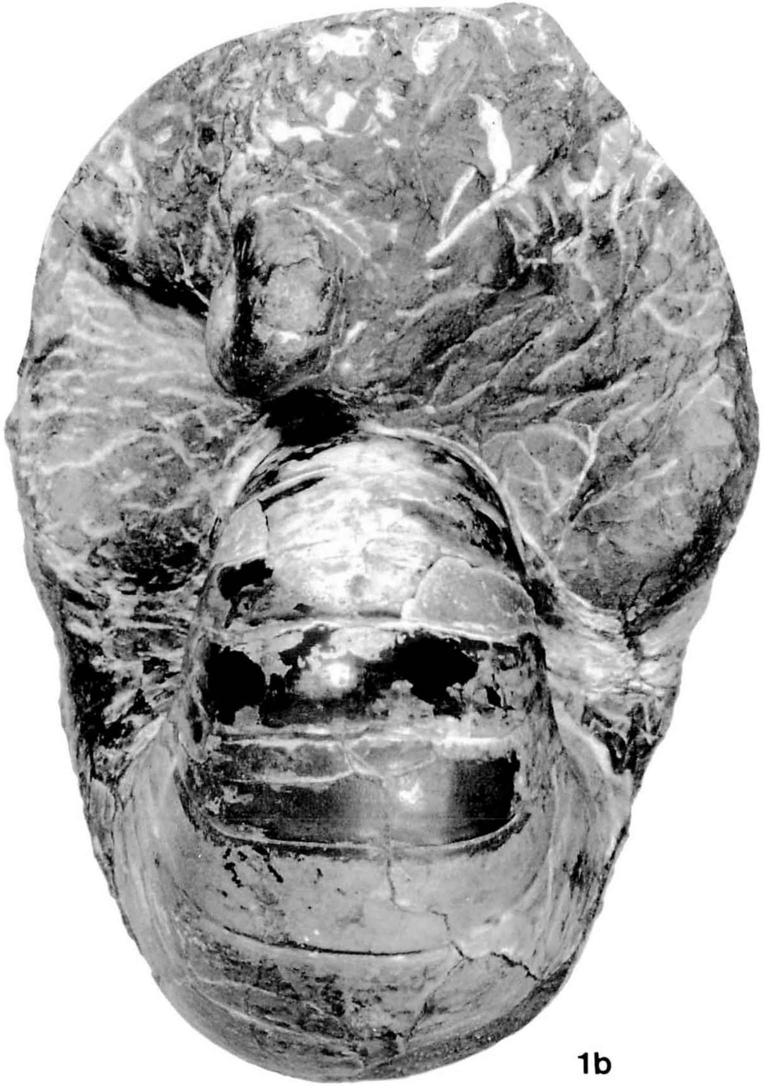
Explanation of Plate 19

Fig. 1. *Cymatoceras pacificum* sp. nov. . . . . Page 92
Holotype, MC. TS-3025, ventral (a) and frontal (b) views, x1.

1a



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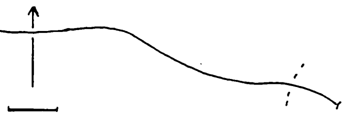


Text-fig. 3. *Cymatoceras pacificum* sp. nov. The last 5th external suture of holotype, MC. TS-3025, at whorl-height = 45 mm. Bar = 10mm. (T. Matsumoto *delin.*)

is very broad and shallow or almost negligible; the lateral lobe is distinct but broad, passing to an indistinct saddle at the umbilical shoulder. The septa are fairly close-set, numbering about 10 per half whorl.

The position of the siphuncle is not observable in the holotype. It is clearly shown in GK. H5918 at some distance below the midst of the dorso-ventral median-line. The same is for the smaller paratype, though indistinctly shown.

Remarks:—In GK. H5918 the body-chamber is preserved only for about 90°. Should it be preserved completely for about 160°, then its diameter would be about 90 mm. This is, however, still smaller than the holotype. The specimen may represent a shell of middle-growth age or an unusually small adult shell.

Comparison:—The present species resembles *Cymatoceras saussureanum* (Pictet) (1847, p. 273, pl. 1, figs. 3a-c), from the Albian of Europe, with respect to the rounded whorl, rather coarse ribs, mode of bifurcation or intercalation of shorter ribs and fairly close-set sinuous sutures. Especially GK. H5918 resembles closely the illustrated type of Pictet. Our species, however, has a somewhat broader whorl, with B/H 1.21 (±0.05) as compared with 1.14 in the latter, slightly more numerous ribs in the corresponding part (10 as compared with 8 in the latter within the distance on the venter as long as the whorl-height) and less pronounced saddle at the umbilical shoulder than the latter. A still clearer distinction is in the siphuncle position: somewhat dorsad of the center in the present species and somewhat ventrad of the center in that species (the center means the midst of the dorso-ventral median line of the whorl-section).

The holotype of the present species is somewhat similar to that of *Cymatoceras atlas* (Whiteaves) (1876, p. 17) [= *Nautilus elegans* of d'Orbigny, 1840, pl. 19, figs. 1—4] (*non* J. Sowerby), from the Cenomanian of France, in the general aspects of the shell and the sutural pattern and frequency, but the former has more rounded whorl and less numerous, somewhat coarser ribs, which show some intercalation or bifurcation. So far as d'Orbigny's illustration is concerned, there occurs no bifurcation or intercalation of the ribs on the outer half of the whorl, although it can be seen near the umbilical shoulder. The umbilicus is closed and the siphuncle is more ventrad in *C. atlas*.

For the same reasons, *Nautilus elegans* of Sharpe (1853, p. 12, pl. 3, fig. 3; pl. 4, fig. 1), from the Cenomanian of England, is better referred to *C. atlas*, as Wright and Wright (1951, p. 11) have already pointed out.

The present species resembles *C. sharpei* (Schlüter) (1876, p. 171, pl. 46, figs. 5—7), from the Lower Cenomanian [Tourtia] of West Germany, with respect to the outline of whorl-

Table 3. Measurements (in mm), *Cymatoceras pacificum* sp. nov.

Specimen	Diameter	Umbilicus	Height	Breadth	B/H
Holotype (end)	130.0 (1)	12.0 (.09)	80.0 (.62)	97.0 (.75)	1.21
Holotype (—90°)	107.0 (1)	10.0 (.09)	62.0 (.58)	78.0 (.73)	1.26
Holotype (last sept.)	90.0 (1)	7.8 (.09)	53.0 (.59)	64.0 (.71)	1.21
Paratype 1	44.0 (1)	—	28.0 (.64)	33.0 (.75)	1.19
GK. H5918	63.0 (1)	6.2 (.10)	35.0 (.55)	~44.0 (.70)	1.26

section and the position of siphuncle, but the latter has a still narrower (almost closed) umbilicus and more distant sutures (8 per half whorl), which show shallower, less distinct lateral lobe but a more pronounced saddle at the umbilical shoulder.

The present species is similar to *C. madagascarense* (Yabe et Shimizu, 1924) [= *N. elegans* of Boule *et al.*, 1907, p. 66, pl. 15, figs. 4,5], from the Senonian of Madagascar, in the shell-form and mode of ribbing, but the siphuncle is highly ventrad in the latter.

C. pacificum is distinguished from *C. pseudoatlas* in its broader whorl, coarser ribs and rather dorsad instead of ventrad siphuncle.

Occurrence:—The holotype was obtained at a point on the stream of the Wakkawembets, in a place now called Yamato, upper reaches of the Abeshinai, a tributary to the River Teshio, northwestern Hokkaido (see Matsumoto, 1942, pl. 10 for the geological map of the area). It is associated with *Sphenoceramus schmidti* Michael and *Tetragonites popetensis* Yabe, being evidently referable to the Zone of *Sphenoceramus schmidti*, substage K6a2 in the Japanese province, approximately Middle Campanian in terms of the international scale. The smaller paratype (MC-TS3010) was also from the Wakkawembets, close to the type locality. GK. H5918 has no precise record of occurrence but probably from the Upper Cretaceous of the "Kawakami Colliery", south of the Naibuchi. The lithology of the rock matrix, dark grey siltstone, containing several immature shells of *Sphenoceramus*, suggests its derivation from Zone Mh7 (uppermost part of the Miho Group), i.e. the Zone of *Sphenoceramus orientalis*, aproximately Lower Campanian in terms of the international scale.

References Cited

(For brevity the references listed at the end of Part 1 are not repeated here.)

Binckhorst, J. T. (1861): *Monographie des gastéropodes et des céphalopodes de la craie supérieure de Limbourg.* Bruxelles et Maastricht, p. 1—83, pls. 1—6; p. 1—44, pls. 5b—d, 7, 8, 8a, 9 (reprinted in 1873).

Boule, M., Lemoine, P. and Thévenin, A. (1906—1907): Paléontologie de Madagascar, III — Céphalopodes crétacés des environs de Diego-Suarez. *Ann. Paléont.*, vol. 1, p. 173—192, pls. 14—20 (1906); vol. 2, p. 1—56, pls. 1—8 (1907).

Hauer, F. von (1858): Über die Cephalopoden der Gosauschichten. *Beitr. Palaeontogr. Österr.*, vol. 1, no. 1, p. 7—14, pls. 1—3.

Kobayashi, T. (1954): A new cymatoceratid from the Palaeogene of northern Kyushu in Japan. *Japan. Jour. Geol. Geogr.*, vol. 24, p. 15—21, pls. 4,5.

Kobayashi, T. and Kamada, Y. (1959): An Eocene nautiloid from Kyushu, Japan. *Japan. Jour. Geol. Geogr.*, vol. 30, p. 105—114, pl. 9.

Martin, K. (1933): Eine neue Tertiäre Molluskenfauna aus dem Indischen Archipel. *Leidsche Geol. Meded.*, vol. 6, pt. 1, p. 7—32, pls. 1—5.

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

Matsumoto, T., Kanie, Y. and Yoshida, S. (1979): Note on *Pachydiscus* from Hokkaido. *Mem. Fac. Sci., Kyushu Univ.*, ser. d, vol. 24, no. 2, p. 47—73, pls. 8—13.

Matsumoto, T., Muramoto, K., Hirano, H. and Takahashi, T. (1981): Some Coniacian ammonites from Hokkaido. *Trans. Proc.*

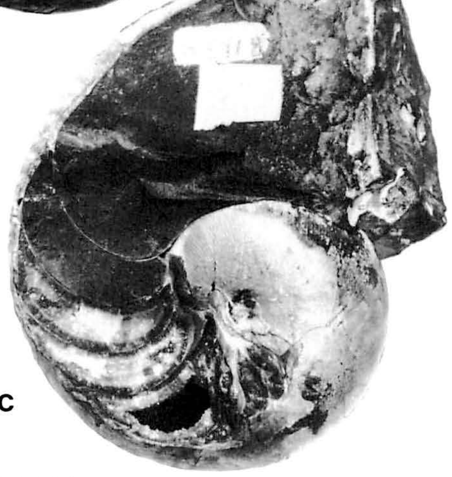
Explanation of Plate 20

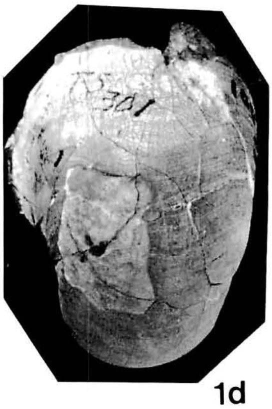
Figs. 1, 2. *Cymatoceras pacificum* sp. nov. . . . . Page 92

1. Paratype, MC. TS-3010, two lateral (a, b), frontal (c) and ventral (d) views, x1.
2. Paratype, GK. H5918, right lateral (a) and ventral (b) views and natural longitudinal section of outer whorl with left lateral view of inner whorl (c), x1.


2a


2b

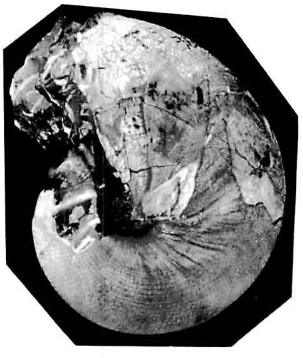

2c



1d

1a


1c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Palaeont. Soc. Japan, n.s., no. 121, p. 51—73, pls. 6—8.

Miller, A. K. and Harris, R. A. (1945): North American Cymatoceratidae (Mesozoic Nautiloidea). *Jour. Paleont.*, vol. 19, p. 1—13, pls. 1—6.

Morris, J. and Lycett, L. (1850): A monograph of the Mollusca from the Great Oolite, chiefly from Minchinhampton and the coast of Yorkshire. *Palaeontogr. Soc.* (London), 4 parts, viii + 130 + 147 + 129 p., 45 pls.

Pictet, F. J. (1847) in Pictet, F. J. and Roux, W. (1847—1853): Description des mollusques fossiles qui se trouvent dans les Gres Verts des environs de Geneve. *Mem. Soc. Phys. Hist. Nat., Geneve*, vol. 11, no. 2 (1847), p. 257—412; vol. 12 (1849), p. 157—287; vol. 13, no. 1 (1853), p. 73—173; 489—558, pls. 1—51.

Redtenbacher, A. (1873): Die Cephalopoden fauna der Gosauschichten in den nördöstlichen Alpen. *Abhandl. Geol. Reichsanst.*, vol. 5, p. 91—140, pls. 22—30.

Reeside, J. B. Jr. (1924): A new nautiloid cephalopod, *Eutrephoceras sloani*, from the Eocene of South Carolina. *U. S. Nat. Mus. Proc.*, vol. 65, art. 5, p. 1—4, pls. 1—3.

Rouchadzé, J. (1931): Notice sur les Belemnites et les Nautilus de l'Aptien de Koutais. *Bull. Mus. Géorgie*, vol. 6 (1929—1930), p. 125—138, pls. 1—3.

Shimizu, S. (1926): On two species of Nautiloidea from the Tertiary of Japan. *Sci. Rept. Tohoku Imp. Univ.*, ser. 2, vol. 9, p. 25—27, pl. 8.

Shumard, B. F. (1860): Descriptions of new Cretaceous fossils from Texas. *St. Louis Acad. Sci. Trans.*, vol. 1, p. 590—610 (inaccessible here).

Ueda, Y. (1962): The type Himenoura Group. *Mem. Fac. Sci. Kyushu Univ.*, ser. D, vol. 12, no. 2, p. 129—178, pls. 22—27.

Ueda, Y., Matsumoto, T. and Akatsu, K. (1962): The Cretaceous deposits in the Chikubetsu area, Hokkaido. *Sci. Rep. Dept. Geol. Kyushu Univ.*, vol. 6, no. 1, p. 15—32 (in Japanese with English abstract).

Wright, C. W. and Wright, E. V. (1951): A survey of the fossil Cephalopoda of the Chalk of Great Britain. Primarily a nomenclatorial revision of Daniel Sharpe's "Description of the fossil remains of mollusca found in the Chalk of England, Part I. Cephalopoda" (1853—1857). *Palaeontogr. Soc.*, London (1950), p. 1—40.

Zittel, K. A. von (1868): Palaeontologische Studien über die Gremzschichten der Jura und Kreide-Formation im Gebiete der Karpathen, Alpen und Apenninen, I. Abtheilung, Die Cephalopoden der Stramberger Schichten. *Mus. K. Bayer. Staates Palaeont. Mittl.* (begonnen von Oppel, forgesetzt von Zittel), vol. 2, p. 33—118, pls. 1—24 in an atlas.

Abeshinai (アベシナイ＝安平志内), Amakusa (天草), Deto-futamata (デト二股), Haboro (羽幌) Himenoura (姫浦), Hobetsu (穂別), Ikushumbets (幾春別), Inasato (稲里), Kawakami (川上) Kumamoto (熊本), Miho (美保), Mikasa (三笠), Naibuchi (内淵), Obira (小平), Pisshiri-zawa (ピッシリ沢), Sanushi (佐主), Sanushibe (サヌシベ), Sapporo (札幌), Teshio (天塩), Urakawa (浦河), Wakkawembets (ワッカウェンベツ), Yamato (大和), Yoshiyachi-zawa (ヨシヤチ沢)

北海道産白亜紀オウムガイ類—II．その2として，北海道のサントニアンとカンパニアン(一部)から産した3種を記載・図示した。3種のうちの1は羽幌の下部サントニアン産のもので代表され，*Eutrephoceras sublaevigatum* (d'Orbigny) に似るが，縫合線がもっと波状で *Kummeloceras* (その1で設立) の1新種とした。2番目は幾春別の下部サントニアン産の大小2個体で代表され，従来九州天草の姫浦層群の下部サントニアンから報ぜられていた *Cymatoceras pseudoatlas* (Yabe et Shimizu) に同定される。3番目は天塩アベシナイの中部カンパニアン産の大小2個体と，昔の南樺太（川上の下部カンパニアン?）から採取されていた中位の大きさのもので代表され，*Cymatoceras* の新種とした。これは *C. saussureanum* (Pictet) に似るが，サイファンクルがやや腹側に位置することなどで区別される。なお論文中の一部（松本単著）で，Cymatoceratidae 及び *Cymatoceras* につき論述し，1新属を提唱した。

松本達郎・村本喜久雄

Trans. Proc. Palaeont. Soc. Japan, N. S., No. 130, pp. 96—116, pl. 21—27, July 15, 1983

763. MIDDLE PALAEOZOIC PALAEOSCENIDIIDAE (RADIOLARIA) FROM MT. YOKOKURA, SHIKOKU, JAPAN. PART I

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Abstract. Palaeoscenidiidae have most basically a bar-centered, eight-spined and polarized spicule. The eight spines consist of four shorter apical spines and four longer basal spines, although the apicals may be reduced to as few as one. It is widely recognized in many species of palaeoscenidiids that one of the apical spines is distinctively developed. Each spine is distinguished by comparative location with the distinctive apical spine and the median bar. Skeletal construction and systematics of palaeoscenidiids are easily understandable in terms of these identifications.

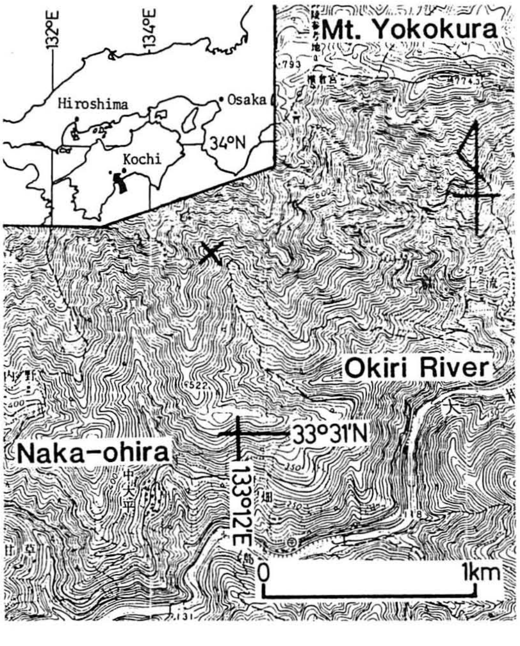
Palaeoscenidiidae are composed of Palaeoscenidiinae and Pentactinocarpinae. Palaeoscenidiinae contain the following genera; *Palaeoscenidium, Archaeosemantis, Parentactinia, Pactarentinia* n. gen. and *Tlecerina* n. gen., and probably *Sepsagon* and *Parasepsagon*.

Five new and two indeterminable species of *Palaeoscenidium?, Parentactinia, Pactarentinia* and *Tlecerina* are described. Genera of *Parentactinia, Pactarentinia* and *Tlecerina* may be simply termed a lattice-shelled *Palaeoscenidium*. They are distinguished by degree of development of the shell. Each shell is situated under the basal spines in *Parentactinia*, covers a part of each basal spine in *Pactarentinia*, and involves the whole of the spicule in *Tlecerina*.

These radiolarians were obtained from a specimen of siliceous shale in the middle part of the G_4 of Mt. Yokokura. The geological age of it is estimated early or middle Devonian on the basis of the stratigraphic relationship between the G_4 and associated fossil-bearing formations and comparisons with known Palaeozoic radiolarians.

Introduction

The family Palaeoscenidiidae was established by Riedel (1967) on the basis of the genus *Palaeoscenidium* Deflandre, 1953 as a spicular form consisting of two to four apical spines and four basal spines proximally connected by flat lamellae. *Palaeoscenidium* was the only component of the family at first. It had been known only from the Lower Carboniferous of France (Deflandre, 1953) and Turkey (Holdsworth, 1973), and the Upper Devonian of Ohio (Foreman, 1963) and Kazakhstan (Nazarov, 1975) unitl recently. The systematic position of this family at suborder rank had remained as *incertae sedis*. Holdsworth (1977) somewhat emended it and supposed that it might relate to *Haplentactinia*, and he tentatively assigned it to the superfamily Entactiniacea, the suborder Spumellaria. Moreover, he found Silurian occurrence from Cornwallis Islands, Arctic Canada. Dumitrică (1978) proposed the subfamily Pentactinocarpinae, which contain five genera, four of them are new, on the basis of the material obtained from Middle Triassic rocks of Italy and Romania. Recently occurrence of middle or late Ordovician



Text-fig. 1. Location of Y-19(X). Base map is the 1:25,000 "Osaki" topographical map issued by the Geographical Survey Institute.

Palaeoscenidium was reported by Igo *et al.* (1980) with no illustrations, although the age remains uncertain as pointed out by me (Furutani, 1981).

In the summer of 1980, I discovered fairly well-preserved radiolarian assemblages in siliceous shale of the G_4 Formation in the Gionyama Group exposed on the southern slope of Mt. Yokokura (=Yokokurayama), Ochi-cho, Kochi Prefecture, Shikoku, Japan (Text-fig. 1). One of them which is named *Tlecerina horrida* assemblage consists of *Palaeoscenidium?* sp. A, *Parentactinia vetustum* n. sp., *Pactarentinia holdsworthi* n. gen. n. sp., *Tlecerina horrida* n. gen. n. sp., *T. exilis* n. gen. n. sp., *T. fenestrata* n. gen. n. sp. and *T.* sp. A with minor elements such as *Haplentactinia* (*s. l.*) sp., *Ceratoikiscum* sp., some other forms of palaeoscenidiids and indeterminable spumellarians. Above-mentioned major species extracted from a rock sample no. Y-19 are described herein and the construction of the skeletons of them are fully examined. Extent of the Palaeoscenidiidae is discussed in comparison with previously known radiolarians. Evolution of this family are briefly remarked also. Other assemblages will be described in near future.

The sample was mainly dissolved for 24 to 30 hours in HF and HC1 diluted 1 part HF (45%) and the same volume of HC1 (36%) to 8 or 7 parts of waters. Subsequently the residues were sieved with a piece of bolting cloth of mesh opening 60μ, and cleaned by boiling in diluted H_2O_2.

Acknowledgements

I am much indebted to Dr. Paulian Dumitrică of Institutul de geologie şi geofizică, Romania, Dr. Brian K. Holdsworth of the University of Keele, England and Dr. Kojiro Nakaseko of Osaka University for critical reading of the typescript of this paper and giving me valuable suggestions. I am grateful to Prof. Akira Morishita and Dr. Junji Itoigawa of Nagoya University for kind reviewing an early typescript and helpful suggestions. I wish to thank Dr. Shigenori Maruyama of Toyama University for persuading me to study the radiolarians of Mt. Yokokura and assistance in field work. Thanks are also due to Mr. Atsushi Takemura of Kyoto University for giving me valuable discussion, and to Mr. Hiroaki Ishiga of Osaka City University for the information on the Permian palaeoscenidiid.

Geologic setting and age

Hamada (1961) gave a general name "Gionyama Series" to Middle palaeozoic rocks scattered in the Kurosegawa Tectonic Zone, Outer zone of Southwest Japan. He divided the series into four stages in ascending order; G_1 (thickness is unknown) tuffaceous sandstone, G_2 (25m+) fossiliferous limestone, calcareous sandstone and so on, early-middle Wenlockian in age, G_3 (240m) fossiliferous limestone, early Ludlovian, G_4 (1100m) acid volcanic rocks with occasional occurrence of radiolarian remains, and subordinate amounts of tuffaceous sandstone and conglomerate, late Ludlovian to ?middle Devonian. Mt. Yokokura is one of the best locality of the series cropping out. Afterward Hirata (1966a) discovered late Devonian plant remains and brachiopods including *Leptophloeum rhombicum* Dawson, *Lepidodendropsis* sp. and *Orbiculoidea* sp. from the overlying pelitic rocks named the Ohira Formation by him. Subsequently the name of the formation was revised to the Ochi Formation by the same author (1966b), who considered the Ochi Formation occupies the upper part of the G_4. However according to Yoshikura (1982) it is incorrect. According to Hamada (1961) the G_4 conformably overlies the G_3, whereas exact stratigraphic relationship between the G_4 and the Ochi Formation is indetermined. Although no reliable index fossils occur from the G_4, the geological age of it can be estimated between late Ludlovian and middle Devonian times by its stratigraphic relationship with the G_4 and the Ochi Formation. The present material was collected from roughly middle part of the G_4. Therefore, it is presumed to be early or middle Devonian in age.

In general, determination of geological age of Palaeozoic rocks only by radiolarians is very difficult, because our knowledge of biostratigraphy about Palaeozoic radiolarians is very poor. It is only possible to estimate period, at the best, especially before the Late Devonian. In this case co-occurrence of conodonts is expected as a time indicator. However, they have never been detected until the present. The *Tlecerina horrida* assemblage described herein is quite unique among known Palaeozoic assemblages. Therefore, it is impossible to assume the age of this assemblage by itself. However another slightly older assemblage, which consists of *Palaeoscenidium* spp., *Parentactinia* sp., *Haplentactinia* (*s. l.*) sp., *Ceratoikiscum* spp. and unnamed spumellarians, may somewhat relate to known Devonian radiolarians (Hinde, 1899; Foreman, 1963; Nazarov, 1975) in general aspect except the occurrence of *Parentactinia*. Radiolarians of after Middle Devonian time are comparatively well known than older fauna. The complete absence of albaillellids in these assemblages excludes possibility of Carboniferous and Permian ages. Previously known Ordovician (Fortey and Holdsworth, 1972; Nazarov, 1975; Nazarov and Popov, 1980; Igo *et al.*, 1980) and Silurian (Holdsworth, 1977; Furutani, 1981) radiolarians are far apart from these assemblages. Thus the geological age of the *Tlecerina horrida* assemblage is assumed to be Devonian. This is not contradictory with the preceding estimation from the stratigraphy.

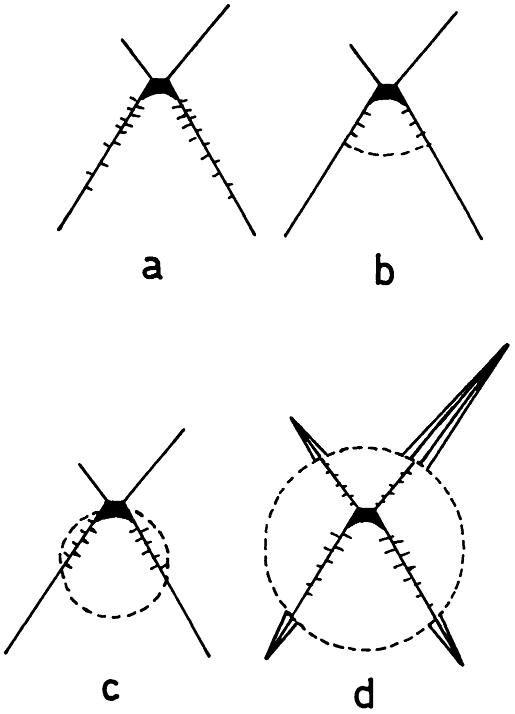
Construction of the skeletons

Palaeoscenidiidae are characterized by a polarized, five- to eight-spined and bar- or point-centered spicule. Amongst those variations of the spicule the eight-spined and bar-centered one is regarded as the most fundamental type. It consists of a short median bar and eight spines; a pair of shorter apical spines and a pair of longer basal spines radiate from each end of the median bar. The basal spines usually have spinules. Imperforate lamellae may connect with the median bar and proximal parts of the basal spines, thus forming the "tent-like shell" of Holdsworth (1977). When the tent-like shell develops the median bar is not recognized as a distinct bar. The skeleton of the genus *Palaeoscenidium* Deflandre (Text-fig. 2a) consists of the six- to eight-spined spicule and usually the tent-like shell. When the spicule has eight spines, it is widely recognized in many species of *Palaeoscenidium* from the Ordovician (Pl. 21, Fig. 6) and Silurian of Fukuji, Central Japan, in addition to the species of Mt. Yokokura, that one of the four apical spines is distinctively longer and thicker than the others. For convenience of descriptions I term the distinctive apical spine principal apical spine (PA spine in abbreviation). Each spine is discriminated by comparative situation with the PA spine and the median bar. Other apical spines are also termed as follows (Pl. 21, Fig. 1);

counter apical apine: an apical spine situated opposed to the PA spine (CA spine in abbreviation)

lateral apical spine: an apical spine paired with the PA spine (LA spine in abbreviation)

counter lateral apical spine: an apical spine



Text-fig. 2. Schematic profiles of genera of Palaeoscenidiidae from Mt. Yokokura viewing from the lateral side of the median bar.
a, *Palaeoscenidium*; b, *Parentactinia*; c, *Pactarentinia*; d, *Tlecerina*.

paired with the CA spine (CLA spine in abbreviation).

The basal spines are termed as follows;

PB spine: a basal spine underlying to the PA spine
CB spine: a basal spine underlying to the CA spine
LB spine: a basal spine underlying to the LA spine
CLB spine: a basal spine underlying to the CLA spine

The number of the apical spines is essentially four, but it may be reduced to three or even two. Holdsworth (1977) reported Silurian *Palaeoscenidium* having two or three apical spines from Cornwallis Islands, Arctic Canada. In my collection almost all specimens of *Palaeoscenidium* have four apical spines. However, some specimens seem to have only two or even one apical spine at a glance. When the number of apicals seems to be two, it is owing to the minute LA and CLA spines. In the latter case it is due to the minute CA, LA and CLA spines. Foreman (1963) found two specimens of cf. *Palaeoscenidium cladophorum* having only three basal spines, and Holdsworth (1977) stated the number of the basals was three or four in his specimens from Cornwallis. The number of the basal spines, however, is invariably four in my specimens obtained from Mt. Yokokura and Fukuji. I suppose *Palaeoscenidium* originally had four basal spines, and such forms having three basals are freaks or specialized species.

Such genera as *Parentactinia*, *Pactarentinia* and *Tlecerina* may be simply termed a lattice-shelled *Palaeoscenidium*. The skeleton of *Parentactinia* Dumitrică, 1978 (Text-fig. 2b) is composed of a short median bar, four or three apical spines, four basal spines and an incomplete sphaerical lattice shell. Medial part of the basals participates in construction of the shell lattice. The apical spines are invariably four in number as far as I could observe in the specimens from Mt. Yokokura. The PA spine is not very distinct. Degree of differentiation of the PA spine is rather different from specimen to specimen. When it is discriminated, other spines are termed like *Palaeoscenidium*.

Pactarentinia n. gen. (Text-fig. 2c) is composed of *Palaeoscenidium*-like eight-spined spicule and complete globular lattice shell. The number of the apical and basal spines is invariably four respectively. The shell covers medial part of the basal spines. The basal spines bear spinules on the covered part by the shell. The median bar is situated slightly above the level of the shell surface. A small tent-like shell, consisting of the median bar, proximal parts of the basal spines and imperforate lamellae, penetrates the lattice shell from the inner to outer side. The PA spine is distinct. Other spines are named in the same rule as *Palaeoscenidium* (Pl. 23, Fig. 1a).

Tlecerina n. gen. (Text-fig. 2d) is a single sphaerical lattice-shelled form with eight-rayed polarized spicule in the shell. The internal spicule is just like *Palaeoscenidium*. It is composed of a short median bar, four shorter rays bearing very small spinules and four longer rays bearing longer spinules and a lamellate tent-like shell which is made up of the median bar, proximal parts of the longer rays and imperforate lamellae. The median bar is not recognized as a distinct bar by the development of the tent-like shell. *Tlecerina* has six to eight main spines in the meaning of Foreman (1963). Each spine connects with one of the rays of the internal spicule. One of the main spines is four-bladed and more massive than any other main spines. The thickest main spine always connects with one of the shorter "apical" rays, commonly with the thickest apical ray, of the spicule. The thickest spine plus the connected ray obviously homologous to the principal apical spine of other genera. The thickest apical spine is termed principal apical spine (PA spine in abbreviation), and the rays connecting with the PA spine is termed principal apical ray (PA ray in abbreviation). Other rays are termed as follows, however, "ray" is used instead of "spine" (Pl. 24, Figs. 1, 3a);

counter apical ray: an apical ray situated opposed to the PA ray (CA ray in abbreviation)
lateral apical ray: an apical ray paired with the PA ray (LA ray in abbreviation)
counter lateral apical ray: an apical ray paired with the CA ray (CLA ray in abbreviation)
PB ray: a basal ray underlying to the PA ray
CB ray: A basal ray underlying to the CA ray
LB ray: a basal ray underlying to the LA ray
CLB ray: a basal ray underlying to the CLA ray

Four of the main spines except the PA spine always connect with the basal rays of the internal spicule. They are less massive than the PA spine and ususally three-bladed or rod-like. Remaining one to three spines are generally weakly developed and connect with the rest of the apical rays. When the remaining spine is one in number, it always connects with the CA ray. The main spines except the PA spine are termed as follows (Pl. 24, Figs. 1, 3a; Pl. 26, Fig. 3a);

counter apical spine: a spine connecting with the CA ray (CA spine in abbreviation)
lateral apical spine: a spine connecting with the LA ray (LA spine in abbreviation)
counter lateral apical spine: a spine connecting with the CLA ray (CLA spine in abbreviation)
PB spine: a spine connecting with the PB ray
CB spine: a spine connecting with the CB ray
LB spine: a spine connecting with the LB ray
CLB spine: a spine connecting with the CLB ray

In general, extending directions of the spines more or less reflect the direction of the spicular rays.

Above discrimination of each spine or ray will be good aid for understanding skeletal construction and systematics of Palaeoscenidiinae, and phylogenetic relationship between Palaeoscenidiinae and other groups.

The next problem is whether the PA spine would seem to extend to the right or left from the end of the median bar, if we stood on the apical side of the median bar, although biological significance of it is unknown. In the herein described species of *Pactarentinia* and *Tlecerina*, the right extending and the left extending forms are almost equally observed even in a species. In *Palaeoscenidium* of Fukuji, in contrast, the right extending form apparently exceeds the left extending one.

In some species of palaeoscenidiins, the angle between the PB and LB spines, or the CB and CLB spines is larger than the angle between the PB and CLB spines, or the CB and LB spines. This phenomenon is commonly observed among my specimens of *Palaeoscenidium* and *Parentactinia vetustum*. However the spicule of *Pactarentinia holdsworthi* has not such character. In *Tlecerina* it is not confirmed.

In a species of *Telecerina* (*T. fenestrata*) usually one large pore opens above the median bar. The apical spines are disposed round the pore. The pore is termed apical window. On the detail of the apical window, see a description of *Tlecerina fenestrata*.

Pentactinocarpinae, another subfamily of

Palaeoscenidiidae, contain five genera such as *Palacantholithus?* Deflandre [=*Triassothamnus* by Kozur and Mostler, 1981], *Pentactinocarpus* Dumitrică, *Pentactinocapsa* Dumitrică, *Pentactinorbis* Dumitrică and *Lobactinocapsa* Dumitrică. They are throughout described and illustrated by Dumitrică (1978) on the basis of the excellently preserved specimens from the Middle Triassic of Italy and Romania. *Palacantholithus?* is a pentactin spicular form and other four genera are a lattice-shelled form in some kinds of manner. They are all characterized by having a pentactin spicule consisting of an apical spine and four basal spines without the median bar. The apical spine is most probably homologous to the principal apical spine of Palaeoscenidiinae.

Extent of Palaeoscenidiidae

Palaeoscenidiidae are characterized by having a five- to eight-spined and strongly polarized spicule, while Entactiniidae, which are one of the best known group amongst Palaeozoic radiolarians, have a typically six- to four-spined spicule with no strong polarity in itself. Generally they are easily distinguishable by strong polarity in the spicule of the former and the number of the spines. However, more or less eccentrically located median bar of the internal spicule is observed in the medullary shells of many known species of the Entactiniidae. Hence, when palaeoscenidiids have six-spined spicule, they may seem to be confusing with entactiniids.

If the typical spicule of palaeoscenidiids is projected to a perpendicular plane to the median bar as viewed along the median bar, the projection becomes tetraradiate (Text-fig. 3a) by overlapping one spine upon the other. The four pairs are the PA and CLA, the CA and LA, the PB and CLB, and the CB and LB spines. On the other hand in the typical spicule of entactiniids, such as *Haplentactinia arrhinia* Foreman, the projection becomes hexaradiate by radiations of each spine from the center with an interval of 60° (Text-fig. 3b). When an apical spine degenerates at each end of the median bar of palaeoscenidiids, the LA and CLA spines are expected to extinct, the projection of the spicule becomes tetraradiate if the two apicals preserve the original extending direction, or triradiate if the apicals extend in a plane containing the median bar (Text-fig. 3c). In the forms having a six-spined spicule, whether the projection of the spicule is tetraradiate or triradiate, or hexaradiate may be a good criterion for discrimination between palaeoscenidiids and entactiniids.

Some of the known entactiniids, which have a six-rayed spicule, actually seem to be able to refer to Palaeoscenidiidae. For example *Entactinosphaera fredericki* Foreman, which was well illustrated by Foreman (1959, 1963), has a six-rayed spicule made up of a distinct median bar, four longer rays bearing a group of spinules on the each ray and two shorter rays having no spinules, and the thickest spine among six main spines connects with one of the shorter rays. The polarity in the spicule seems to be evident. Another example is *Entactinosphaera unimana* Nazarov in Kruchek and Nazarov (1977). It has also a polarized six-rayed spicule and a heavier main spine arising from a shorter ray of the spicule. The morphology of them reminds us of palaeoscenidiids. However, I assume here they are entactiniids because the projection of the spicule of them are supposed to be hexaradiate.

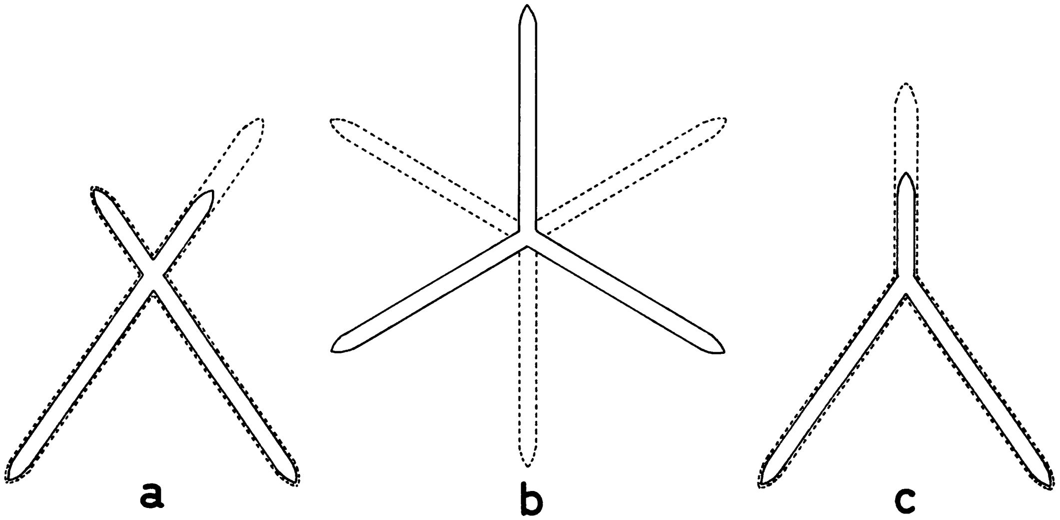
Foreman (1963) presumed that *Haplentactinia arrhinia*, with two groups of the spinules on the each of the spines and without a lattice shell, *Haplentactinia rhinophyusa* Foreman, some of the proximal groups of the spinules form the base for a rudimentary lattice shell, and *Entactinosphaera fredericki* represent three consecutive early stages in the development of the radiolarian lattice shell. If it is correct, the spicule of *E. fredericki* has originally no polarity, and hence it is not a palaeoscenidiid in accordance with the above assumption. Moreover, the spicule, which seems to be polarized owing to the eccentrically located median bar in the medullary shell, of many other species of entactiniids may also originate from the unpolarized entactiniid spicule.

Besides the above-mentioned species, a heavier spine, like that of *Tlecerina*, than the other is observed in many species of known entactiniids such as *Entactinia cometes* Foreman, *Entactinia monalloea* Foreman, *Entactinia? additiva* Foreman, *Entactinia diversita* Nazarov, *Entactinosphaera riedeli* Foreman, *Entactinosphaera euthlasta* Foreman, *Entactinosphaera palimbola* Foreman, and *Entactinosphaera? diplostraca* Foreman. However, origin of the heavier spine is unknown. Since, unfortunately, detailed morphology of the internal spicule of them is not clear, it is impossible to discuss more about the relationship between Palaeoscenidiidae and them.

Dumitrică (1978) proposed the genus *Parentactinia* and assigned it to the family Entactiniidae, on the grounds that Triassic forms are more commonly bar-centered than Palaeozoic *Palaeoscenidium* and have a globular lattice shell. However, Holdsworth (1977) defined the family Palaeoscenidiidae to have most commonly a short median bar, actually bar-centered *Palaeoscenidium* is very common in my collection from Mt. Yokokura and Fukuji, and presence of some forms of lattice-shelled palaeoscenidiids including a species of *Parentactinia* is clarified by the present study. Moreover, the projection as viewed along the median bar is apparently tetraradiate in the Triassic *Parentactinia* in like manner of the Devonian species described herein. It is reasonable to remove *Parentactinia* from Entactiniidae to Palaeoscenidiidae and Palaeoscenidiinae, based on the essentially same spicular system and strong polarity in the spicule.

Archaeosemantis, also described as a entactiniid by Dumitrică (1978), is a curious form which consists of two apical and four basal spines with a short median bar. It is apparently allocated to Palaeoscenidiidae and Palaeoscenidiinae by the strong polarity in its spicule. Dumitrică (1978) regarded it to be a degenerate form from *Parentactinia*. His view is highly acceptable for me.

The Triassic genus *Sepsagon* Dumitrică, Kozur and Mostler, 1980 has a spicule consisting of three apical rays, four basal rays and a median



Text-fig. 3. Projections of idealized spicules of Palaeoscenidiinae and Entactiniidae to a perpendicular plane to the median bar as viewed along the median bar. Solid lines are the projections of the spines on this side of the median bar, and broken lines are the projections of the spines on the other side of the median bar.

bar. The spicule seems to be like that of the Palaeoscenidiinae, although the exact position of the median bar is obscure. Thus this genus very probably belongs to the Palaeoscenidiinae, and is assumed to relate to *Parentactinia*, because the medullary portion is comparable to *Parentactinia* in respect of the number of the apical rays and the relationship between the basal rays and the latticed medullary shell. *Parasepsagon* Dumitrică, Kozur and Mostler, 1980 also probably belongs to the Palaeoscenidiinae, as it has a similar medullary shell to that of *Sepsagon* according to the description by the authors. Dumitrică *et al.* (1980) stated that in some Triassic forms such as *Styloshpaera?* and *Hindeosphaera* by Kozur and Mostler (1979), and as *Archaeospongoprunum?* or Actinommid group A by De Wever *et al.* (1979) seemed to belong to the same group with Triassic "entactiniids" including *Sepsagon*. Amongst them *Hindeosphaera* Kozur and Mostler, 1979 has a strong spine and seven, at the maximum, weak spines. The external aspect of the genus reminds us of *Tlecerina*. However, recent work by Kozur and Mostler (1981) revealed that the inner shell resembling that of *Pentactinocarpus* has a pentactin spicule, thus it might relate rather to Pentactinocarpinae.

Foreman (1963) proposed the genus *Polyentactinia* consisting of an irregular lattice shell and a six- to eight-rayed internal spicule. According to her excellent illustration (pl. 9, fig. 5a) and description of *Polyentactinia craticulata* Foreman, the type species of this genus, the spicule is very eccentrically located and composed of four spinule-bearing rays and three flat rays. It seems to be clear this genus is referred to Palaeoscenidiidae. However, I hesitate to do so, because the supposed projection of the internal spicule may not be necessarily palaeoscenidiid-like. Nazarov (1975) erected the subfamily Polyentactiniinae in the family Entactiniidae, employing *Polyentactinia* as the type genus, which are sphaerical-shelled forms having seven- or more-rayed internal spicule radiating from both the ends of a median bar or corners of a polyhedron. It may become *nomen dubium*, if *Polyentactinia* is allocated to Palaeoscenidiidae. According to Nazarov (1975), Polyentactiniinae include such genera as *Astroentactinia* Nazarov, *Helioentactinia* Nazarov, *Spongentactinnella* Nazarov, and *Somphoentactinia* Nazarov besides *Polyentactinia*. Although many species, which have the polyhedron in the center of the spicule, of these genera cannot be allocated to either Palaeoscenidiidae or Entactiniidae, as Holdsworth *et al.* (1978) suggested, some species, at least, possibly belong to Palaeoscenidiidae on account of their definition. However, it is impossible to judge precisely whether they are members of Palaeoscenidiidae or not, owing to a lack of knowledge on the detail of the internal spicule of them. I exclude them from Palaeoscenidiidae for the time being. (See remarks on the *Tlecerina*.)

A species of "Spumellaria family and genus indet." illustrated by Holdsworth *et al.* (1978, figs. 2v, w), which has at least a single sphaerical lattice shell, a strong four-bladed spine and a weaker spine, may relate to *Tlecerina*. Holdsworth *et al.* (1978) remarked it has only two opposed spines, but fig. 2v seems to show three or more spines. If my view is correct, it is difficult to distinguish this species from *Tlecerina*, at least, only by the external aspect. "Aff. '*Cenosphaera*' cf. '*C.*' *cabrierensis* Group" by Holdsworth *et al.* (1978) may also be in the same condition.

A species of "aff *Entactinia* sp." by Fortey and Holdsworth (1972, pl. 10, fig. 1) possesses an eccentric six-rayed spicule and a loose sphaerical shell. Four of the rays generate the shell by terminal bifurcations, and remaining two emerge immediately the shell. The projection of the spicule is assumed to be triradiate, and the polarity is apparent. Therefore, this species probably relates rather to Palaeoscenididae than to Entactiniidae.

Nazarov in Nazarov and Popov (1980) tentatively assigned *Bissylentactinia* Nazarov, 1975 to Palaeoscenidiidae. *Bissylentactinia* is a spicular form having six to twelve spines radiating from a center with spinules on one or two levels of the each spine. The type species of the genus (*B. rudicula* Nazarov) has apparently no polarity in itself. Therefore, the genus *Bissylentactinia* should be excluded from Palaeoscenidiidae. However, *Bissylentactinia quadriramosum*, which was first described by Foreman (1963) as *Palaeoscenidium? quadriramosum*, clearly shows natures of palaeoscenidiids. Namely it consists of eight-spined spicule, and four spines of it bear spinules on one side of the spicule. Thus it is included into Palaeoscenidiinae.

Deflandre (1960) illustrated many species of radiolarians from the Lower Carboniferous of Montagne Noire, France without descriptions. One of the illustrations (fig. 15, "*Lithocannosphaeropsis fallax*") shows a somewhat palaeoscenidiid-like internal spicule with one or two sphaerical shell without external spines. It might relate to Palaeoscenidiidae.

Some kinds of spicular radiolarians were described by Deflandre (1973a, b). Among them, although the type species of *Palhindeolithus* (*P. ambiguus*) has two groups of four spines radiating from both ends of the median bar, it has no trace of the polarity, hence it cannot be a palaeoscenidiid.

Palacantholithus Deflandre, to which Dumitrică (1978) tentatively allocated the Triassic *Palacantholithus?*, consists of four or five radiating spines and a perpendicular spine. I can recognize five spines in the illustration (Deflandre, 1973a, pl. 3, fig. 2) of the holotype of *Palacantholithus stellatus*, which is the type species of the genus, but the spines do not seem to have the palaeoscenidiid disposition. Moreover, a spicule possessing five basal spines is totally absent in palaeoscenidiids. Therefore, the genus *Palacentholithus* is probably excluded from Palaeoscenidiidae. However, a specimen of pl. 3, fig. 5 is not impossibly a palaeoscenidiid, whereas Triassic *Palacantholithus?* belongs to Palaeoscenidiidae without doubt.

Xiphachistrella is also described by Deflandre (1973a, b), and has a strong perpendicular apical spine and four divergent basal spines with some arches arising from the apical spine. Although Deflandre (1973a) considered it might relate to Ceratoikiscidae, I am of the opinion that it is rather comparable to Pentactinocarpinae in the disposition of the five spines. But my conclusion is reserved, because the medial portion of the spicule remains obscure.

Pylentonemidae Deflandre, 1963 have a bar-centered, seven-rayed spicule. The spicule may rather relate to that of Nassellaria in homology. Eight-rayed spicular forms have never been known in it, and the pylome, which all pylentonemids characteristically have, is entirely absent in Palaeoscenidiidae. Therefore, they are evidently discriminated from each other.

The spicule of Palaeoscenidiidae and that of Cainozoic Orosphaeridae Haeckel, 1887, which

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Explanation of Plate 21

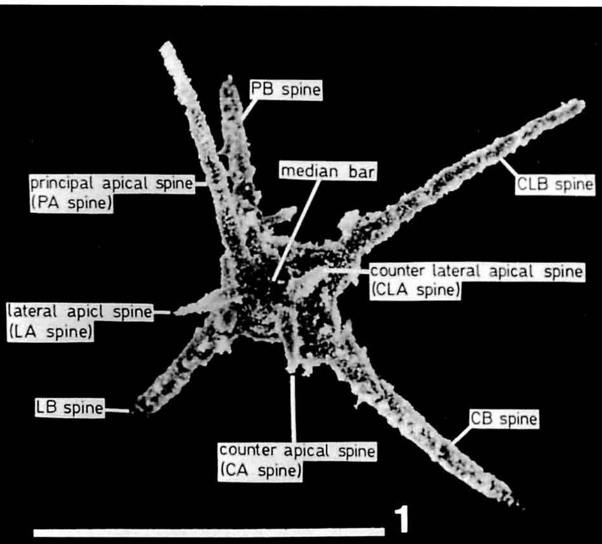
Fig. 1. *Palaeoscenidium* sp.
  1. Apical view indicating terms of spines. This specimen was obtained from an older horizon than Y-19.

Figs. 2, 3. *Palaeoscenidium* sp. A
  2. ESN 144001; a, oblique view; b, apical view.
  3. ESN 144002; a, view along the median bar; b, oblique view.

Figs. 4, 5. *Parentactinia vetustum* n. sp.
  4. Paratype (ESN 144003); apical view showing a verticil on an apical spine.
  5. Holotype (ESN 144004); a, side view; b, oblique view.

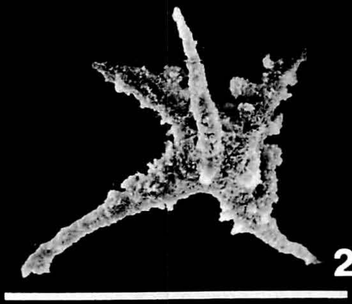
Fig. 6. *Palaeoscenidium* (*s. l.*) sp.
  6. This specimen was obtained from the Yoshiki Formation (middle or late Ordovician) of Fukuji, Central Japan.

Scale = 100μm.



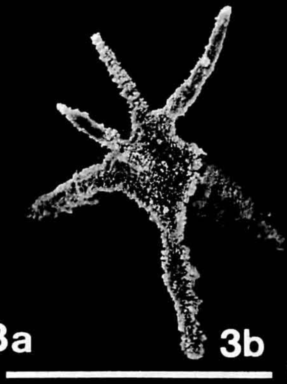
1

2a



2b

3a



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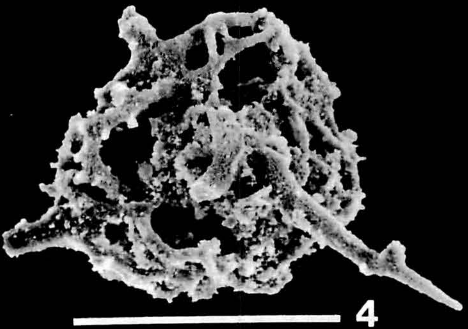

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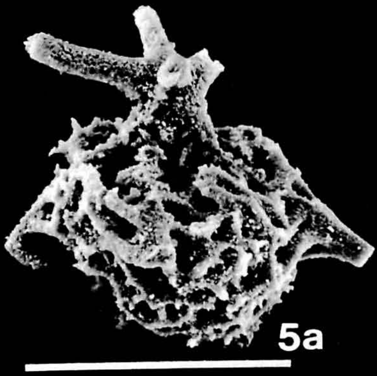

5a

5b

6

was comprehensively described by Friend and Riedel (1967), are closely resembling each other in having an eight-spined, bar-centered spicule with strong polarity in itself, as pointed out by Dumitrică (1978), although the shells of the latter are far larger than those of the former. However, I tend to distinguish them for the present, because Jurassic and Cretaceous record of both the family is lacking and the size of the skeletons is remarkably different between them.

Very recently, Takemura and Nakaseko (1982) described two new genera such as *Hilarisirex* and *Diceratigalea* from the Jurassic of Central Japan under the new subfamily Hilaricirecinae, and they considered this subfamily belongs to the family Palaeoscenidiidae based on their cephalic skeletal structure. Judging from their descriptions and illustrations, the projections of their six-rayed spicules become triradiate. The median bar of their spicules is distinctively long, although that of previously known palaeoscenidiids is short. Moreover, a specimen (pl. 70, fig. 2) of *Hilarisirex quadrangularis* Takemura and Nakaseko, the type species of the genus, has a slight protuberance at the same spots as the dorsal and the axial spines of Nassellaria. *Diceratigalea hemisphaera* Takemura and Nakaseko, the type species of the genus, also has a slight protuberance at the same spot as the dorsal spine of Nassellaria. These facts suggest that the "basal spines" of Hilaricirecinae do not homologous to the basal spines of the family Palaeoscenidiidae. Therefore, the Hilaricirecinae are assumed to be excluded from the family Palaeoscenidiidae.

It is concluded from above discussions that Palaeoscenidiinae contain *Archaeosemantis* and *Parentactinia*, and *Sepsagon* and *Parasepsagon* with slight question, besides *Palaeoscenidium*, *Pactarentinia* n. gen. and *Tlecerina* n. gen. Pentactinocarpinae include the five genera described by Dumitrică (1978). Familial assignment of many other genera or species having the confusing spicule cannot be decided for certain owing to a lack of knowledge on the detailed morphology of the spicule. It is expacted that the morphology of the spicule is studied in more detail.

Additional remarks

There was a long interval between the latest records, the Tournaisian of France by Deflandre (1953) and Turkey by Holdsworth (1973), of Palaeozoic palaeoscenidiids and Middle Triassic ones. Very recently, however, Ishiga *et al.* (1982) discovered *Palaeoscendidium?* sp. possessing perforate lamellae between the proximal parts of the neighbouring basal spines, from the upper Permian of the Tamba Belt, Southwest Japan, although the median bar and the apical portion are not preserved. It may be regarded as a link between the Carboniferous and Triassic records.

Although older occurrences of unshelled *Palaeoscenidium* are known from the Japanese Ordovician (Igo *et al.*, 1980) and the lower Silurian of Arctic Canada (Holdsworth, 1977), the present occurrence is the oldest record of the definitely lattice-shelled Palaeoscenidiinae. Thus it is assumed that Palaeoscenidiinae acquired the shell between late Silurian and middle Devonian, at the latest, ages.

In Pentactinocarpinae, if Carboniferous *Palacantholithus* described by Deflandre (1973a, b) is a true member of Pentactinocarpinae, although it is fairly questionable as already discussed, the spicular form also precedes Triassic shelled forms. Dumitrică (1978) supposed this acquisition had occurred somewhere between late Carboniferous and Permian ages. Such sequence shown in both the subfamilies as from the spicular forms to the lattice-shelled forms strongly suggests evolutional trend of this family. Furutani (1982) briefly discussed the evolution of this family. I will discuss this problem in more detail in a forthcoming paper which will describe primitive lattice-shelled palaeoscenidiinae from Mt. Yokokura.

Systematic palaeontology

Subclass RADIOLARIA Müller

Order POLYCYSTINA Ehrenberg

Suborder SPUMELLARIA Ehrenberg

Superfamily Entactiniacea Riedel, 1967

Family Palaeoscenidiidae Riedel, 1967 (emended herein)

1967. Palaeoscenidiidae, Riedel, p. 149.
1971. Palaeoscenidiidae, Riedel, p. 658.
1977. Palaeoscenidiidae, emended, Holdsworth, p. 168.
1981. Palaeoscenidiidae, Kozur and Mostler, p. 17.
1981. Pentactinocarpidae, Kozur and Mostler, p. 18.
1981. Parentactiniidae, Kozur and Mostler, p. 34.
1981. ?Sepsagonidae, Kozur and Mostler, p. 35.

Type genus:–*Palaeoscenidium* Deflandre, 1953

Diagnosis:—Palaeozoic and Mesozoic radiolarians having bar- or point-centered spicule which comprises of four to one shorter apical spines and four, rarely three, longer basal spines. The median bar is short or absent. A pair of the apical spines and that of the basal spines radiate from both ends of the median bar, when the spicule has eight spines and the median bar. A lamellate tent-like shell, made up of the median bar, the proximal parts of the basal spines and imperforate lamellae, is common. The principal apical spine generally develops. The basal spines frequently have spinules. The projection of the spicule to a perpendicular plane to the median bar becomes tetraradiate or triradiate. Many genera have one or more lattice shells.

Contained subfamily:—Palaeoscenidiinae Riedel, 1967, Pentactinocarpinae Dumitrică, 1978.

Remarks:—Systematic position of this family at suborder rank had remained as *incertae sedis* since the establishment by Riedel (1967) until recently. Holdsworth (1977) tentatively assigned this family to the suborder Spumellaria, the superfamily Entactiniacea on the basis of the presence of intermediate forms between *Haplentactinia* and *Palaeoscenidium* in Cornwallis. Dumitrică (1978) proposed Pentactinocarpinae as a new subfamily of Palaeoscenidiidae. It is characterized by having a pentactin spicule, which is composed of an apical spine and four basal spines without the median bar, and includes some kinds of the lattice-shelled forms. It was endorsed that Palaeoscenidiidae belonged to the suborder Spumellaria by his study. Holdsworth (1977) stated that the suborder assignment of Entactiniacea was probably incorrect although it is a tradition. However, because the external aspect of the lattice-shelled palaeoscenidiids shows strong resemblance to typical spumellarians, it is the best treatment to assign Palaeoscenidiidae, at least, to Spumellaria in the present circumstances.

This family is distinguished from the Entactiniidae in the nature of the spicule. The number

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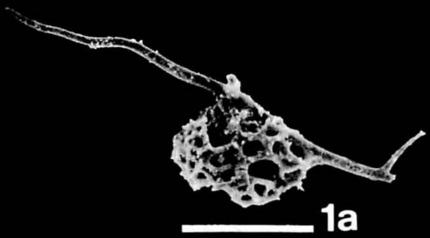
Explanation of Plate 22

Figs. 1—4. *Parentactinia vetustum* n. sp.
1. Paratype (ESN 144005); a, side view showing a long apical spine and a spinule on a basal spine; b, enlargement of the lattice shell.
2. Paratype (ESN 144006); a, oblique view showing a verticil on basal spines; b, apical view showing small angles between the PB and CLB spines and the CB and LB spines.
3. Paratype (ESN 144007); a, oblique view showing nodes on the outer surface; b, apical view.
4. Paratype (ESN 144008); a, oblique view; b, enlargement of the opposite side of the a.

Figs. 5, 6. *Pactarentinia holdsworthi* n. gen., n. sp.
5. Paratype (ESN 144009); apical view.
6. Paratype (ESN 144010); side view.

Scale = 100μm.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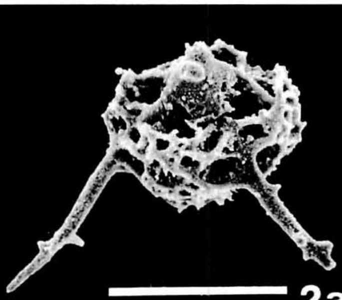
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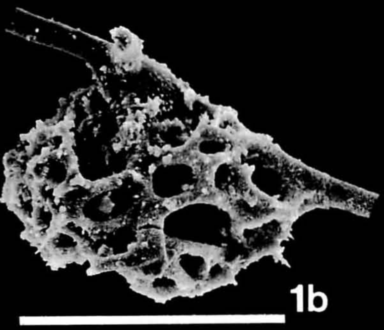
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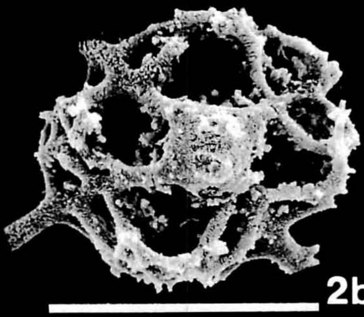
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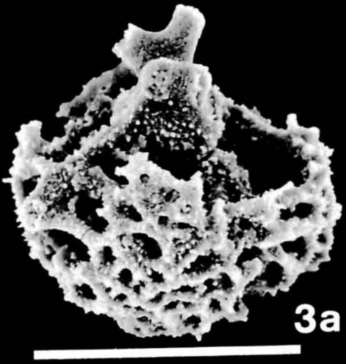
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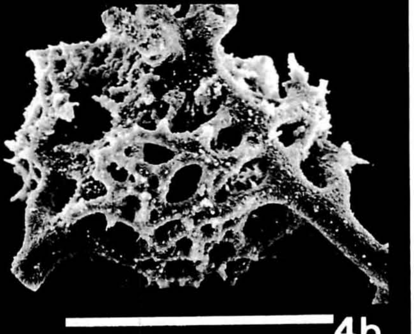
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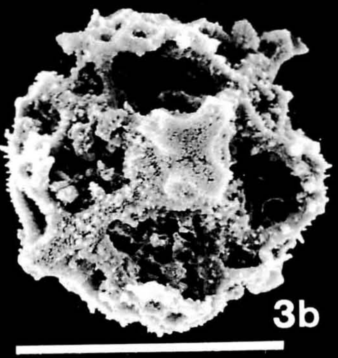
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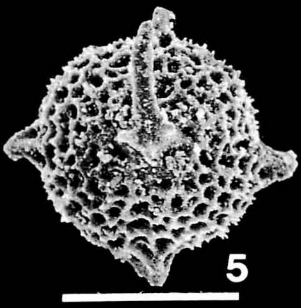
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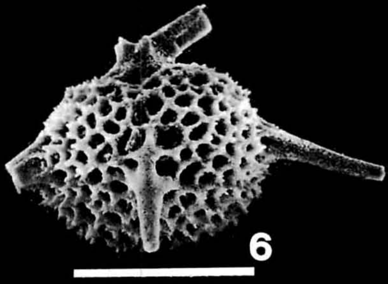
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of the spines of the spicule is five to eight and the apical-basal polarity is evident in the former, while the number is four to six or rarely more and the polarity is not clearly recognized in the latter. Moreover, the projection of the spicule is tetraradiate or triradiate in the former, while that of the latter is not so and it becomes hexaradiate in the most common six-spined spicule.

Subfamily Palaeoscenidiinae Riedel, 1967
(emended herein)

1967. Palaeoscenidiidae, Riedel, p. 149.
1971. Palaeoscenidiidae, Riedel, p. 658.
1977. Palaeoscenidiidae, emended, Holdsworth, p. 168.
1981. Palaeoscenidiidae, Kozur and Mostler, p. 17.
1981. Parentactiniidae, Kozur and Mostler, p. 34.
1981. ?Sepsagonidae, Kozur and Mostler, p. 35.

Type genus:—Palaeoscenidium Deflandre, 1953

Diagnosis:—Palaeoscenidiidae which have a spicule possessing two to four apical spines, with or without one or more lattice shells.

Remarks:—Palaeoscenidiinae are distinguished from Pentactinocarpinae by the character of the spicule. The spicule of the latter is composed of an apical and four basal spines without a median bar, whereas that of the former made up of two to four apicals and four basals usually with a median bar.

Contained genera:—Palaeoscenidium; Archaeosemantis Dumitrică, 1978; *Parentactinia* Dumitrică, 1978; *Pactarentinia* Furutani n. gen.; *Tlecerina* Furutani n. gen.; *?Sepsagon* Dumitrică, Kozur and Mostler, 1980; *?Parasepsagon* Dumitrică, Kozur and Mostler, 1980.

Genus *Palaeoscenidium* Deflandre, 1953

1953. *Palaeoscenidium* Deflandre, p. 408.

Type species:—Palaeoscenidium cladophorum Deflandre, 1953

Diagnosis:—Palaeozoic Palaeoscenidiinae usually with straight basal spines and the tent-like shell and without rings formed by the basal spines.

Remarks:—Palaeoscenidium differs from *Archaeosemantis* in having no rings formed by the basals and disposition of the spinules.

Although only two species of *Palaeoscenidium* have ever been described, some distinctive forms are recognized amongst only illustrated *Palaeoscenidium*, which conform to the above diagnosis, by Holdsworth (1977) and in this paper (Pl. 21, Fig. 6). When such forms are described, it will be needed to erect new genera for them.

Contained species:—Palaeoscenidium cladophorum; Palaeoscenidium (*s. l.*) *quadriramosum* Foreman, 1963.

Palaeoscenidium sp. A

Pl. 21, Figs. 2, 3

Material:—Two specimens were examined by a scanning electron microscope (SEM).

Description:—Eight-spined form, two apical and two basal spines arise from each end of a short median bar. The PA spine is distinct, needle-like, thickest and longest of the four apical spines. The CA and LA spines are also needle-like, well developed. The CLA spine may only be a trace. The basal spines are four in number, longer than the PA spine, and needle-like. Spinules arise from the lateral sides of the proximal portion of each basal spine towards the neighbouring basal spines. The length of the spinules is unknown owing to destruction of them. Proximal ends of the basal spines and the median bar are connected by imperforate lamellae which thus make a small tent-like shell. The angle between the PB and LB spines, or the CB and CLB spines is larger than the angle between the PB and CLB spines, or the CB and LB spines.

Dimensions:—Length of the PA spine 50μ, as far as preserved; length of the basal spines 100μ; angle between the PB and LB, or the CB and CLB spines 80° and 51° (ESN 144001), and 68° (ESN 144002); angle between the PB and CLB, or the CB and LB spines 55° (ESN 144001) and 35° (ESN 144002).

Remarks:—This species rarely occurs in the *Tlecerina horrida* assemblage. Presence or absence of the lattice shell is not confirmed owing to ill-preservation, thus exact generic position of this species is obscure. This species differs from *Palaeoscenidium cladophorum* in the smaller size of the skeleton and the number of the spinules, and the arising position of the spinules. A proposal of a new specific name for this species is reserved because of ill-preservation and the poverty of the specimens.

Genus *Parentactinia* Dumitrică, 1978

1978. *Parentactinia* Dumitrică, p. 49.

Type species:—*Parentactinia pugnax* Dumitrică, 1978

Diagnosis:—Palaeoscenidiinae with single, imperfect, sphaerical and irregularly latticed shell under the basal spines. A part of each basal spine lies in the thickness of the lattice shell and forms a part of the shell lattice. Apical portion of the shell is usually opened.

Remarks:—Nevertheless no occurrence of *Parentactinia* is recorded during Carboniferous and Permian times, strong affinity of the Devonian form to the Triassic forms does not permit an erection of a new genus for the Devonian form. *Parentactinia* differs from *Pactarentinia* n. gen. on the grounds that a part of each basal spine of the latter is covered by the shell, and the sphaerical shell of the latter is complete unlike the former.

Contained species: *Parentactinia pugnax*; *P. inerme* Dumitrică, 1978; *P. vetustum* Furutani n. sp.

Parentactinia vetustum n. sp.

Pl. 21, Figs. 4, 5; Pl. 22, Figs. 1—4

1982. *Parentactinia* sp. A Furutani, pl. 1, fig. 5.

Holotype:—Reg. No. ESN 144004.

Material:—Twenty-five specimens were examined by the SEM.

Diagnosis:—*Parentactinia* with eight straight needle- or rod-like spines, a tent-like lamellate shell and small lattice shell. The basal spines have a verticil of two or three spinules. The similar verticil is frequently observed on the apical spines.

Description:—Eight-spined and bar-centered spicule with single incomplete sphaerical lattice shell under the basal spines. The spicule comprises of a short median bar, invariably four needle- or rod-like apical spines and four straight slightly tapered rod-like basal spines. The PA spine is indistinct. The basal spines have a verticil of two or three spinules at a distance of 100—120μ from the median bar. The apical spines

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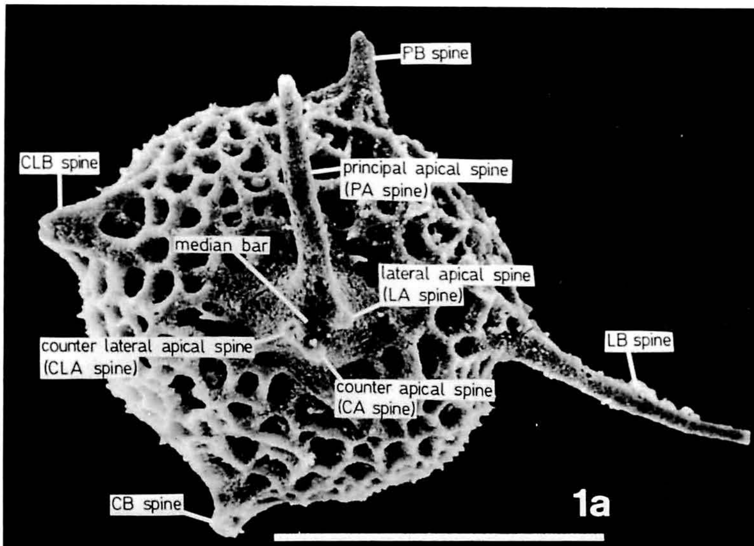
Explanation of Plate 23

Figs. 1—6. *Pactarentinia holdsworthi* n. gen., n. sp.
1. Paratype (ESN 144011); a, apical view indicating terms of spines; b, side view.
2. Paratype (ESN 144012); apical view showing the long PA spine.
3. Holotype (ESN 144013); a, slightly oblique view showing a curved basal spine; b, apical view; c, side view.
4. Paratype (ESN 144014); a, apical view showing comparatively well developed the CA, LA and CLA spines; b, oblique view.
5. Paratype (ESN 144015); broken specimen showing internal structure.
6. Paratype (ESN 144016); broken specimen showing internal structure.

Fig. 7. *Tlecerina horrida* n. gen., n. sp.
7. Paratype (ESN 144017); specimen showing the PA and CA spines (upper two) and three basal spines (lower three), note extending directions of them.

Scale = 100μm.



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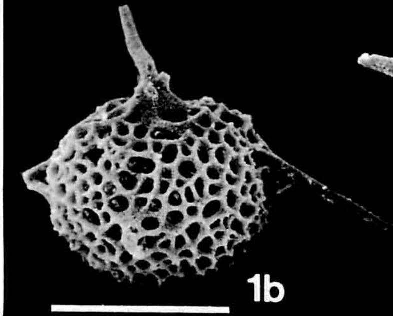

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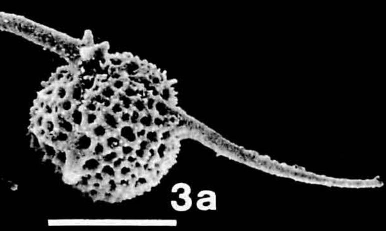

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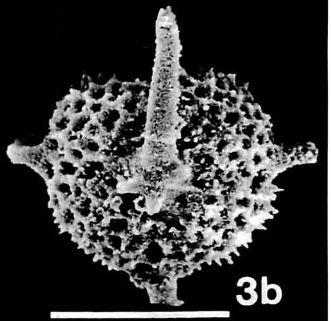

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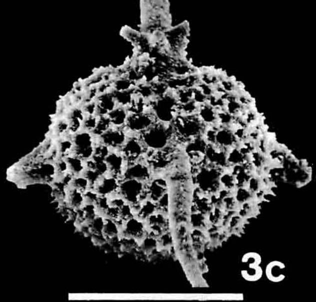

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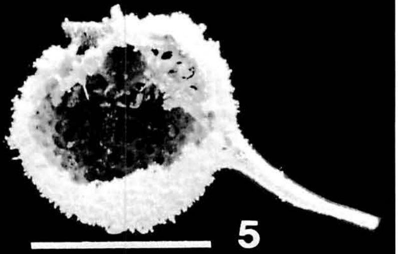

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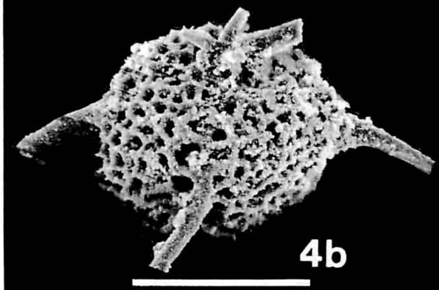

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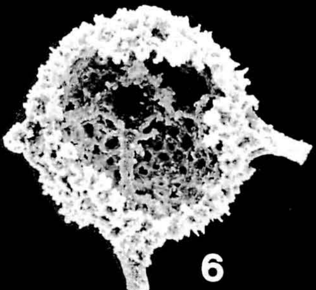

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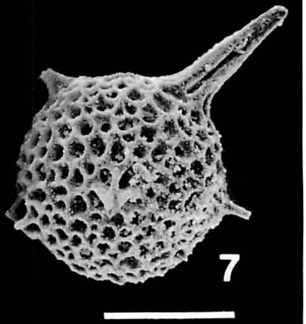

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also frequently have a similar verticil. A tent-like shell, which consists of the proximal parts of the basal spines, the median bar and imperforate lamellae, develops with concave under margins. The angle between the PB and LB spines, or the CB and CLB spines is larger than the angle between the PB and CLB spines, or the CB and LB spines. Medial portion of each basal spine takes part in the construction of the shell lattice. The lattice shell is small, opened in apical region. Pores are very variable in size and shape, large and circular near to the basal spines, subcircular or subrectangular in other parts. Small conical by-spines arise from the intervening bars of the pores. Numerous minute nodes are distributed on the outer surface of the latticed and tent-like shells.

Dimensions:—Diameter of the lattice shell 100—130μ; length of an apical spine 200μ based on a specimen (ESN 144005, Pl. 22, Fig. 1); angle between the PB and LB, or the CB and CLB spines 60°—65°; angle between the PB and CLB, or the CB and LB spines 45°—60°

Remarks:—*Parentactinia vetustum* n. sp. is commonly found in the *Tlecerina horrida* assemblage. This species is distinguished from *Parentactinia pugnax* in having the tent-like shell, invariably straight basal spines, verticillate spinules on the basal spines or apical spines and longer apical spines.

Etymology:—Latin *vetustus -a - um*, means old.

Genus *Pactarentinia* n. gen.

Type species:—*Pactarentinia holdsworthi* Fufutani n. sp.

Diagnosis:—Palaeoscenidiinae with single sphaerical lattice shell and rod- or needle-like spines. A part of each basal spine covered by the shell. The median bar is situated above the shell.

Remarks:—*Pactarentinia* somewhat resembles *Parentactinia* in the location of the lattice shell, but differs from the latter in the following respects. The lattice shell of the latter does not cover the basal spines, and is not complete unlike the former. This genus is distinguished from *Tlecerina* n. gen. by the location of the median bar, inside of the lattice shell in *Tlecerina*, and having rod-like spines unlike the bladed spines of *Tlecerina*. "*Parentactinia pugnax?*" illustrated by Dumitrică (1978, pl. 4, fig. 4) might be an intermidiate form between this genus and *Tlecerina*.

Contained species:—*Pactarentinia holdsworthi* n. sp.

Etymology:—*Pacterentinia* (feminine) is an anagram of *Parentactinia*.

Pactarentinia holdsworthi n. sp.

Pl. 22, Figs. 5, 6; Pl. 23, Figs. 1—6

1982. *Pactarentinia* (MS), sp. A Furutani, pl. 1, fig. 6.

Holotype:—Reg. No. ESN 144013.

Material:—Forty-four specimens were exmined by the SEM.

Diagnosis:—*Pactarentinia* with a prominent PA spine, weak other apical spines and, usually, numerous small by-spines.

Description:—Eight-spined and bar-centered spicule with single sphaerical lattice shell. The spicule comprises of a short median bar, four downward rod-like basal spines, a prominent rod-like PA spine and three conical or needle-like other apical spines. The PA spine is long. In a specimen having perfectly preserved PA spine, it measures 300μ (Pl. 23, Fig. 2). The basal spines are also long. The angle between the PB and LB spines, or the CB and CLB spines is approximately the same with that betweeen the PB and CLB spines, or the CB and LB spines. A small tent-like shell, which is formed by lamellae connecting proximal portions of the basal spines and the median bar, penetrate the lattice shell from inner to outer side. Spinules arise from the covered parts of the basal spines by the lattice shell. Some of the spinules fuse to the shell. Rarely the basal spines directly fuse to the shell to form the shell lattice. The basal spines frequently have a support at the just emerged part from the lattice shell. The lattice shell sometimes slightly compressed in the apical-basal direction. Pores are variable in shape, as circular to subangular, and in size. In many specimens, small needle-like by-spines arise from the intervening bars especially from the junctions of the bars. The shell surface seems to be smooth in some specimens.

Dimension:—Diameter of the lattice shell 110—140μ.

Remarks:—*Pactarentinia holdsworthi* is one of the most abundant species in the *Tlecerina horrida* assemblage.

Etymology:—This species is named for Dr. Brian K. Holdsworth in honour of his great contributions to the study of Palaeozoic radiolarians.

Genus *Tlecerina* n. gen.

Type species:—*Tlecerina horrida* Furutani n. sp.

Diagnosis:—Palaeoscenidiinae containing the spicule in single sphaerical lattice shell with six to eight, commonly bladed, main spines connecting with rays of the spicule. The principal apical spine is distinct and bladed.

Remarks:—Although Nazarov's (1975) descriptions and illustrations are, unfortunately, not enough for full understanding of the internal spicule of *Astroentactinia*, *Tlecerina* is somewhat similar to *Astroentactinia* in the number of the spicular rays. An illustration (fig. 11) of the internal spicule of *Astroentactinia* by Nazarov (1975) seems to be *Palaeoscenidium*-like, but another one (fig. 5-V) does not so. Therefore, *Astroentactinia* may be a member of Palaeoscenidiidae as already remarked. However, if so, *Tlecerina* is distinguished from *Astroentactinia* in having the distinct PA spine and very rudimentary by-spines.

Contained species:—*Tlecerina horrida* n. sp.; *T. exilis* Furutani n. sp.; *T. fenestrata* Furutani n. sp.

Etymology:—*Tlecerina* (feminine) is a name formed by an arbitrary combination of letters.

Tlecerina horrida n. sp.

Pl. 23, Fig. 7; Pl. 24, Figs. 1—3; Pl. 25, Figs. 1—3

1982. *Tlecerina* (MS) sp. A Furutani, pl. 1, figs. 7—9.

Holotype:—Reg. No. ESN 144021.

Material:—Sixty-two specimens were examined by the SEM.

Diagnosis:—*Tlecerina* with a large lattice shell (180—210μ), usually six main spines and numerous thorn-like nodes on the shell surface. The PA spine is thick.

Description:—Eight-rayed spicule contained in a sphaerical lattice shell with usually six to possibly eight main spines. The internal spicule is composed of a short median bar, four apical rays, the PA, CA, LA and CLA rays, and four basal rays, the PB, CB, LB and CLB rays. The PA ray is very commonly the thickest of all the apical rays. Numerous minute spinules are disposed at random on the surface of the apical rays. All the rays are rod-like and round in the transverse section. Larger spinules, which have minute subspinules, arise from the basal rays,

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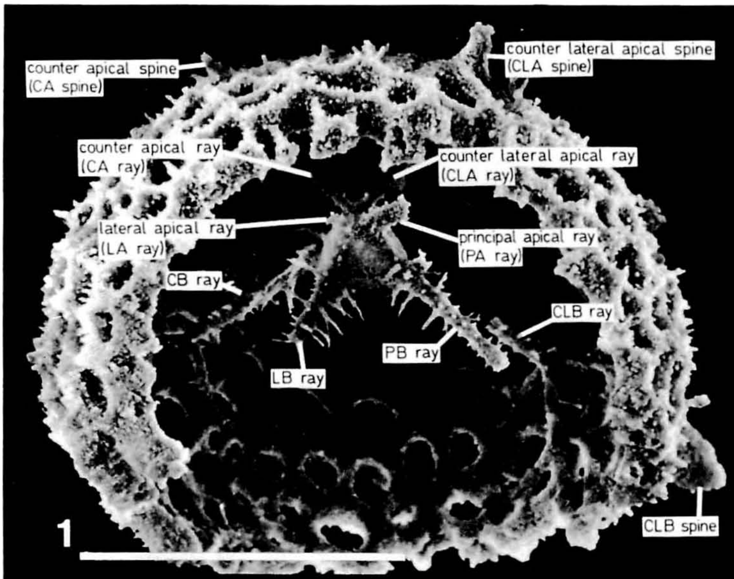
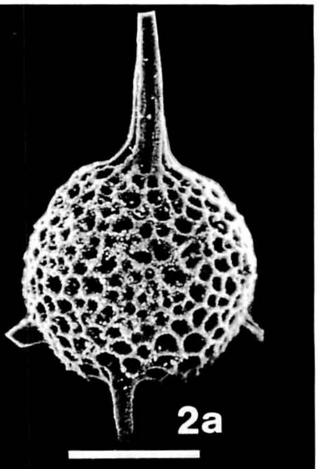
Explanation of Plate 24

Figs. 1—3. *Tlecerina horrida* n. gen., n. sp.

1. Paratype (ESN 144018); broken specimen indicating terms of rays of the internal spicule and three main spines.
2. Paratype (ESN 144019); a, side view; b, apical view, note the oblique PA spine; c, enlargement of right side of the a and b showing minute probable CA spine.
3. Paratype (ESN 144020); a, broken specimen showing internal structure and main spines; b, enlargement showing four apical rays and basal view of the tent-like shell; c, note the thick PA spine, thin rod-like CA spine and absence of the LA and CLA spines.

Scale = 100μm.


1
counter apical spine (CA spine)
counter lateral apical spine (CLA spine)
counter apical ray (CA ray)
counter lateral apical ray (CLA ray)
lateral apical ray (LA ray)
principal apical ray (PA ray)
CB ray
CLB ray
PB ray
LB ray
CLB spine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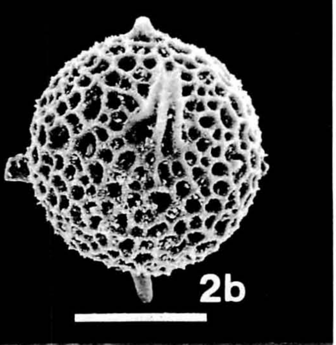
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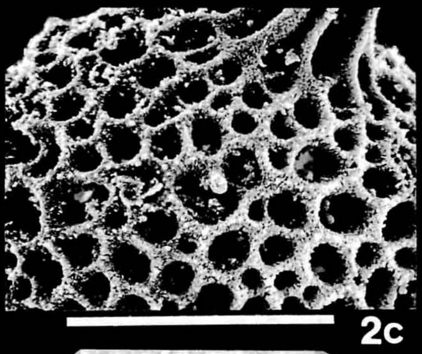
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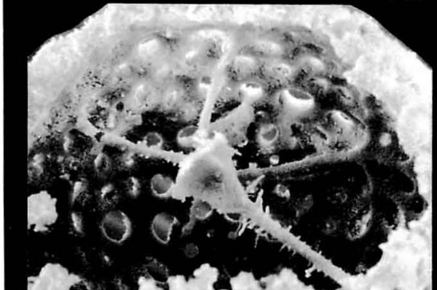
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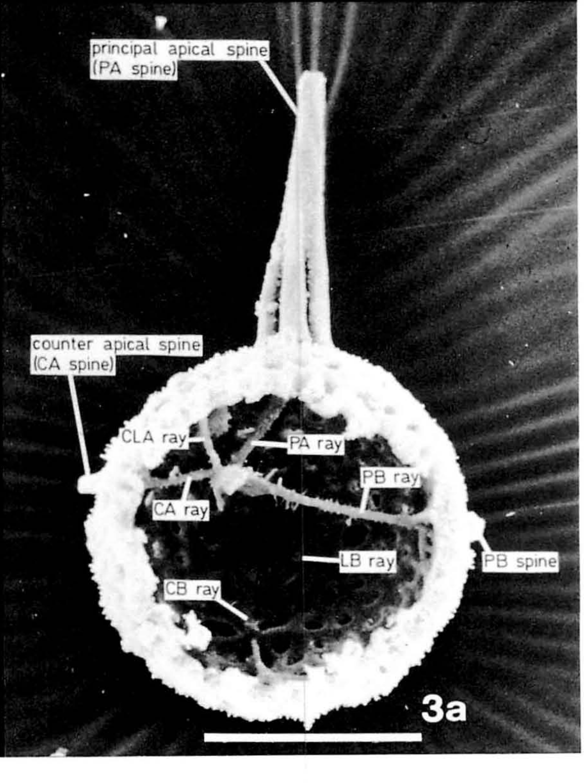
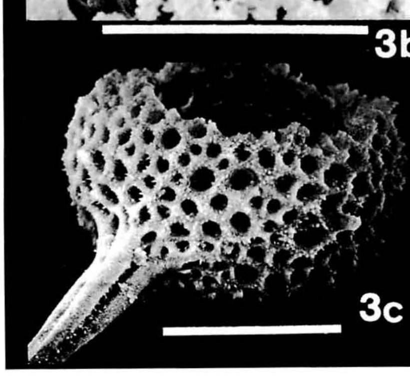

principal apical spine (PA spine)
counter apical spine (CA spine)
CLA ray
PA ray
PB ray
CA ray
LB ray
PB spine
CB ray
3a


3c

and their length proximally increase on the basal rays. The median bar and proximal parts of the basal rays are connected by imperforate lamellae which thus form a tent-like shell with concave under margins. Near the inner surface of the lattice shell, the basal rays may ramify some branches which distally amalgamate to the lattice. The PA, CA, PB, CB, LB and CLB spines are always present. The CLA spine is observed in one specimen (Pl. 24, Fig. 1). The LA spine is not yet observed, but may exist. Extending directions of the spines more or less reflect the directions of the spicular rays. The main spines are fairly variable in shape. The PA spine is distinct, thickest, gently tapered and usually four-bladed, or very rarely three-bladed, and distally becomes unbladed. Blades of it have a swollen edge. An additional ridge rarely develops in the grooves of the PA spine. Sometimes the grooves may slightly be spirally disposed. The CA spine is slender, rod-like or sometimes three-bladed at the base. The CLA spine is slender when it is present. The basal spines are tapered, three-bladed or sometimes rod-like, and more slender than the PA spine, and distally become round in the transverse section. They are rarely four-bladed, but easily distinguished from the PA spine by the slender blades. The sphaerical lattice shell is large and thick. Pores of the shell are circular or subcircular in shape and rather irregular in size. Numerous small thorn-like nodes are disposed on all over the outer surface of the lattice shell. Inner surface of the shell is smooth.

Dimension:—Diameter of the sphaerical shell 180—210μ.

Remarks:—*Tlecerina horrida* is the most abundant species in the *Tlecerina horrida* assemblage. This species resembles *Tlecerina* sp. A, but the former differs from the latter in having generally thicker spines and no distinct by-spines.

Etymology:—Latin *horridus -a -um*, means rough.

Tlecerina exilis n. sp.

Pl. 25, Figs. 4—8; Pl. 26, Fig. 1

Holotype:—Reg. No. ESN 144024.

Material:—Fifty-two specimens were examined by the SEM.

Diagnosis:—*Tlecerina* with a thin medium-sized (150—185μ) sphaerical lattice shell and invariably six slender main spines. Small by-spines arise form junctions of the intervening bars. Numerous small nodes are disposed on the lattice shell.

Description:—Eight-rayed, bar-centered spicule contained in a sphaerical lattice shell with invariably six main spines. The internal spicule consists of a short median bar, four apical rays, the PA, CA, LA and CLA rays, and four basal rays, the PB, CB, LB and CLB rays. Imperforate lamellae connecting with the median bar and proximal parts of the basal rays make a tent-like shell with concave under margins. The rays are rod-like and round in the transverse section. The basal rays have perpendicular spinules, bearing very small subspinules, especially on the proximally two third part of them. The apical rays may have minute spinules. The main spines are the PA, CA, PB, CB, LB and CLB spines. The LA and CLA spines are absent. The PA spine is four-bladed, slender and not very tapered. Other main spines are three-bladed, more slender than the PA spine, and also not very tapered.

Pores are circular, subcircular or oval in shape and variable in size. Th intervening bars are slender and have a weak edge. Small needle-like by-spines arise from the junctions of the intervening bars. Numerous small nodes are observed upon the outer side of the lattice shell. The inner side of the shell is smooth.

Dimension:—Diameter of the lattice shell 150—185μ.

Remarks:—*Tlecerina exilis* is an abundant species in the *Tlecerina horrida* assemblage. This species differs from *Tlecerina horrida* in having slender and not so tapered spines, thin intervening bars, and well developed by-spines from the junctions of the intervening bars.

Etymology:—Latin *exilis -e*, means thin.

Tlecerina fenestrata n. sp.

Pl. 26, Figs. 2—4; Pl. 27, Figs. 1—4

1982. *Tlecerina* (MS) sp. B, Furutani, pl. 1, fig. 10.

Holotype: —Reg. No. ESN 144031.

Material:—Forty-four specimens were examined by the SEM.

Diagnosis:—*Tlecerina* with a small lattice shell (110—135μ), eight main spines and the apical window. The PA spine is outstandingly developed. Other apical spines are minute.

Description:—Eight-rayed spicule contained in a sphaerical lattice shell with eight main spines. The internal spicule is made up of a short median bar, four apical rays, the PA, CA, LA and CLA rays, and four basal rays, the PB, CB, LB and CLB rays. At and near the junctions of the median bar and the basal rays, they are connected by imperforate lamellae which thus make a tent-like shell with concave under margins. The apical rays are generally short and rod-like, but fairly variable in the length and shape. They may be flattened and proximally tapered when very short. The basal rays are always rod-like. They have spinules which bear very small subspinules. Spinules are not observed on the apical rays. The main spines are the PA, CA, LA, CLA, PB, CB, LB and CLB spines. Extending directions of them fairly well reflect the directions of the spicular rays. The apical spines are disposed around the apical window. The PA spine is outstandingly developed, four-bladed, gently tapered, and proximally becomes unbladed. Additional grooves or ridges may develop on the proximal part of the PA spine. Other apical spines are minute, not bladed, and sometimes obscure. They are usually not directly connected with the apical rays. The basal spines are slender, tapered, always three-bladed at the base but soon become rod-like, and may slightly curve to the basal trend. The apical window opens above the median bar. When the median bar locates very near to the shell, in other words apical rays are very short, the apical window becomes a primary pore, in the meaning of Baumgartner (1980), of the PA spine. The apical winodw is very variable in shape, circular, oval, tear-shaped or gourd-like. It is rarely divided into two parts (Pl. 27, Fig. 4). The lattice shell is small and thin. Pores are fairly variable in shape and size. Short by-spines arise from the junctions of the intervening bars. Numerous minute nodes are distributed on the outer surface of the lattice shell.

Dimension:—Diameter of the lattice shell 110—135μ.

Remarks:—*Tlecerina fenestrata* is very abundant in the *Tlecerina horrida* assemblage. This

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Explanation of Plate 25

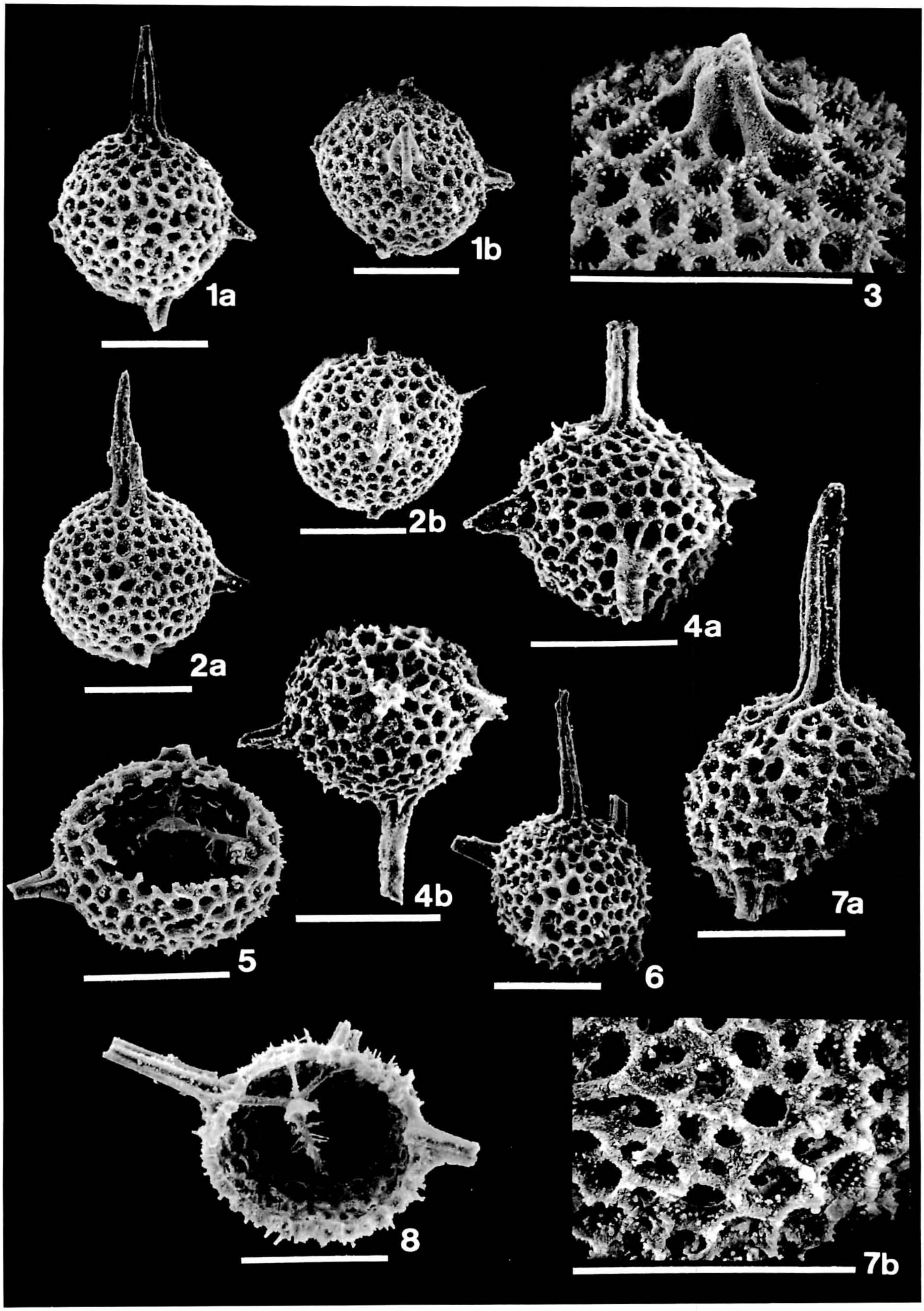
Figs. 1—3. *Tlecerina horrida* n. gen., n. sp.

1. Holotype (ESN 144021); a, side view; b, apical view showing the PA spine and bases of the CA, PB, LB and CLB spines, note the oblique PA spine.
2. Paratype (ESN 144022); a, side view; b, apical view showing the PA spine and bases of the CA, PB, LB and CLB spines, note the oblique PA spine.
3. Paratype (ESN 144023); specimen showing base of the PA spine and fine structure of surface of the lattice shell.

Figs. 4—8. *Tlecerina exilis* n. gen., n. sp.

4. Holotype (ESN 144024); a, side view; b, apical view, note the four-bladed PA spine.
5. Paratype (ESN 144025); broken specimen showing the internal spicule.
6. Paratype (ESN 144026); specimen showing the PA, CA and three of basal spines.
7. Paratype (ESN 144027); a, note the strong PA spine; b, fine structure of surface of the lattice shell.
8. Paratype (ESN 144028); broken specimen showing the internal spicule and the PA, CA and CB spines.

Scale = 100μm.


1a
1b
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2a
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4a
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5
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7a
8
7b

species is easily distinguished from any other species of this genus by the smaller lattice shell and the presence of the apical window.

Etymology:—Lain *fenestra* means a window. Latin suffix *-atus -a -um*, is added to noun stems to form adjective meaning provided with. Thus *fenestratus -a -um*, means provided with a window.

Tlecerina sp. A

Pl. 27, Figs. 5—7

Material:—Six specimens were examined by the SEM.

Description:—Eight-rayed spicule contained in a sphaerical lattice shell with six main spines. The internal spicule is composed of four apical rays and four basal rays. Presence of the median bar is not confirmed. A "tent-like shell" is present. Spinules having very small subspinules arise from the basal rays. The apical rays also have minute spinules. All the rays are rod-like. One of the six main spines which is probably the PA spine is four-bladed and the thickest of all. Other main spines are slender, and three-bladed or rod-like. The sphaerical lattice shell medium to large in size. Pores are rather irregular in size and shape. Needle-like by-spines arise from the junctions of the intervening bars. Numerous small nodes are disposed on the whole of the outer surface of the shell.

Dimension:—Diameter of the lattice shell 150—190μ.

Remarks:—*Tlecerina* sp. A is rare in the *Tlecerina horrida* assemblage. This species differs from *Tlecerina horrida* in having thinner main spines and distinct by-spines. This species is somewhat similar to *Tlecerina exilis* in having slender main spines and distinct by-spines. However, the former differs from the latter in having thicker PA spine and weakly bladed other main spines. A proposal of a new specific name is reserved, since the specimens are scarce in number.

All specimens registered with the ESN number are deposited in the Department of Earth Sciences, Nagoya University.

References

Baumgartner, P. O. (1980): Late Jurassic Hagiastridae and Patulibracchiidae (Radiolaria) from the Argolis Peninsula (Peloponnesus, Greece). *Micropaleontology*, vol. 26, no. 3, p. 274—322, pls. 1—12.

Deflandre, G. (1953): Radiolaires fossiles. *In* Grasse, P. P. *ed.*, *Traité de Zoologie*. vol. 1, pt. 2, p. 389—436, Masson et Cie., Paris.

——(1960): A propos du développement des recherches sur les Radiolaires fossiles. *Revue Micropaléont.*, vol. 2, no. 4, p. 212—218, pl. 1.

——(1973a): Sur quelques nouveaux types de Radiolaires Polycystines viséens, d'attribution systématique ambiguë, certains évoquant à la fois des Plectellaires et des Spumellaires. *Comptes Rendus Acad. Sci. Paris*, Ser. D, Vol. 276, p. 289—293, pls. 1—4.

——(1973b): Compléments historiques et taxinomiques sur les Radiolaires viséens. Remarques critiques sur les Plectellaires. *Ibid.*, ser. D, vol. 276, p. 497—500.

De Wever, P., Sanfilippo, A., Riedel, W. R. and Gruber, B. (1979): Triassic radiolarians from Greece, Sicily and Turkey. *Micropaleontology*, vol. 25, no. 1, p. 75—110, pls. 1—7.

Dumitrică, P. (1978): Triassic Palaeoscenidiidae and Entactiniidae from the Vicentinian Alps (Italy) and Eastern Carpathians (Romania). *Dări de seamă ale şedinţelor*, vol. 64, p. 39—54, pls. 1—5.

——, Kozur, H. and Mostler, H. (1980): Contribution to the radiolarian fauna of the Middle Triassic of the Southern Alps. *Geol. Paläont. Mitt. Innsbruck*, vol. 10, no. 1, p. 1—46, pls. 1—15.

Foreman, H. P. (1959): A new occurrence of Devonian Radiolaria in calcareous concretions of the Huron member of the Ohio shale. *Jour. Paleont.*, vol. 33, no. 1, p. 76—80, pl. 15.

——(1963): Upper Devonian Radiolaria from the Huron member of the Ohio shale. *Micropaleontology*, vol. 9, no. 3, p. 267—304, pls. 1—9.

Fortey, R. A. and Holdsworth, B. K. (1972): The oldest known well-preserved Radiolaria.

Boll. della Soc. Paleont. Italiana, vol. 10, no. 1, p. 35—41, pls. 10—11.

Friend, J. K. and Riedel, W. R. (1967): Cenozoic orosphaerid radiolarians from tropical Pacific sediments. *Micropaleontology*, vol. 13, no. 2, p. 217—232, pls. 1—3.

Furutani, H. (1981): Ordovician and Silurian of the Fukuji area, Gifu Prefecture, with special reference to the radiolarian fossils. *In* Kano, H. *ed.*, *Some geological and petrological problems on the Lower Palaeozoic and Upper Proterozoic in the Japanese Islands and its adjacent area.*, p. 13—16 (in Japanese).

——(1982): Skeletal construction and phylogeny of Palaeoscenidiidae. *News of Osaka Micropaleontologists*, spec. vol., no. 5, p. 11—16, pl. 1 (in Japanese with English abstract).

Hamada, T. (1961): The Middle Palaeozoic group of Japan and its bearing on her geological history. *Jour. Fac. Sci. Univ. Tokyo*, sec. 2, vol. 13, pt. 1, p. 1—79.

Hinde, G. J. (1899): On the Radiolaria in the Devonian rocks of New South Wales. *Quat. Jour. Geol. Soc. London*, vol. 55, p. 38—64, pls. 8—9.

Hirata, M. (1966a): On the Upper Devonian Ohira Formation in the Outer zone of Shikoku, Japan. *Chigakukenkyu*, vol. 17, no. 4, p. 102—105 (in Japanese with English abstract).

——(1966b): Mt. Yokokura, Kochi Prefecture. *Ibid.*, vol. 17, nos. 10—12, p. 258—273, pls. 1—3 (in Japanese).

Holdsworth, B. K. (1973): The Radiolaria of the Baltalimani Formation, Lower Carboniferous, Istanbul. *In* Kaya, O. *ed.*, *Paleozoic of Istanbul; Ege Universitesi Fen Fakultesi Kitaplar Seresi*, no. 40, p. 117—134, pl. 1.

——(1977): Paleozoic Radiolaria; stratigraphic distribution in Atlantic borderlands. *In* Swain, F. M. *ed.*, *Stratigraphic micropaleontology of Atlantic basin and borderlands*, p. 167—184, pls. 1—2, Elsevier, Amsterdam.

——, Jones, D. L. and Allison, C. (1978): Upper Devonian radiolarians separated from chert of the Ford Lake Shale, Alaska. *Jour. Resear. U. S. Geol. Surv.*, vol. 6, no. 6, p. 775—788.

Igo, H., Adachi, S., Furutani, H. and Nishiyama, H. (1980): Ordovician fossils first discovered in Japan. *Proc. Japan Acad.*, ser. B, vol. 56, no. 8, p. 499—503.

Ishiga, H., Kito, T. and Imoto, N. (1982): Late Permian radiolarian assemblages in the Tamba district and an adjacent area, Southwest Japan. *Earth Science*, vol. 36, no. 1, p. 10—22, pls. 1—5.

Kozur, H. and Mostler, H. (1979): Beiträge zur Erforschung der mesozoischen Radiolarien. Teil III: Die Oberfamilien Actinommacea Haeckel 1862 emend., Artiscacea Haeckel

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Explanation of Plate 26

Fig. 1. *Tlecerina exilis* n. gen., n. sp.

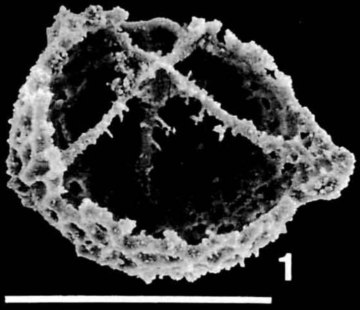
1. Paratype (ESN 144029); a, broken specimen showing the internal spicule; b, basal view of the internal spicule.

Figs. 2—4. *Tlecerina fenestrata* n. gen., n. sp.

2. Paratype (ESN 144030); a, side view; b, enlargement of the lattice shell, note three weak apical spines.
3. Holotype (ESN 144031); a, terms of the skeleton are indicated; b, side view showing seven main spines except the PB spine; c, apical view showing the PB spine at the bottom, this specimen is probably depressed; d, enlargement of the apical window and three weak apical spines; e, enlargement of the LA spine, note the internal LA ray.
4. Paratype (ESN 144032); a, oblique view, note the apical window becoming a primary pore of the PA spine; b, enlargement of the apical window, note four apical rays and the median bar of the internal spicule.

1a, 1b, 2a, 2b, 3a, 3b, 3c, 4a; Scale = 100μm.

3d, 3e, 4b; Scale = 10μm.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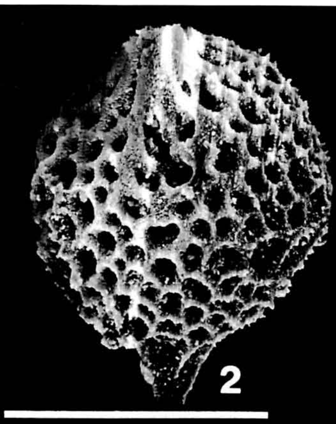
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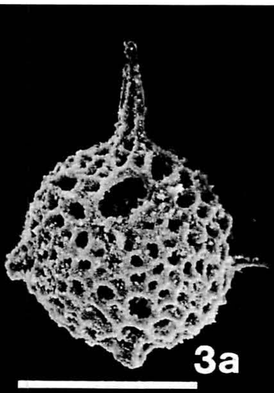
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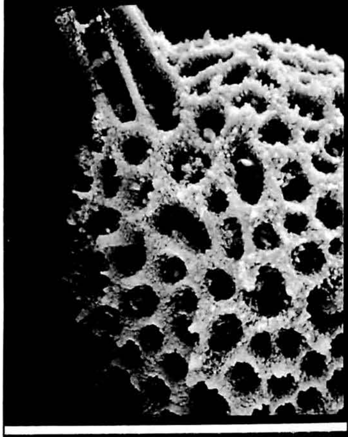
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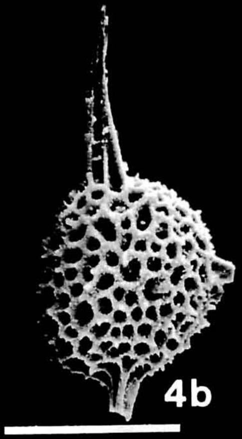
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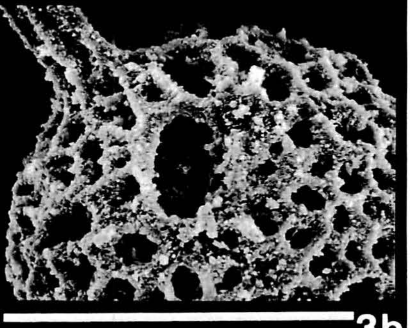
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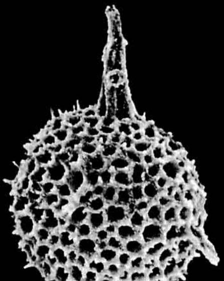
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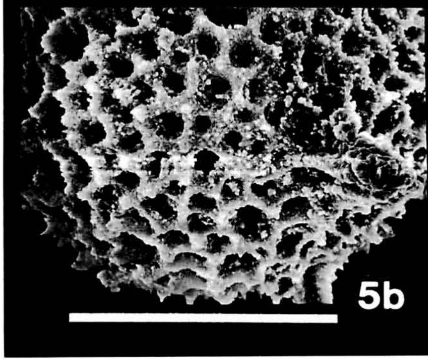
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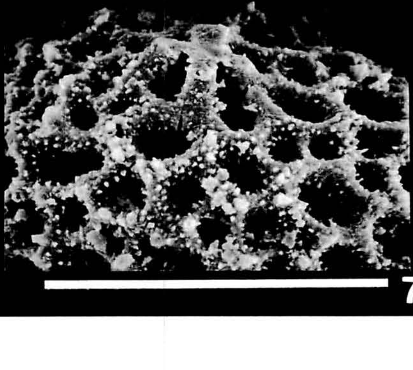
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1882, Multiarcusellacea nov. der Spumellaria und triassische Nassellaria. *Geol. Pälaont. Mitt. Innsbruck*, vol. 9, nos. 1—2, p. 1—132, pls. 1—21.

—— and —— (1981): Beiträge zur Erforschung der mesozoischen Radiolarien. Teil IV: Thalassosphaeracea Haeckel, 1862, Hexastylacea Haeckel, 1882 emend. Petruševskaja, 1979, Sponguracea Haeckel, 1862 emend. und weitere triassische Lithocycliacea, Trematodiscacea, Actinommacea und Nassellaria. *ibid.*, Sonderbd., p. 1—208, pls. 1—69.

Kruchek, S. A. and Nazarov, B. B. (1977): Late Devonian radiolarians from the Russian Platform. *Dokl. Akad. Nauk SSSR*, vol. 237, no. 6, p. 1445—1449 (in Russian).

Nazarov, B. B. (1975): Lower and Middle Paleozoic radiolarians of Kazakhstan. *Akad. Nauk SSSR, Geol. Inst., Trudy*, vol. 275, p. 1—203, pls. 1—21 (in Russian)

—— and Popov, L. Ye. (1980): Stratigraphy and fauna of Ordovician siliceous-carbonate deposits of Kazakhstan. *Ibid.*, vol. 331, p. 1—190, pls. 1—32 (in Russian).

Riedel, W. R. (1967): Some new families of Radiolaria. *Proc. Geol. Soc. London*, no. 1640, p. 148—149.

—— (1971): Systematic classification of polycystine Radiolaria. *In* Funnel, B. M. and Riedel, W. R. *eds.*, *The Micropalaeontology of Oceans*, p. 649—661, Cambridge Univ. Press, London.

Takemura, A. and Nakaseko, K. (1982): Two new Jurassic genera of family Palaeoscenidiidae (Radiolaria). *Trans. Proc. Palaeont. Soc. Japan, N. S.*, no. 128, p. 452—464, pls. 70—73.

Yoshikura, S. (1982): The geology of the Yokokurayama Lenticular Body and the Usuginu Conglomerate. *Mem. Geol. Soc. Japan*, no. 21, p. 213—229 (in Japanese with English abstract).

Fukuji 福地，Mt. Yokokura 横倉山，Ochi-cho 越知町

高知県横倉山から得られた中期古生代のPalaeoscenidiidae科（放散虫）—その1：Palaeoscenidiidae科は，最も基本的にはmedian barの両端から放射する8本のspineからなる，極性を持ったspiculeで特徴づけられる。8本のspineは4本ずつの短いapical spineと長いbasal spineからなる。ただし，apical spineは1本にまで減少することがある。Palaeoscenidiidae科の多くの種でapical spineのうち1本が特によく発達することが認められる。それぞれのspineは，その特によく発達したapical spineとmedian barに対する位置関係から，それぞれ識別することができる。この識別はPalaeoscenidiidae科の骨格構造および分類を検討する上で有用である。

Palaeoscenidiidae科はPalaeoscenidiinae亜科およびPentactinocarpinae亜科を含む。前者は*Palaeoscenidium, Archaeosemantis, Parentactinia, Pactarentinia* n. gen., *Tlecerina* n. gen. の各属を含み，わずかに疑問はあるものの，*Sepsagon, Parasepsagon*の両属も含むと考えられる。

Palaeoscenidium?, *Parentactinia, Pactarentinia*および*Tlecerina*の5新種と2未定種を記載した。*Parentactinia, Pactarentinia, Tlecerina*の3属は簡潔に言えば格子殻を持った*Palaeoscenidium*で，それらは格子殻の発達の程度によって区別される。つまり，*Parentactinia*では格子殻はbasal spineの下に位置し，*Pactarentinia*では格子殻がbasal spineの一部を覆う。また，*Tlecerina*ではspicule全体が格子殻に覆われる。

記載された放散虫は横倉山のG_4中部から得られた珪質頁岩の1標本から抽出された。地質時代はG_4と上下の含化石層との層序関係，および既知の古生代放散虫との比較から早～中期デボン紀と推定される。　古谷　裕

Explanation of Plate 27

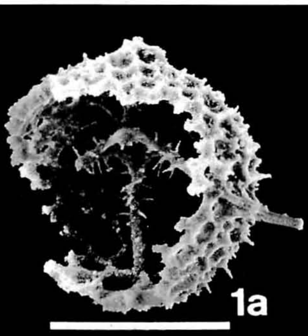
Figs. 1—4. *Tlecerina fenestrata* n. gen., n. sp.

1. Paratype (ESN 144033); broken specimen showing the internal spicule, note the broken apical window.
2. Paratype (ESN 144034); specimen showing four apical rays.
3. Paratype (ESN 144035); a, side view; b, enlargement of the apical window.
4. Paratype (ESN 144036); a, side view; b, enlargement of the divided apical window.

Figs. 5—7. *Tlecerina* sp. A

5. ESN 144037; a, oblique view; b, base of the PA spine and fine structure of surface of the lattice shell.
6. ESN 144038; note distinct by-spines.
7. ESN 144039; a, broken specimen showing the internal spicule; b, base of the PA spine and fine structure of surface of the lattice shell.

Scale = 100μm.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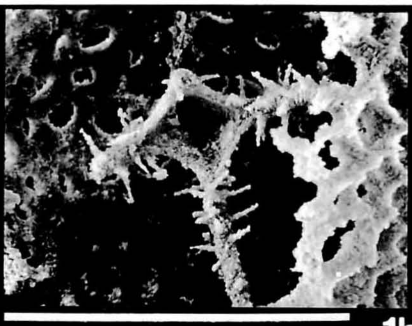
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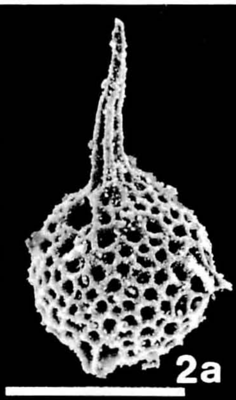
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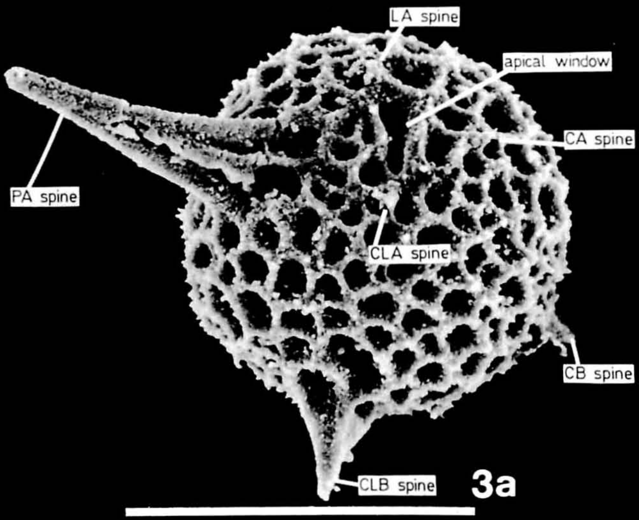

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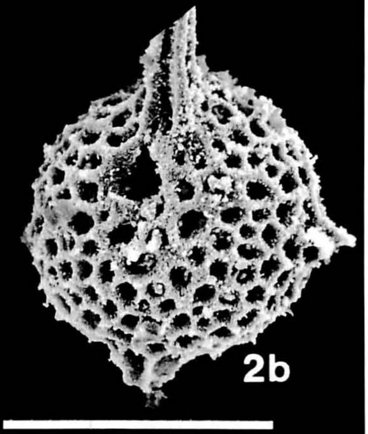
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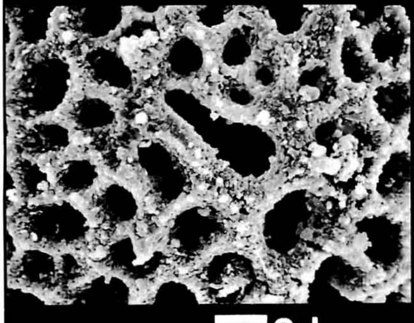
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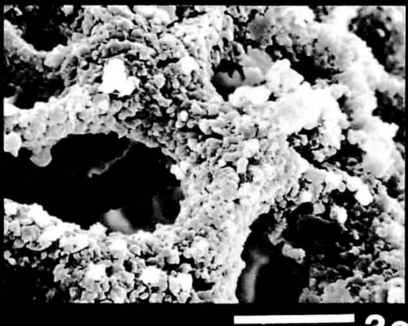
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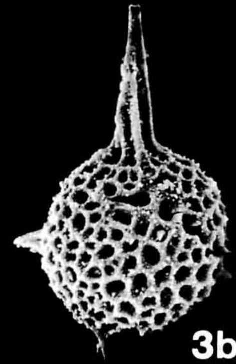
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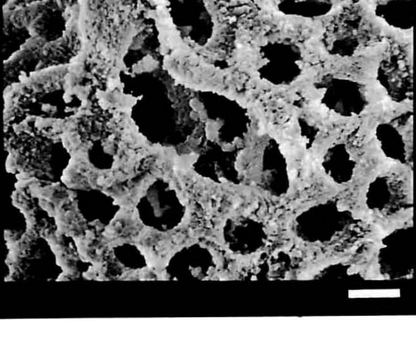
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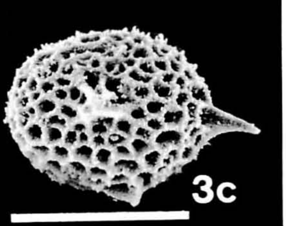
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Trans. Proc. Palaeont. Soc. Japan, N. S., No. 130, pp. 117—122, July 15, 1983

764. URANIUM-SERIES AGES OF SOME SOLITARY CORALS FROM THE RIUKIU LIMESTONE ON THE KIKAI-JIMA, RYUKYU ISLANDS*

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Abstract. ^{230}Th/^{234}U ages averaging 82,000±2,000 years old were determined for three species of ahermatypic solitary corals (*Trochocyathus hanzawai*, *Micrabacia japonica* and *Flabellum rubrum*) from the Riukiu Limestone of grainstone facies in the northern area of Kamikatetsu, Kikai-jima, Ryukyu Islands. It is most likely that this type of limestone was deposited at the water depth of 120 m or less as a forereef sediment, in front of the reef which has been elevated up to 184 m in present altitude by the vertical tectonic movement and is now forming a marine terrace developing to the south of Gusuku. The surface of terrace including the dated grainstone is thought to be partly constructional and partly erosional. Because two types of limestone, coralline limestone and this grainstone formed separately during times of two interstadial high sea stands (approximately 60,000 and 82,000 years ago, respectively), are recognized in the terrace deposit distributed at the same altitude.

Introduction

^{230}Th/^{234}U ages for some solitary corals from the Riukiu Limestone on the Kikai-jima, Ryukyu Islands, are dealt with in this paper. These are not only the first dates from the other type of limestone than that formed as a reef itself, but also one of the most valuable informations to reconstruct the paleoenvironment under which a coral reef was developed and to discuss the tectonic history of the island.

The staircase morphology of the Kikai-jima is essentially due to the mutual relationship between the construction of coral reefs during times of Pleistocene high sea stands and the tectonic movement, vertical displacement up to the present time. The Pleistocene reefs are occurred landward, developing five or probably more marine terraces bounded by the remarkable terrace scarps, while the Holocene reefs are surrounding the whole island in the maximum width of about 1.2 km, forming topographically distinctive four terraces. They have been chronologically studied in some detail by means of the uranium-series dating techniques like ^{230}Th/^{234}U and ^{231}Pa/^{235}U methods and the radiocarbon method of dating, as shown in works of Konishi *et al.* (1974) and Ota *et al.* (1978).

So far, the Pleistocene limestone (Riukiu Limestone of Hanzawa, 1935) on the Kikai-jima has been thought to be an assortment of several reef complexes, each of which was dated to be 35,000—45,000, 55,000—65,000, 80,000—100,000 and 120,000—130,000 years (Konishi *et al.*, 1974). The individual reef complex has been correlated with the elevated Pleistocene reefs in other areas, *e.g.* Barbados, West Indies

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* Received July 5, 1982; read Jan. 24, 1982 at Chiba.

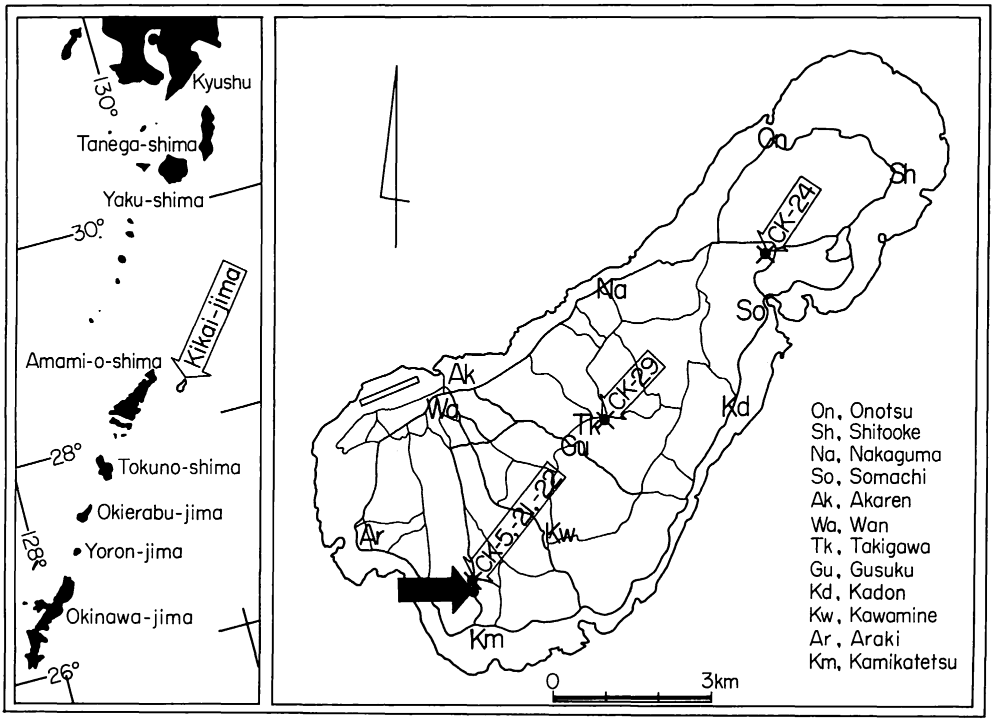

Fig. 1. Index map showing the localities of samples stated in the present paper. (Black arrow shows the sampling site of solitary corals examined in this study. See text for details.)

(Bender *et al.*, 1979; and others) and the Huon Peninsula, New Guinea (Bloom *et al.*, 1974; and others). However, details of stratigraphic relations among those reef complexes and their distribution remain still equivocal. The major reasons of it seem to be that only hermatypic corals from the reefy limestone have been dated before and that stratigraphy has not been completely resolved, because of limited numbers of outcrops on the island.

Radiochemical analyses for uranium and thorium isotopes were carried out on three species of ahermatypic solitary corals, *Trochocyathus hanzawai*, *Micrabacia japonica* and *Flabellum rubrum*, selected out of many species from an outcrop along a road which lies approximately 650 m north of Kamikatetsu (Fig. 1). The locality is situated at a height of about 40 m in lat. 28°17.1′ N. and long. 129°57.2′ E. Because of its unique lithologic nature, the limestone near by the sampling site has been attracted the notice of some paleontologists and/or geologists since the 1930s. It is moderately sorted, unconsolidated to weakly cemented, and grain-supported limestone made up of a wide variety of small-sized (less than 10 cm in diameter) bioclastics. This limestone can be regarded as the typical grainstone defined by Dunham (1962). Foraminifers, brachiopods, bryozoans, molluscs, echinoids, solitary corals and fragmental calcareous algae are included as main bioclastic components, while larger bioclastics such as hermatypic corals and coralline algae in growth position are seldom or never seen in this grainstone facies. The bryozoan and coral faunas in this type of limestone were studied by Kataoka (1961) and Yabe and Eguchi (1932). They found conclusions independently upon each full description that this grainstone was probably deposited at a depth of from 40 to 100 m or approximately 100 m, respectively.

The details of separation and purification methods for uranium and thorium isotopes in carbonate samples are omitted here. The overall chemical yields of uranium and thorium isotopes were checked by using two kinds of ^{232}U-^{228}Th spikes (Table 1), as yield tracers in the repeated analyses for each sample, separately. Alpha spectrometries were employed by a 4096 channel multichannel analyzer coupled with four solid-state silicon detector systems.

Table 1. ^{232}U concentration and $^{228}Th/^{232}U$ activity ratio of the ^{232}U-^{228}Th spikes used as yield tracers for checking overall chemical yield of uranium′ and throium isotopes. (Measurements were carried out on August 26, 1981.)

Name of Spike	^{232}U (dpm/g)	$^{228}Th/^{232}U$ (activity ratio)
"Harwell"	22.53±0.20	0.990±0.010
"KU (Kanazawa Univ.)"	17.30±0.10	0.999±0.012

X-ray powder diffraction patterns revealed that all of the samples examined in this study are free of the secondary calcite. This evidence suggests that they have not been altered mineralogically throughout their diagenetic history.

Results of the alpha spectrometries are presented in Table 2, in which the $^{230}Th/^{234}U$ age of each sample also is shown. The quoted errors are standard deviation derived from counting statistics.

The following equation and half-lives ($T_{1/2}$) of objective radionuclides, which were arranged in the Uranium-Series Intercomparison Project (USIP; Harmon *et al.*, 1979), were used here in order to calculate the $^{230}Th/^{234}U$ age:

$$^{230}Th = {}^{238}U\,[1 - \exp(-\lambda_0 t)] + ({}^{234}U - {}^{238}U)\,[\lambda_0/(\lambda_0 - \lambda_4)]\,[1 - \exp(\lambda_4 t - \lambda_0 t)]$$

^{238}U : $T_{1/2} = 4.468 \times 10^9$ years
^{234}U : $T_{1/2} = 2.48 \times 10^5$ years
^{232}U : $T_{1/2} = 7.2 \times 10^1$ years
^{230}Th : $T_{1/2} = 7.52 \times 10^4$ years
^{228}Th : $T_{1/2} = 1.913$ years
^{224}Ra : $T_{1/2} = 3.64$ days

Table 2. Isotopic composition and $^{230}Th/^{234}U$ ages of fossil solitary corals from the Riukiu Limestone on the Kikai-jima.
(*T.h., *Trochocyathus hanzawai*; M.j., *Micrabacia japonica*; F.r., *Flabellum rubrum*: For the same sample, the results in upper and lower rows were obtained by use of "Harwell" and "KU" spikes, respectively.)

Material*	Isotope Concentration				Activity Ratio		$^{230}Th/^{234}U$ Age ($\times 10^3$ yrs)
	^{238}U (ppm)	^{234}U (dpm/g)	^{232}Th (ppm)	^{230}Th (dpm/g)	$^{234}U/^{238}U$	$^{230}Th/^{234}U$	
T. h.	3.56 ± 0.08	2.92 ± 0.06	<0.02	1.57 ± 0.03	1.10 ± 0.02	0.521 ± 0.015	79 ± 4
	3.46 ± 0.06	2.92 ± 0.05		1.49 ± 0.03	1.11 ± 0.02	0.521 ± 0.014	79 ± 3
M. j.	4.42 ± 0.12	3.72 ± 0.10		1.91 ± 0.05	1.13 ± 0.02	0.513 ± 0.020	77 ± 4
	4.46 ± 0.11	3.69 ± 0.09		1.99 ± 0.04	1.09 ± 0.02	0.539 ± 0.017	83 ± 4
F. r.	3.77 ± 0.10	3.22 ± 0.08		1.78 ± 0.04	1.15 ± 0.02	0.553 ± 0.014	85 ± 5
	4.34 ± 0.08	3.59 ± 0.06		1.94 ± 0.04	1.11 ± 0.02	0.540 ± 0.014	83 ± 3

where λ_0 and λ_4 are decay constant of ^{230}Th and ^{234}U, respectively.

The ^{230}Th/^{234}U activity ratios in Table 2 are characterized by the limited range of 0.513 ±0.020 to 0.553±0.014, and accordingly the ^{230}Th/^{234}U ages are in agreement within the statistical error. The mean age is calculated to be 82,000±2,000 years.

This ^{230}Th/^{234}U age is most reliable for some reasons itemized below:

(1) All samples are entirely free of recrystallization, as shown by the absence of the secondary calcite.

(2) It can be safely assumed from the reproducibility in the analyses repeated by using two sorts of ^{232}U-^{228}Th spikes that all of the analytical values in the table are truthworthy.

(3) ^{238}U concentration of each sample almost equals those which have appeared in literature for ahermatypic corals to date.

(4) The assumption of negligible initial ^{230}Th is supported by the observation that ^{232}Th concentration does not exceed the analytical limitation (0.02 ppm in this study).

(5) The average ^{234}U/^{238}U activity ratio of 1.12±0.01 is consistent with the mean value of ^{230}Th/^{234}U ages.

The ^{230}Th/^{234}U age of 82,000 years fits in the time of an interstadial phase after the last interglacial stage. The reef complex including the grainstone facies is correlative with the terrace deposit composed of the Barbados terrace I of Mesolella (1968) and the Worthing terrace of Bender *et al.* (1979) on Barbados, West Indies, and with the reef complex V on the Huon Peninsula in New Guinea (Bloom *et al.*, 1974). Konishi *et al.* (1974) proved the existence of the reef which was formed at that time and stratigraphically separated it as the Middle Limestone Member from their former Younger Limestone Member of Riukiu Limestone (Konishi *et al.*, 1970), because the same ^{230}Th/^{234}U dates were obtained from two hermatypic coral samples (CK-24, *Favia* sp., 81,000±3,000 yrs.; CK-29, *Porites* sp., 86,000±4,000 yrs.). However, the details of this uplifted reef complex on the island, namely the distribution and the lithologic nature of its forereef sediment, are not yet definitely solved.

The Riukiu Limestone of the grainstone facies can be traced also in the eastern area of the locality where the samples analyzed in the present study were collected. The maximum height of the area is about 70 m. The present elevation of the reefy limestone dated as approximately 80,000 years old is 184 m at the maximum. The difference in distributing height between the reefy limestone and the grainstone of the same age is 114 to 144 m. Assuming that both facies have undergone the vertical displacement of the same extent up to the present time, this difference may be roughly taken as the depth of water where the grainstone was deposited. The actual depth of sedimentation, however, may be less than 120 m, because of local difference in vertical displacement expected from the existence of some faults as seen in the geologic map of Konishi *et al.* (1974). Such an inference seems to be well-matched with the conclusions drawn from the faunal analyses for bryozoans and solitary corals by Kataoka (1961) and Yabe and Eguchi (1932), respectively. In any case, there is very little doubt that the Riukiu Limestone near by the locality, where the samples dated here were collected, was deposited as a forereef sediment.

Besides the grainstone, some different types of limestone are occurred as the terrace deposits on the same terrace. In other words, the lateral change of limestone facies is obviously recognized in the terrace deposit. The ^{230}Th/^{234}U ages of 55,000 to 65,000 years have been previously reported on two hermatypic corals (CK-5, *Acanthastrea echinata*, 59,000±5,000 yrs.; CK-21, *Cyphastrea* sp., 54,000±2,000 yrs.) from the coralline limestone (Younger Limestone Member of Riukiu Limestone) by Konishi *et al.* (1974). The author also has once dated a fossil hermatypic coral sample (CK-22, *Porites* sp.) and got the respective ^{230}Th/^{234}U and ^{231}Pa/^{235}U. ages of 52,000±3,000 and 61,000±3,000 years. Those samples were collected at the spot which is very close to the locality of the solitary coral samples examined in this study and which is of the same height, 40 m above sea level. All such dates are in accord with the age of another interstadial phase, being represented by the reef complex IV on the Huon Peninsula, New Guinea (Bloom *et al.*, 1974).

The evidence stated above may imply that a couple of limestone units formed separately during times of two interstadial high sea stands are now seen on the same terrace. The sea level of 55,000 to 65,000 years B.P. is thought to have been apparently attained up to 40 m or more in present altitude, regardless of the subsequent tectonic movement. A part of the terrace surface, therefore, appears to have been eroded at that time or in process of upheaval to the present elevation. After all, it can be safely said that the surface of terrace extending to the north of Kamikatetsu is partly constructional and partly erosional.

In conclusions, the author can briefly summarize as follows:

(1) Six ^{230}Th/^{234}U ages, the mean of which is 82,000±2,000 years, were obtained for three species of ahermatypic solitary corals from the Riukiu Limestone of grainstone facies distributed in the northern area of Kamikatetsu, Kikai-jima, Ryukyu Islands.

(2) Such a grainstone was deposited as the forereef sediment while the reefy limestone occurred in Gusuku and its vicinity was formed during a time of interstadial high sea stand, about 82,000 years ago.

(3) The surface of terrace, which is extending at a height of 40 m to the north of Kamikatetsu, is very likely to be partly constructional and partly erosional.

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References

Bender, M. L., Fairbanks, R. G., Taylor, F. W., Matthews, R. K., Goddard, J. G. and Broecker. W. S. (1979): Uranium-series dating of the Pleistocene reef tracts of Barbados, West Indies. *Geol. Soc. Amer. Bull.*, Part I, vol. 90, p. 577—594.

Bloom, A. L., Broecker, W. S., Chappell, J. M. A., Matthews, R. K. and Mesolella, K. J. (1974): Quaternary sea level fluctuations on a tectonic coast: New ^{230}Th/^{234}U dates from the Huon Peninsula, New Guinea. *Quaternary Res.*, vol. 4, p. 185—205.

Dunham, R. J. (1962): Classification of carbonate rocks according to depositional texture. *Amer. Assoc. Petrol. Geol.*, Memoir 1, p. 108—121.

Hanzawa, S. (1935): Topography and geology of the Riukiu Islands. *Sci. Rep. Tohoku Univ.*, 2nd Ser. (Geol.), vol. 17, p. 1—61.

Harmon, R. S., Ku, T. L., Matthews, R. K. and Smart, P. L. (1979): Limits of U-series analysis: Phase 1 results of the Uranium-Series Intercomparison Project. *Geology*, vol. 7, p. 405—409.

Kataoka, J. (1961): Bryozoan fauna from the "Riukiu Limestone" of Kikai-jima, Kagoshima Prefecture, Japan. *Sci. Rep. Tohoku Univ.*, 2nd Ser. (Geol.), vol. 32, p. 213—272.

Konishi, K., Schlanger, S. O. and Omura, A. (1970): Neotectonic rates in the Central Ryukyu Islands derived from ^{230}Th coral ages. *Marine Geol.*, vol. 9, p. 225—240.

——, Omura, A. and Nakamichi, O. (1974): Radiometric coral ages and sea level records from the Late Quaternary reef complexes of the Ryukyu Islands. *Proc. 2nd Int. Coral Reef Symp.*, vol. 2, p. 595—613.

Mesolella, K. J. (1968): *The uplifted reefs of Barbados: Physical stratigrphy, facies relationships, and absolute chronology* (Ph. D. dissert.). Providence, R.I., Brown Univ., 701 pp.

Ota, Y., Machida, H., Hori, N., Konishi, K. and Omura, A. (1978): Holocene raised coral reefs on Kikai-jima (Ryukyu Islands) — An approach to Holocene sea level study —.

Geogr. Rev. Japan, vol. 51, p. 109—130. (in Japanese with English abstract)

Yabe, H. and Eguchi, M. (1932): Deep-water corals from the Riukiu Limestone of Kikai-jima, Riukiu Islands. *Proc. Imp. Acad. Tokyo*, vol. 8, p. 442—445.

喜界島の琉球石灰岩より産出した単体サンゴの放射年代：喜界島の更新統琉球石灰岩のうち，上嘉鉄の北方約650 m・高度40 mの地点付近に分布するものは，その特徴的な岩相（典型的なDunham, 1962, の grainstone）と，保存のよい多くの種類の単体サンゴを産することなどで，古くから注目されてきた。本研究では，それらの中から3種（*Trochocyathus hanzawai*, *Micrabacia japonica* および *Flabellum rubrum*）を選んで，^{230}Th/^{234}U 法による放射年代測定を試み，平均82,000±2,000年の年代値を得た。この値は，世界各地（例えば，西インド諸島 Barbados 島やニューギニア Huon 半島など）で，その存在が確認されている一亜間氷期の年代と一致する。

一方，当時の礁石灰岩は，現在城久南部に発達する海成段丘の構成物として，すでに確認されている（Konishi *et al.*, 1974)。すなわち，城久南部にみられる礁石灰岩がサンゴ礁として形成されていた当時，上述の grainstone はその礁前縁相として堆積したものと考えられる。そして，この grainstone と礁石灰岩との現在の分布高度差（114～144 m）は，もし両者がこれまでに等量の構造運動（垂直変動）をうけてきたとすれば，大よそ grainstone の堆積深度を示しているといえる。しかし，島内で確認される断層から局地的な変動量の違いも考慮しなければならず，実際の堆積深度は120 m以浅と推定される。この推定値は，単体サンゴおよび蘚虫類の研究から Yabe and Eguchi (1932) や Kataoka (1961) によって推定された grainstone の堆積深度と決して矛盾しない。また，以前 Konishi *et al.* (1970, 1974) が報告した55,000～65,000年前の Younger Limestone Member of Riukiu Limestone の礁性サンゴに富む石灰岩の分布地点が，この grainstone の分布地域と近接し，形成時代と堆積深度が全く異なると思われる両者が段丘構成物としてみられることから，上嘉鉄北方に広がる高度40 mの平坦面は，一部が堆積面一部が侵食面であると考えられる。 大村明雄

PROCEEDINGS OF THE PALAEONTOLOGICAL SOCIETY OF JAPAN

日本古生物学会第131回例会

日本古生物学会第131回例会が1983年6月19日に，宇都宮大学を会場として開催された（参会者100名）。

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行事予定

	開催地	開催日	講演申込締切
第132回例会	熊本大学	1983年10月23日	1983年8月23日
1984年　年会・総会	京都大学	1984年1月21，22日	1983年11月21日

講演申込：113 先東京都文京区弥生 2-4-16
日本学会事務センター　日本古生物学会　行事係

お知らせ

◎「化石」が本会の定期発行の機関誌になりましたので，従来本誌で扱っていた学会記事の一部を「化石」に掲載することになりました。

◎今春から常務委員などの役割分担が一部変更になりました。会務の円滑を期するため，1983-84年度の本会関係の連絡先を用務別に記しておきますのでよろしく御協力下さい。

○会費の払込→お送りしている銀行振込用紙で日本学会事務センター

○会費に関する問合せ→会計係：木村達明（東京学芸大学地学教室）

○本会の常務委員会への連絡一般→庶務係：鎮西清高・阿部勝己（東京大学理学部地質学教室）

○住所変更・入退会申込・報告紀事および特別号バックナンバー購入申込→日本学会事務センター内日本古生物学会

○報告紀事への投稿→なるべく書留便で同上に，または編集係：速水　格（東京大学総合研究資料館）〔原稿コピー1部と投稿カードを同封または別送して下さい。投稿にあたっては編集出版規約（No. 121）と原稿作成上のお願い（No. 122）を参照して下さい。報告紀事に関する問合せ・投稿カードの請求も上記にお願いします。〕

○本会所蔵の図書閲覧の問合せ→速水　格（同上）〔No. 120 に外国誌の目録と利用案内を掲載してあります。〕

○特別号に関する問合せ・購入申込→特別号編集委員会：首藤次男・柳田寿一（九州大学理学部地質学教室）（三和銀行福岡支店普通預金口座 12172；振替　福岡 19014）〔一部の特別号バックナンバーの郵送によらない直接販売は東大総合研究資料館（速水　格），国立科学博物館分館（藤山家徳）でも取扱います。〕

○“化石”に関する問合せ・投稿・バックナンバー購入申込→化石編集部：高柳洋吉・石崎国熙（東北大学理学部地質学古生物学教室）（振替　仙台 17141）

○各種の賞に関する問合せ・推薦依頼→賞の委員会幹事：鎮西清高（同上）〔1983年度のみ〕

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