Biostratigraphical and Paleontological Studies on the Endothyroid Foraminifera* from the Atetsu Limestone Plateau, Okayama Prefecture, Japan

By

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with 8 Plates and 1 Table

ABSTRACT. Biostratigraphical study of the Lower Carboniferous through the endothyroid Foraminifera, has very recently been advanced by some paleontologists of North America and Russia. But their biozones are proposed only by E. J. ZELLER (1957) who has studied endothyroids from the Mississippian rocks of the Cordilleran region, North America. In the Atetsu limestone plateau the Carboniferous deposits are named Mitsudô group by the writer, and further subdisivisible into two formations, i. e. the lower, Nagoe formation of Mississippian and the upper, Kodani formation of Pennsylvanian in age. By careful thin section study of samples from the lower Nagoe formation of the Morikuni-Kodani measured section and two other adjacent ones in this area, the present writer recognizes the following five foraminiferal fossil zones in ascending order; 1) *Plectogyra communis* zone, 2) *Plectogyra primaeva* zone, 3) *Endothyra spiroides* zone, 4) *Endothyra symmetrica* zone and 5) *Atetsuella meandera* zone. The endothyroid faunal succession of the intermediate three zones is very similar to that of the Osagian to the Upper Meramecian faunal zones proposed by E. J. ZELLER stated above, and moreover both species of *Plectogyra communis* and *P. primaeva* from the lowest two zones were described by D. M. RAUSER-CHERNOUSSOVA (1936) from the Lower Tournaisian in the central Kazakhstan, Russia. However, the lower part of the *Endothyra spiroides* zone yields such coral forms as *Hexaphyllia* sp. and *Siphonodendron* sp. generally thought to belong to the Upper Viséan (Chesterian) Onimaru type fauna which has never been reported from the Carboniferous limestone of Chûgoku. Although it has been believed generally that *Profusulinella* follows *Millerella* in phylogenic position of Fusulinidae, the present writer discovered *Profusulinella* from the uppermost limestone of the Nagoe formation underlying perhaps disconformablly the lowest part of the Pennsylvanian Kodani formation in which *Millerella* appears first. The fact that a distinct abrupt change in faunas is recognizable between the uppermost *Atetsuella meandera* zone of the Nagoe formation and the overlying Pennsylvanian Kodani formation may stratigraphically indicate there a noticeable disconformity between the Mississippian and the Pennsylvanian deposits. A new genus *Atetsuella*, which is an intermediate type of Fusulinidae and Endothyridae, two new species of *Atetsuella*, three new species of a new genus *Paraplectogyra* belonging to the Endothyridae, and a new species of *Granuliferella* are described.

CONTENTS

* Endothyroid Foraminifera in North American sense. Some genera of the family Endothyrida and Ammodiscida which were proposed by D. M. RAUSER-CHERNOUSSOVA and E. A. REITLINGER in 1957, may be included in the North American Endothyridae.

I. INTRODUCTION AND ACKNOWLEDGEMENTS

INTRODUCTION: The stratigraphical and paleontological studies on the Permo-Carboniferous limestone in Japan have greatly promoted by many Japanese students of fusulinid Foraminifera: especially by H. YABE, Y. OZAWA, S. HANZAWA, H. FUJIMOTO, R. TORIYAMA, K. KANMERA, M. KANUMA, R. MORIKAWA, H. IGO and others. So far as the fusulinid fauna is concerned, the Permo-Carboniferous limestones in Japan have been considered to be divisible into the world-wide nine fusulinid zones as follows in descending order:

9. Zone of *Yabeina-Lepidolina*
8. Zone of *Neoschwagerina*
7. Zone of *Parafusulina*
6. Zone of *Pseudoschwagerina*
5. Zone of *Triticites*
4. Zone of *Fusulina**
3. Zone of *Fusulinella*
2. Zone of *Profusulinella*
1. Zone of *Millerella*

On the other hand, in Japan the Lower Carboniferous (Mississippian) has not been subdivided yet through the use of primitive fusulinids or endothyroid foraminifers, except for the zonation through the brachiopod and coral fauna.

The genus "*Endothyra*" was described on one and the same specimen by both authors, T. BROWN (1843) and J. PHYLLIPS (1845), but the obscurity of and difference between both descriptions had provoked unavoidable confusions including the problem of the true authorship.

In 1950, E. J. ZELLER who studied mainly the Mississippian endothyroid foraminifers asserted that J. PHYLLIPS was true author of genus *Endothyra*, and classified it into two genera; one planispiral *Endothyra* and the other plectogyroid *Plectogyra*. While in Russia, the genus *Endothyra* is of plectogyroid forms as well as *Plectogyra* defined by E. J. ZELLER, and here the planispiral forms have nothing to do with what is called *Endothyra*. And the planispiral forms are subdivided into a few genera of *Eostaffella*, *Parastaffella*, *Staffella* etc.**

* K. ISHII (1957) proposed to use the name "Zone of *Veedeina*" instead of the "Zone of *Fusulina*".
** The present writer treats them as the group *Staffella* in this paper.

In 1957, E. J. ZELLER distinguished the following five endothyroid faunal zones below the *Millerella* zone throughout the Mississippian rocks of the Cordilleran region, North America.

Paramillerella Zone ..... Chesterian
Endothyra symmetrica Zone ..... Upper Meramecian
Endothyra spiroides Zone ..... Lower Meramecian
Plectogyra tumula Zone ..... Osagian
Granuliferella Zone ..... Kinderhookian

Since 1954 the present writer has been engaged in a systematic research on the Permo-Carboniferous limestone of the Atetsu plateau, Okayama prefecture, Southwest Japan, and discovered first in Japan endothyroid Foraminifera in abundance in the lower part of the Carboniferous limestone. Through the stratigraphical and paleontological studies on the endothyroid foraminifers of this district, a remarkable similarity between the faunal succession of the western United States and that of the Atetsu plateau has been recognized, and also endothyroids of the Atetsu plateau are very similar to that of Russia, especially in shell form and septal length. So far as the Mississippian rocks of the Atetsu area are concerned, the following systematic zonation in descending order can be proposed, based upon the above-stated foraminifers.

5. *Atetsuella meandera* zone
4. *Endothyra symmetrica* zone
3. *Endothyra spiroides* zone
2. *Plectogyra primaeva* zone
1. *Plectogyra communis* zone

Five new species of endothyroid Foraminifera are described: a new species of *Granuliferella*, three new species of a new genus *Paraplectogyra*, and two new species of a new genus *Atetsuella* which is of an intermediate type of Endothyridae and Fusulinidae.

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II. THE SECTIONS MEASURED AND SAMPLED

By many Japanese stratigraphers it has been generally thought that the Mississippian limestone does not distribute in any limestone region of Chugoku district, South-

west Japan. The Carboniferous deposits in the Atetsu limestone plateau are designated the **Mitsudô group**, further subdivided into two fomations of the lower **Nagoe** and the upper **Kodani.**

The Mitsudô group indicates a monoclinal structure with northwest to southeast trend, dipping to the southwest and the lower limit of this group is fault contact with Permian limestone.

Biostratigraphical succession of the Carboniferous deposits in this area can best be observed along the valley from Morikuni to Kodani, its branched valley from Nagoe to Honmura and the adjacent valley from Nishinoo to Mitsudô, Toyonaga-machi, Niimi City as shown in the accompanying plate. (Pl. 30, Figs. 1 and 2)

Recently, since the writer could expect that the Mitsudô group might contain not only the lower and Middle Pennsylvanian but also Mississippian formations, he chose the following three columnar sections measured and sampled for its detailed study (Plate 2).

1. Morikuni-Kodani section
2. Nagoe-Honmura section
3. Nishinoo-Mitsudô section

As a result of the careful thin section study he has discovered first in Japan abundant Mississippian endothyroid foraminifers in them.

1. *Morikuni-Kodani section*: This section is the type. This section exposing well along the valley line was measured and sampled from Morikuni to Kodani, Toyonaga-machi, Niimi City.

Two formations are recognized, the lower formation of Nagoe of about 195 meters thick is composed of limestone, chert, and granular and agglomeratic schalstein, while the upper formation of Kodani mainly consists of limestones alternated with cherts in the lower part. Almost all horizons of the Nagoe formation except the lower 20 meters thick of the lowest schalstein bed yield rich endothyroid fauna clearly of Mississippian age. Nearly in the Middle part of the Nagoe formation, agglomeratic schalstein beds were discovered between the sample localities MA05 and MA11, yielding abundantly coral fauna containing Onimaru type elements as *Hexaphyllia* sp. and *Siphonodendron* sp. of Upper Viséan in Japan. On the other hand, such primitive fusulinid fauna as *Millerella*, *Schubertella*, *Profusulinella* and *Fusulinella* of the Lower and Middle Pennsylvanian type has been sampled only from the Kodani formation, moreover at the very base of the Kodani formation, alternation of cherts and brecciated or fine conglomeratic limestones of 8 meters thick with many small limestone pebbles abounding destroyed Mississippian endothyroids, is recognized.

All samples collected from the Nagoe and Kodani formations of type section are distributed with fossil contents as follows in ascending order:

Kodani formation – KA01–KA15 ..... Probably upper part of the *Millerella* Zone up to the *Fusulinella* Zone.

Nagoe formation
- KA16 ..... *Atetsuella meandera* zone
- MA01–MA02 ..... *Endothyra symmetrica* zone
- MA03–MA05 and coral bed ..... *Endothyra spiroides* zone
- MA10–MA11,M.W.S and B.L.C ... *Plectogyra primaeva* zone
- MA07–MA09 and B.L.B ..... *Plectogyra communis* zone

2. *Nagoe-Honmura section*: This section was measured and sampled from Nagoe to Honmura, Toyonaga-machi, Niimi City. It consists of the lower formation of Nagoe of about 140m thick and the upper formation of Kodani of about 60m thick. Their precise thickness can not be verified because of ill exposure near the boundary part of both formations. In this section almost all limestones and calcareous schalsteins, excluding cherts of the lower and middle portions were clarified to be the endothyroids bearing rocks, while the massive limestones of the upper portion to be of fusulinid limestone of Pennsylvanian. The coral and endothyroid faunas from the lower and middle portions of this section include the same species as that in the Nagoe formation of the type section stated before, and the fossil fauna from the upper portion coincides with the fusulinids fauna of the Kodani formation, but the boundary part between the upper and middle portions is missing for collecting samples, because of no outcrops. The real relation of both Nagoe and Kodani formations, therefore, is still unknown in this section.

All samples from this section are sorted out as follows in accordance with the distribution of the type section.

Kodani formation – SB21–SB27 ..... Probably upper part of the *Millerella* Zone up to the *Fusulinella* Zone

Nagoe formation
- NB04–NB05 ..... *Atetsuella meandera* zone
- coral bed, NB03 and WO103 ..... *Endothyra spiroides* zone
- NB02 and WO102 ..... *Plectogyra primaeva* zone
- NB01 ..... *Plectogyra communis* zone

3. *Nishinoo-Mitsudô section*: This section was measured and sampled along the route from Nishinoo to Mitsudô, Toyonaga-machi, Niimi City. Only Nagoe formation develops in this section, and its total thickness is measured 85 meters. Its rocks consist of schalstein intercalated with limestone lenses and nodules. Besides, the uppermost part of this section may probably consist of chert. The coarse-grained calcareous schalstein directly underlying the chert is fossiliferous bed corresponding to the coral bearing agglomeratic schalstein of the type section. It is of special importance because of its containing coral and endothyroid faunas. In this section the rich endothyroids, which were collected from limestones and calcareous schalsteins of almost all horizons, show the faunal assemblage as well as those from the lower part of the type section. All samples from this section are sorted out as follows in accordance with the distribution of the type section.

Nagoe formation
- ME04–ME05 ..... *Endothyra spiroides* zone
- ME02–ME03 and WO53 ..... *Plectogyra primaeva* zone
- ME01 and WO52 ..... *Plectogyra communis* zone

III. Stratigraphical Distribution of Fusulinid and Endothyroid Foraminifers

As stated in the preceding chapter, the Carboniferous deposits of the Atetsu limestone plateau are subdivisible into two formations; the upper formation of Kodani and the lower formation of Nagoe. The Kodani formation consists almost of limestones with fusulinids, while the Nagoe formation is characterized with alternation of schalstein and limestone, yielding endothyroids. Moreover, no common species of foraminifers between the both formations has been observed, and a conspicuous faunal change can be recognized as will be described in next chapter.

Such primitive fusulinids as *Fusulinella*, *Profusulinella*, *Millerella*, *Eoschubertella*, *Schubertella*, *Pseudostaffella* and *Fusiella* have been observed abundantly from the Kodani formation, but the writer can not yet define its biostratigraphical zonation, because of unsufficient thin section study. Accordingly the writer will discuss fully on its fusulinid zones in near future. However, he supposes that the Kodani formation may be referable to the Lower to Middle Pennsylvanian by its above-stated primitive fusulinid genera.

On the other hand, some abundant endothyroid foraminifers from the Nagoe formation are considered to be of special value in the biostratigraphical zonation of this area, because of the fact that their abundant occurrences and stratigraphical distribution throughout this formation are restricted to comparatively short vertical range and such endothyroids are useful as zone marker.

The Nagoe formation can be subdivided into the following five fossil zones in descending order:

1. *Atetsuella meandera* zone
2. *Endothyra symmetrica* zone
3. *Endothyra spiroides* zone
4. *Plectogyra primaeva* zone
5. *Plectogyra communis* zone

The lower limit of the Nagoe formation is uncertain because of its fault contact with the Permian limestone, while the upper limit of the fifth zone is also obscure because the precise biostratigraphical observation of the overlying Kodani formation had not yet been worked.

1. Plectogyra communis zone

Plectogyra communis zone is about 35 meters thick or more, representing the lowest fossil zone in this area. The lower half of this zone consists mainly of schalstein with

impure limestone nodules, while the upper half of about 18 meters is composed of thin alternation of schalstein and calcareous schalstein.

The impure limestone nodules in the lower half of the thick schalstein underlying this zone are mostly crystalline and nonfossiliferous, while those in the upper half of it and overlying calcareous banded schalstein yield following fossil species abundantly:

Plectogyra communis (RAUSER-CHERNOUSSOVA)
P. sp. A
Granuliferella plectula E. J. ZELLER
G. pauciseptata, sp. nov.
G. sp. A

Only *Plectogyra communis* (RAUSER-CHERNOUSSOVA) occurs commonly or rarely in places throughout this zone, while the other foraminifers appear first in the upper half of this zone.

2. Plectogyra primaeva zone

Plectogyra primaeva zone is about 22 m thick or more, overlying conformablly the above-stated *Plectogyra communis* zone. It is composed of thin alternation of schalsteins and calcareous schalstein or subordinate impure limestones, yielding abundantly excellent well-preserved endothyroid foraminifers in the calcareous schalstein. Following fossil species occur from this zone:

Plectogyra primaeva (RAUSER-CHERNOUSSOVA)
P. cf. *trachida* E. J. ZELLER
P. sp. A
Paraplectogyra masanae, gen. et sp. nov.
P. longiseptata, gen. et sp. nov.
P. sp. A
Granuliferella plectula E. J. ZELLER
G. pauciseptata, sp. nov.
G. sp. A

Plectogyra primaeva (RAUSER-CHERNOUSSOVA) appears very abundantly throughout this zone associated with subordinate amount of *Plectogyra* cf. *trachida* E. J. ZELLER, *Paraplectogyra masanae*, gen. et sp. nov. and *P. longiseptata*, gen. et sp. nov. Throughout this zone *Granuliferella plectula* E. J. ZELLER, *G. pauciseptata*, sp. nov., *G.* sp. A, *Plectogyra* sp. A and *Paraplectogyra* sp. A are found, successively from the underlying lowest fossil zone.

3. Endothyra spiroides zone

Endothyra spiroides zone overlies conformablly the *Plectogyra primaeva* zone and varies laterally in its total thickness from 30 to 60 meters thick. The lower part of this zone mainly consists of coarse-grained or agglomeratic schalstein, while the upper of limestone, chert and thin schalstein in alternation or sometimes of only chert. The lower

agglomeratic schalstein which yields abundant fossil corals exposes well about 170 meters west of Morikuni, containing angular fragments of shale, sandstone and basic rocks. At Mitsudô, however, coarse-grained calcareous schalstein takes its place and yields such smaller form corals as *Hexaphyllia* sp. and *Siphonodendron* sp. M. MINATO and K. NAKAZAWA (1957) reported *Clisaxophyllum awa atetsuense* MINATO et NAKAZAWA and *Amygdalophyllum giganteum* (YABE & HAYASAKA) obtained from the same locality, mistaking it for the Middle Carboniferous in age. The present writer has discovered the following coral and endothyroid faunas in the lower part:

Hexaphyllia sp.
Clisaxophyllum awa MINATO
C. awa atetsuense MINATO et NAKAZAWA
Siphonodendron sp.
Amygdalophyllum giganteum (YABE et HAYASAKA)
Stylidophyllum sp.
Paraplectogyra cf. *masanae*, gen. et sp. nov.*
P. sp. B
Endothyra spiroides E. J. ZELLER
E. discoidea (IGO)**
E. sp. A
Plectogyra sp. C
P. cf. *trachida* E. J. ZELLER

It is noteworthy that no species of endothyroids which occur in the *Plectogyra primaeva* zone extend into this *Endothyra spiroides* zone. The upper part is characterized with such large endothyroids as *Paraplectogyra gigantea*, gen. et sp. nov. and *P.* cf. *masanae*, gen. et sp. nov. in association with no coral fauna. The following fossils are obtained from the limestones of the upper part:

Plectogyra aff. *omphalota* (RAUSER-CHERNOUSSOVA & REITLINGER)
P. sp. C
Paraplectogyra gigantea, gen. et sp. nov.
P. cf. *masanae*, gen. et sp. nov.
P. sp. B
Endothyra spiroides E. J. ZELLER
E. discoidea (IGO)
E. sp. A and B

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* *Paraplectogyra* cf. *masanae*, gen. et sp. nov. is rare in number, and shows very large form, but other characters of this species are similar to that of *Paraplectogyra masanae*, gen. et sp. nov.

** The same fossil name had been reported from the upper part of Batesville sandstone(Upper Mississippian) by G. H. GIRTY, but that of GIRTY must be emended as *Plectogyra discoidea* (GIRTY) because of its plectogyroid coiling and two layered wall. This species may be referred to some one of *Ammodiscus* of Russia, but it is clear to be not differing from the definition of *Endothyra* that E. J. ZELLER proposed to classify the endothyroid Foraminifera.

Endothyra spiroides E. J. ZELLER occurs abundantly enough throughout this zone to be useful as a stratigraphical zone marker.

4. Endothyra symmetrica zone

Endothyra symmetrica zone is assumed to be about 17 meters thick, consisting of limestone with chert bands, and its good exposure is observed 230 meters west of Morikuni. The most species of endothyroid foraminifers from this zone are characterized with planispiral form, while the plectogyroid form is small in number. The following species are found in this zone:

Endothyra symmetrica E. J. ZELLER
E. spiroides E. J. ZELLER
E. spp. A. B and C
Plectogyra aff. *omphalota* (RAUSER-CHERNOUSSOVA & REITLINGER)
Paraplectogyra spp. B and C

In the upper part *Endothyra symmetrica* E. J. ZELLER occurs very abundantly, and *E. spiroides* E. J. ZELLER also is observable successively from the underlying *Endothyra spiroides* zone.

5. Atetsuella meandera zone

Atetsuella meandera zone overlies conformably the *Endothyra symmetrica* zone, consisting of only massive limestones of 10 to 15 meters thick. It is recognized easily 240 meters west of Morikuni, and well preserved fossils are found 150 meters west of Nagoe though its exposure is very poor.

Profusulinella has never been reported from any bed underlying the *Millerella* zone. And moreover the *Profusulinella* zone has been generally regarded to overlie the *Millerella* zone by fusulinid paleontologists in the world, but the present writer discovered *Profusulinella* in the massive limestone of the upper part of the *Atetsuella meandera* zone which underlies the base of Kodani formation. Moreover, the new genus *Atetsuella* considered by the writer to be more primitive fusulinid than the genus *Profusulinella* or the most advanced endothyroid, appears abundantly throughout this zone. The rocks of this zone contain abundant fossils of genus *Atetsuella* and *Profusulinella* listed as follows:

Atetsuella imamurai, gen. et sp. nov.
A. meandera, gen. et sp. nov.
A. sp.
Profusulinella spp. A and B
Endothyra symmetrica E. J. ZELLER
E. spiroides E. J. ZELLER
E. sp. B
E. aff. *radiata* BRADY var. *tateana* HOWCHIN

Profusulinella spp. A and B from this zone seem to be of more primitive type than

any known species from the *Profusulinella* zone in Japan and they were discovered in the stratigraphically lower bed than that where the *Millerella* has been first observed in this limited area. So, some important new problems on the ancestral fusulinids and the internationally recognized *Profusulinella* zone of the Middle Carboniferous will be studied in the writer's future research work.

6. Kodani formation

The Kodani formation exposes well in the two routes of Morikuni-Kodani and Mitsudô-Honmura, Toyonaga-machi, Niimi City, but in the latter the exposure of the lower banded limestone of this formation is lacking. This formation is overlain with distinct unconformity by the limestone conglomerate of the Lower Permian *Pseudoschwagerina* zone of the **Iwamoto formation.** It is about 56 meters thick in the Morikuni-Kodani type section, consisting mainly of oolitic, massive or partly conglomeratic and banded limestone intercalated with chert.

The lower half, about 26 meters thick, of the Kodani formation is composed of banded limestone intercalated whih chert and highly fossiliferous at several horizons. The lowest part, about 8 meters thick, of this unit is composed of banded limestone conglomerate which is of a simple lithologic composition and is made up invariably of very small angular or slightly rounded pebbles in a matrix of fine lime materials.

Many of the small limestone pebbles abound with partly destroyed individuals of *Paraplectogyra gigantea* type which seem to be derived from the underlying *Endothyra* zone. *Millerella inflecta* THOMPSOM, *M. marblensis* THOMPSON, *M.* sp., *Plectogyra* sp. B and *Granuliferella* sp. B, all of which are entirely different from the fossils of the underlying Nagoe formation, are identified from the matrix of the conglomeratic limestone, and are successively common whithin the upper part of the lower half banded limestone of about 18 meters thick.

The lower part of the upper half limestone facies of about 18 meters thick which succeeds to the lower banded limestone is generally greyish white in color, and the collected fossils from two horizons in this part of the type section are *Millerella* spp., *Profusulinella* spp. A and B, *Schubertella* sp., *Eoschubertella* sp., *Fusiella* sp., *Pseudostaffella* sp. and *Plectogyra* sp. B.

In the Nagoe-Honmura section, the massive limestone characterized with the occurrence of *Profusulinella* spp. C and D is about 28 meters thick and yields the following fusulinids and endothyroids at four horizons: *Millerella marblensis* THOMPSON, *M. inflecta* THOMPSON, *M.* sp., *Pseudostaffella* sp., *Schubertella* sp., *Plectogyra* sp. B, and *Granuliferella* sp. B.

The uppermost part of this formation is followed upward by the oolitic or partly conglomeratic limestone of about 17 meters thick, overlying the preceding greyish limestone. This uppermost part is characterized by the appearance of some *Fusulinella* in association with *Profusulinella* spp. A and B, *Pseudostaffella* sp., *Plectogyra* sp. B etc.

Considering the above-stated data, there is no doubt that the upper half of the

Kodani formation is referable to both zones of the *Fusulinella* and *Profusulinella*. But it is still an open question whether the lower half of the same formation belongs also to the *Profusulinella* zone or to some part of the *Millerella* zone. To settle this question further sufficient paleontological thin section study is of urgent needs. The writer wishes to discuss the problem on the biostratigraphical zonation of the Kodani formation in near future.

IV. The Significance of Faunal Change between Both Formations of the Nagoe and Kodani

The present writer has sampled from many horizons of three measured sections of Morikuni to Kodani, Nagoe to Honmura and Nishinoo to Mitsudô, and examined their contained fossils in detail. As the result of it, he found the fact that a remarkable faunal change is observed abruptly at the base of the Kodani formation. Observing carefully the features of shells of endothyroid foraminifers from the lowest zone of the *Plectogyra communis* towards the upper, they increase gradually in shell size and their secondary deposits also become larger towards the upper. This tendency of becoming larger in shell size or thicker in secondary deposits is noticed successively from the lowest zone of *Plectogyra communis* to the upper most one of *Atetsuella meandera*, although such tendency disappears suddenly at the base of the Kodani formation.

On the other hand, the total angular distortion of endothyroids becomes smaller gradually towards the upper horizon: thus the forms of endothyroid foraminifers in the upper horizon resemble very much the planispiral forms as *Endothyra* and *Millerella*. The *Endothyra* characterized with the planispiral form also becomes larger in shell size and disappears abruptly in the above Kodani formation. All endothyroids obtained from the Kodani formation, especially from the conglomeratic limestones of its base, are very small in size and number. E. J. Zeller did not pay special attention to the faunal succession in the Mississippian of the Cordilleran region of North America, but it is undoubtedly clear from the zone names that the foraminfers of planispiral form are characteristic in the upper horizon.

The occurrence of a new genus *Atetsuella* characterized with three coiling axes is restricted the *Atetsuella meandera* zone of the uppermost Nagoe formation and primitive fusulinid *Profusulinella* appears first in the upper horizon of the same zone. But the writer could not find even one species of *Millerella* from any horizons of Nagoe formation.

Turning the view points, the rock facies of the lower four zones of endothyroid Foraminifera in this area is characterized with schalsteins alternating with impure limestones or sometimes calcareous schalsteins. On the other hand, the rocks of the overlying Kodani formation are mainly composed of limestone with intercalating cherts in its lower part. But the limestones of this alternation facies are conglomeratic through the lowest 8 meters thickness, and only destroyed forms of *Paraplectogyra*

gigantea gen. et sp. nov. are found very abundantly in the small pebbles of the conglomeratic limestones. The question whether above-stated lithological and paleontological features indicate some unconformity or not, has not yet been solved thoroughly by the writer because such features are observed only in the measured type section from Morikuni to Kodani, while in the other two measured sections the exposure of the basal part of the Kodani formation is lacking.

The kodani formation must be correlated with the Pennsylvanian on the basis of its faunal assemblage of fusulinids, and the lower four zones of endothyroid Foraminifera must be referred to the Mississippian as will be discussed in next chapter. On the basis of the remarkable faunal change between the lowest Kodani formation and the uppermost fossil zone of the Nagoe formation, and of the conglomeratic limestone with derived fossils at the base of the former, a discontinuous relationship of the Mississippian-Pennsylvanian boundary should be expected to exist, though the writer could not find any unconformable physical evidence in the field.

The important problems of the true stratigraphical relationship between the Kodani and the Nagoe formation in this area and the true meaning of the above-stated remarkable faunal change between them may be dissolved through the more detailed field and laboratory works in near future.

V. Correlation

Previous Works. Jhon L. Wray (1952), who studied on the endothyroid Foraminifera from the Greenbrier Series, northern West Virginia, conceived the possibility of dividing the Mississippian system stratigraphically through the aid of endothyroids. He concluded that some distinct types of the endothyroids occur only at definite stratigraphic horizons, although many of these types may be facies forms and the recognition of different types of endothyroid from surface as well as from subsurface sample should have value in determining local stratigraphical correlation.

In 1950, E. J. Zeller suggested the possibility of the stratigraphical division of the Mississippian system on the basis of the systematic phylogeny of the Mississippian endothyroid Foraminifera. The Mississippian endothyroid foraminifers were collected by him from the most areas of western and central U. S. A. Their shell forms, feature of coiling and other characters are highly diverse vertically and their facies forms are characteristic to each formation widespread laterally. He distinguished five different forms of upper Devonian, Kinderhookian, Osagian, Meramecian and Chesterian, although he did not propose the zone name by endothyroids.

But in 1957, he reported the general formal succession of endothyroid foraminifers from the Mississippian system in the Cordilleran region and succeeded in its zoning through endothyroid foraminifers. The differences of geologic formational types were used for the zonation as he suggested in 1950. There are both zones of the Lower and the Upper Mississippian, the former is further subdivided into two Zones of *Granuliferella* and *Plectogyra tumula*, while the latter into three Zones of *Endothyra spiroides*, *E. symmetrica*

and *Paramillerella*. These Zones were correlated respectively with the type subdivisions of the Mississippian as follows in descending order;

1. *Paramillerella* Zone.....Chesterian
2. *Endothyra symmetrica* Zone.....Upper Meramecian
3. *Endothyra spiroides* Zone.....Lower Meramecian
4. *Plectogyra tumula* Zone with *Granuliferella plectula*.....Osagian
5. *Granuliferella* Zone.....Kinderhookian

In 1953, Doris E. Nodine ZELLER reported the endothyroid Foraminifera from the type Chesteran area. The Chesterian types of *Plectogyra* from this area, *Plectogyra versablis* D. N. ZELLER, *P. excellens* D. N. ZELLER, *P. pandorae* D. N. ZELLER etc. resemble the Osagian or Meramecian types in the Cordilleran region, but the above-stated fact may be explained by the assumption that some species of *Plectogyra* are possibly of long stratigraphical range from the data of the Cordilleran region.

In 1939, D. M. RAUSER-CHERNOUSSOVA described *Plectogyra communis* and *P. primaeva* from the Lower Tournaisian of the central Kazakhstan, Russia, and both of the same species are reported by N. E. CHERNYSHEVA (1940) and B. A. RAZNITSWIN (1956) from the Etroeungtian or Lower Tournaisian of Makarovski district and Ruscou platform, Ural, Russia. *Plectogyra primaeva* (RAUSER-CHERNOUSSOVA), in 1955, was reported from the Lower Tournaisian of Tyan-Shanya (Тян-Шаня), Russia, by M. N. SOLOBEVA as *Glomospironella primaeva* (RAUSER-CHERNOUSSOVA). Recently many species of *Endothyra* and *Plectogyra* have been reported from the White Russia and Vyatska (Вятской) by R. M. PISTRAK (1956), E. N. LARINOVA, T. L. SAFONOVA (1955) and others, and are referred to the Viséan in age as well as that from the Petshora-Land of Russia by D. M. RAUSER-CHERNOUSSOVA, G. M. BELJAEVA and E. A. REITLINGER (1936).*

CORRELATION. Paleontological studies on the endothyroid Foraminifera have started very recently in North America as well as Russia, and in 1957 only a single case of zonation of the Mississippian rocks through endothyroids has been reported first in the world by E. J. ZELLER from the Cordilleran region. Therefore, also in Japan, the similar biostratigraphical zonation of the lower Carboniferous through endothyroids has not yet been reported.

So far as only endothyroid foraminifers are concerned, the Lower Carboniferous endothyroid zones in the Atetsu area seem to be correlative with that of the Cordilleran region. Because the stratigraphical succession of some endothyroids found in the Atetsu area shows close affinity to that ascertained in the Cordilleran region as

* Regarding to the septal length and count, and swelling feature, the endothyroid Foraminifera shows some noticeable differences which may be ascribed to the difference of faunal provinces between both forms of North America and Russia. While some endothyroids from Atetsu plateau have something common with those of Russia and some others something common with those of North America, therefore the present writer supposes that the endothyroid fauna from the Atetsu district may be of intermediate type between the two above faunal provinces.

indicated in the accompanying table (TABLE 1). In other words, the stratigraphical succession of endothyroids from *Granuliferella plectula* E. J. ZELLER of *Plectogyra primaeva* zone through *Endothyra spiroides* E. J. ZELLER to *Endothyra symmetrica* E. J. ZELLER in the Atetsu area is surprisingly the same as that ascertained in the Cordilleran region.

TABLE 1. THE TABLE SHOWING CLOSE SIMILARITY ON THE FAUNAL SUCCESSION OF ENDOTHYROIDS FROM THE CORDILLERAN AND THE ATETSU DISTRICTS.

	Stage		Cordilleran Region (E. J. ZELLER)	Atetsu District (Y. OKIMURA)
Mississippian system	Chesterian		*Paramillerella* Zone	*Atetsuella meandera* zone associated with *Endothyra symmetrica*, *E. spiroides* and *Profusulinella* sp. A & B
	Meramecian	Upper	*Endothyra symmetrica* Zone associated with many other species of *Endothyra*, *Plectogyra* and *Granuliferella*	*Endothyra symmetrica* zone associated with *Endothyra spiroides*
		Lower	*Endothyra spiroides* Zone associated with other species of *Endothyra* and *Plectogyra* (rare)	*Endothya spiroides* zone associated with large forms of *Paraplectogyra* and with rich coral fauna containing the Onimaru type elements of *Hexaphyllia* sp. and *Siphonodendron* sp.
	Osagian		*Plectogyra tumula* Zone associated with many other species of *Endothyra* and *Plectogyra* (*Granuliferella plectula* occurs successively from the lower *Granuliferella* zone)	*Plectogyra primaeva* zone associated with *Paraplectogyra masanae*, *P. longiseptata*, *Granuliferella pauciseptata* and *G. plectula*
				Plectogyra communis zone associated with *Granuliferella plectula* in the upper part.
				(Fault)
	Kinderhookian		*Granuliferella* Zone	

On the other hand, as before stated, *Plectogyra communis* (RAUSER-CHERNOUSSOVA) and *P. primaeva* (RAUSER-CHERNOUSSOVA) were reported from the Lower Tournaisian or Etroeungtian of several districts of Russia. And moreover, according to the writer's opinion, some species of *Ammodiscus* and *Parastaffella* which are described by Russian paleontologists (В. К. Голуъцов, 1957) are considered to be respectively equivalent to *Endothyra discoidea* (IGO) and *E. spiroides* E. J. ZELLER, and they have been reported from the Lower and Middle Viséan of Russia.

It is very worthy of note that the entire group of endothyroid Foraminifera which continuously occurs throughout the both zones of *Plectogyra communis* and *P. primaeva* suddenly disappears at the base of the *Endothyra spiroides* zone, and moreover the larger forms of both genus *Paraplectogyra* and *Endothyra* appear abundantly in the *Endothyra spiroides* zone. The similar abrupt change of endothyroids was pointed out by E. J. ZELLER (1950) from the type Meramecian-Osagian boundary in the Mississippi valley region of North America. While, according to RAUSER-CHERNOUSSOVA and

REITLINGER, the stratigraphical succession of Russian endothyroids indicates similar noticeable faunal change, that is to say, the plectogyroid forms which appeared first in the Middle Devonian in age are observed successively through the Carboniferous and Permian to Trias, but the planispiral forms (*Eostaffella*) appeared first in the age of the Lowest Viséan. Such remarkable change of the coiling feature is closely similar to the first appearance of planispiral form in the *Endothyra spiroides* zone of the Atetsu district.

Considering the above-stated data, three zone of *Plectogyra primaeva* with *Granuliferella plectula* E. J. ZELLER and *Plectogyra* cf. *trachida* E. J. ZELLER, *Endothyra spiroides* with *E. discoidea* (IGO), and *Endothyra symmetrica* may be correlative respectively with three Zones of the Osagian *Plectogyra tumula*, the Lower Meramecian *Endothyra spiroides*, and the Upper Meramecian *Endothyra symmetrica* of the Cordilleran region of North America. And also the *Plectogyra communis* zone of the Atetsu area with *Granuliferella plectula* E. J. ZELLER may be referable to some lower part of the *Plectogyra tumula* Zone of the Cordilleran region.

Though the *Atetsuella meandera* zone yields two species of *Profusulinella* from its upper horizon (probably new and of primitive type), the present writer hesitates to refer it to the Zone of *Profusulinella*. Owing to the following reasons, the writer rather intends to consider it stratigraphically correlatable to the Chesterian *Paramillerella* zone of North America, although no common species has not yet been obseved.

1. *Millerella* has not yet been found from any fossil zone of the Nagoe formation but it appears first at the very base of the overlying Kodani formation.

2. The stratigraphical range of the genus *Atetsuella* is restricted within the *Atetsuella meandera* zone, but does not extend into the overlying Kodani formation.

3. The Mississippian type endothyroids, i. e. *Endothyra spiroides* E. J. ZELLER, *E. symmtrica* E. J. ZELLER and *Plectogyra* aff. *omphalota* (RAUSER-CHERNOUSSOVA & REITLINGER) which are restricted to the Meramecian of North America or to the Viséan of Russia, continuously occur from the underlying fossil zone in this area and throughout the *Atetsuella meandera* zone though they are very scarcely.

4. The *Atetsuella meandera* zone conformablly overlies the *Endothyra symmetrica* zone stratigraphically and paleontologically, but on the other hand, a remarkable faunal change can be recognized at the boundary between the Nagoe and Kodani formation, and their stratigraphical relationship is probably unconformable.

As before stated, the stratigraphic successions of endothyroids resemble one another very much in the three provinces of Japan, Russia and North America. However, the correlation by such similarity is clearly inconsistent with that through the coral fauna from the lower part of *Endothyra spiroides* zone. Because in Japan, *Hexaphyllia* and *Siphonodendron* have been believed to be the characteristic fossils of the *Dibunophyllum* zone of the Upper Viséan Onimaru Series.

Such contradiction of the correlation between both faunas of Mississippian endothyroid and coral should be thoroughly solved by the detailed and biostratigraphical

restudy of the Japanese Lower Carboniferous, especially of the type ones in the Kitakami Massif through the aid of the endothyroid Foraminifera.

VI. SUMMARY

The Cordilleran region of North America is the only one region where the Mississippian rocks have been hitherto divided stratigraphically through the use of endothyroid Foraminifera, while, in Japan, this paper is the first report of the biostratigraphical and paleontological studies on the Lower Carboniferous endothyroid Foraminifera.

The Carboniferous deposits which distributes in the Atetsu limestone plateau, Okayama prefecture, Southwest Japan, are named Mitsudô group by the writer, and it is subdivided into two formations of the lower Nagoe and the upper Kodani. Three columnar sections have been measured and sampled mainly for the detailed biostratigraphical study of the Nagoe formation. Through the rich endothyroid Foraminifera collected from many horizons of these sections and their stratigraphical distribution, the Lower Carboniferous Nagoe formation can be divided into the following five fossil zones in descending order:

5. *Atetsuella meandera* zone
   with *Endothyra symmetrica* E. J. ZELLER, *E. spiroides* E. J. ZELLER and with *Atetsuella imamurai*, gen. et sp. nov., *Profusulinella* spp. A and B in its upper part.
4. *Endothyra symmetrica* zone
   with *Endothyra spiroides* E. J. ZELLER
3. *Endothyra spiroides* zone
   with *Paraplectogyra gigantea* gen. et sp. nov. and with rich corals as *Amygdalophyllum giganteum* (YABE et HAYASAKA), *Clisaxophyllum awa* MINATO, *C. awa atetsuense* MINATO et NAKAZAWA, *Hexaphyllia* sp. and *Siphonodendron* sp.
2. *Plectogyra primaeva* zone
   with *Granuliferella plectula* E. J. ZELLER, *G. pauciseptata*, sp. nov., *Paraplectogyra masanae*, gen. et sp. nov., *P. longiseptata*, gen. et sp. nov.
1. *Plectogyra communis* zone
   with *Granuliferella plectula* E. J. ZELLER and *G. pauciseptata*, sp. nov. in its upper part

Both zonal species of *Endothyra* zones are the same as those of the Meramecian of North America, and those of the lower two *Plectogyra* zones are the same as those of the Tournaisian of Russia, though that of the uppermost zone has not yet been described.

Any species of *Millerella* has not been found from the Nagoe formation, but appears abundantly from the lower half of the Kodani formation, associated only with Pennsylvanian forms except some derived Mississippian fossils. The shell of

endothyroid foraminifers becomes gradually larger in size from the lower horizon to the upper one throughout the Nagoe formation, but such endothyroids suddenly disappear at the base of the Kodani formation, and newly appearing endothyroids are not only of different species from that of the Nagoe formation but also become smaller in their shell size and number. Such remarkable faunal change of the endothyroids may indicates the Mississippian-Pennsylvanian boundary in this area.

Although some questions are unsolved on the precise correlation of each fossil zone, there is no doubt that the entire Nagoe formation is correlatable to the Mississippian age because the coiling characters of the endothyroid Foraminifera from the Atetsu plateau resembles stratigraphically and paleontologically Mississippian ones of North America or Russia, but no endothyroids from the Pennsylvanian there. While the Kodani formation probably overlying disconformablly the Nagoe formation is undoubtedly referred to the Pennsylvanian in age by its fusulinids fauna as *Millerella* spp., *Fusiella* sp., *Schubertella* sp., *Profusulinella* spp., *Pseudostaffella* sp., and *Fusulinella* spp.

Five species of endothyroid Foraminifera are described, including three new species of a new genus *Paraplectogyra* and a new species of *Granuliferella*, and also described a new genus *Atetsuella* of the intermediate type between Fusulinidae and Endothyridae, and its new species.

VII. Systematic Description

Family Fusulinidae Möller, 1878

Subfamily Schubertellinae Thompson & Foster, 1937

Genus *Atetsuella* Okimura, gen. nov.

Type species:- *Atetsuella imamurai* Okimura n. sp.

Diagnosis:- The shell is small, involute, and shows various forms by the trend of cutting; it is ovate to ellipsoid, or sometimes cocoon. The coiling has three axes which move on a simple curved surface is decided by them. Some species which seem to be primitive form of this new genus, show the plectogyroid coiling in the juvenile stage. Such characters of coiling are the most important diagnosis of the new genus *Atetsuella*.

Mature specimens showing five volutions range 0.6 to 0.9 mm long and 0.3 to 0.5 mm wide. The number of chambers in the last volution varies from ten to fifteen, and it is countable only in the horizontal axial section.

The spirotheca consists of three primary layers of tectum, diaphanotheca and lower tectorium, as well as typical fusulinellid wall structure. The tectum is exceedingly thin, dark layer and the diaphanotheca is a less structureless layer which shows colorless clear band. The lower layer which corresponds to the lower tectoria is of little development, while the outermost dense layer probably referred to the upper tectoria of fusulinellid wall, extends broadly, and its base can not be distinguished from the

chomata, but it is not original because of lacking it in the last wall. In the wall of advanced form the diaphanotheca is sometimes not distinctive or may be absence in the outermost wall.

The proloculus is small and spherical. The chambers rather rapidly increase in height, especially in the last volution. The chomata are single, broad or high, reaching to a height of about one-third to two-third of that of the chambers.

The septa are the same in structure as the spirotheca, and are nearly plane or slightly curved. The count of chomata is commonly four in each volution of axial sections, but it becomes larger or smaller in number in the volution which changes the coiling axis as shown in accompanying Plates (Pl. 34, Fig. 2 and Pl. 35, Fig. 10.).

Discussion:- The axial plane of Fusulinidae is of innumerable or one, while that of Plectogyroid does not show a simple curved surface. If the axial plane counts of Plectogyroid were the total number of planes which are decided by two axes as well as some fusulinids, it never exceed two times of volution numbers. The axial plane of this new genus is a simple curved surface and the axial plane counts which are decided by two axes are two or one and twice number of the early volutions. As mentioned above, so far as the coiling considered the most important character for the classification of Foraminifera is concerned, the new genus *Atetsuella* shows an intermediate form between the Fusulinidae and Endothyridae.

This new genus differs from *Fusulinella* MÖLLER, *Profusulinella* RAUSER-CHERNOUSSOVA & BELJEAV, *Pseudostaffella* THOMPSON, *Staffella* OZAWA and any genera of Schubertellinae which the inner volutions are coiled at a large angle to the coiling of the outer volutions, in its movement of coiling axes and also it differs from *Profusulinella* and *Pseudostaffella* in its wall structure as *Fusulinella*.

Atetsuella differs from each of the following endothyroid genera, *Endothyra*, *Plectogyra*, *Granuliferella* and *Paraplectogyra:* 1). *Endothyra* emended by E. J. ZELLER which is of planispiral form and has two layered wall structure consisting of a tectum and lower tectorium, 2). *Plectogyra* E. J. ZELLER which is of plectogyroid form and has two layered wall structure as *Endothyra*, 3). *Granuliferella* E. J. ZELLER which is of plectogyroid form and single layered wall structure and 4). *Paraplectogyra* OKIMURA n. gen. which is of plectogyroid form.

In this new genus the sliced sections of following four directions must be obtained for the description or classification: 1. Vertical axial section, containing the coiling axis of the last stage; 2. Horizontal axial section, crossing at right angle to the axis of coiling in the last stage; 3. Transverse axial section, parallelling to the axis of coiling of the middle stage or to the axis of coiling in the early stage; 4. Oblique section, not being applied to above three definitions. These four sliced sections are originally defined by H. W. SCOTT, E. J. ZELLER and D. N. ZELLER (1947) as the most important character of the genus *Plectogyra*. In the oblique section, the chomata are always not sufficiently observable.

The measurments of chamber height or the height of volutions has been always

reported for the description of fusulinid species. But such description on this new genus may hardly give any importance because of showing the smaller one in the volution which changes the direction of coiling axis. The writer asserts the general characters as follows for the division of species; the shell forms in the four directional sections, volution numbers, feature of chomata, and length and feature of septa etc.

Geologic age:- Probably Chesterian.

Genus *Atetsuella* OKIMURA

Atetsuella imamurai, sp. nov.

Pl. 34, Figs. 2 and 9, Pl. 36, Figs. 4, 5, 6 and 11.

Description:- The shell is small, ellipsoidal and involute. Mature shell of the holotype consists of five volutions and attains to a length of 0.6 to 0.9 mm and to a width of 0.3 to 0.5 mm. The coiling has three axes which move and settle down temporarily in the three stages. The last volution becomes rather rapidly expansible.

The proloculus is minute and spherical and its outside diameter ranges from 80 to 120 microns, averaging 105 microns for 14 specimens. The spirotheca is thin and is composed of a very thin tectum, structureless diaphanotheca and lower tectorium, as well as fusulinellid wall structure. The upper dense layer expands more broadly than the lower tectoria. The septa have the same structure as the spirotheca and are gently curved with convex to the anterior.

The chomata develop strongly in each whorl, as illustrated on Pl. 34, Fig. 2, and is high comparatively. The shell form of vertical axial section shows ellipsoid or ovate and that of the horizontal axial section is nearly spherical.

Remarks:- *Atetsuella imamurai*, the type species of new genus *Atetsuella*, differs from *A. meandera*, sp. nov. in its non plectogyroid of coiling in the early volutions. This new species also differs from the latter in its higher chomata. But, of course, such character of chomata is usefull for the distinction only in three axial sections where they are observable.

Occurrence:- Common only in the upper part of the *Atetsuella meandera* zone, which is the uppermost one of the Nagoe formation. The holotype was obtained from the locality of KA16 in the Morikuni-Kodani type section. It is associated with *Atetsuella meandera*, sp. nov., *Plectogyra* sp., *Endothyra symmetrica* E. J. ZELLER, *E. spiroides* E. J. ZELLER, E. sp. and *Profusulinella* spp. A and B.

Geologic age:- This new species is probably limited to the Chesterian.

Atetsuella meandera, sp. nov.

Pl. 34, Fig. 7, Pl. 35, Figs. 4 and 10, Pl 36, Figs. 1 and 7.

Description:- The shell is small, involute and nearly cocoon in shape of vertical axial

section, but it is spherical in the most sliced sections. Mature specimen shows five volutions and it is 0.4 to 0.7 mm long, and 0.3 to 0.5 mm wide. The coiling is plectogyroid in the early stage though the volutions of the middle stage are coiled at a large angle to both the coilings of outer volutions and of half of the last volution of the early stage.

The proloculus is minute and spherical. The spirotheca is thin and is composed of a very thin tectum which is shown as a dark line, structureless diaphanotheca and lower tectorium as well as fusulinellid wall structure. The septa are the same in structure as the spirotheca and are gently curved with convex to the anterior in the outermost volution.

Throughout the shell, remarkable chomata develop and are broad and low. Their height is not beyond one-third of a chamber height. The chomata seem to suggest the meandering of rivers in its features.

Remarks:- *Atetsuella meandera* differs from *Atetsuella imamurai* in its cocoon shape of vertical axial section, its small shell in any trend slice, its meandering feature of chomata, and in its plectogyroid coiling in the early stage.

Occurrence:- *Atetsuella meandera* is common throughout the *Atetsuella meandera* zone.

The type specimen comes from the locality of KA16 in the Morikuni-Kodani type section. Associated fossils are *Atetsuella imamurai* OKIMURA, A. sp., *Plectogyra* sp., *Endothyra symmetrica* E. J. ZELLER, *E. spiroides* E. J. ZELLER and *Profusulinella* spp. A and B.

Geologic age:- Probably Chesterian.

Family Endothyridae RHUMBER, 1895
Subfamily Endothyrinae BRADY, 1884
Genus *Paraplectogyra* OKIMURA, gen. nov.

Type species:- *Paraplectogyra masanae*, sp. nov.

Diagnosis:- The shell is discoidal and strongly umbilicate on one side than the other. The chambers are swollen between the sutures. The spirotheca consists of three original layers and is usually thick in the outermost wall. The original layers of spirotheca correspond with that of fusulinellid wall structure which consists of tectum, diaphanotheca and lower tectorium.

The coiling is plectogyroid though it varies in total angular distortion among the species. The aperture occurs at the base of the apertural face and is low and narrow.

The septa are long in proportion to the chamber height and nearly plane, but those of some species are slightly convex for the next chamber. Mature shells have four to six volutions, the secondary deposits occur more or less on the chamber floors.

Discussion:- *Paraplectogyra* very closely resembles *Plectogyra* E. J. ZELLER but differs from it in three layered wall structure, which consists primarily of tectum, diaphano-

theca and lower tectorium corresponding to those of the fusulinellid wall. The wall of *Plectogyra* shows two layers, lacking the diaphanotheca, The secondary deposits of *Paraplectogyra* are regarded mistaking for the upper tectoria, but it is not original layer of wall. This new genus differs from *Granuliferella* E. J. ZELLER in the latter single layered coarsely granular wall and the smaller number of volution in the adult shell. This new genus differs also from *Atetsuella* in its plectogyroid coiling. This new genus has not any character to differ from *Plectogyra* in North American sense or *Endothyra* of Russia besides the wall structure of intercalating diaphanotheca between the tectum and the lower tectorium.

Geologic age:- Probably ranges from the Middle Mississippian to the Lower Pennsylvanian: the associated primitive fusulinids and Endothyroids are mentioned in the forgoing chapter.

Genus *Paraplectogyra* OKIMURA

Paraplectogyra masanae, sp. nov.

Pl. 32, Figs. 10, 11 and 16.

Description:- The shell is small, involute and umbilicate on one side only. The chambers of the last volution are strongly swollen between the sutures but those of the early volutions are uncertain because of the secondary deposits fill on the chamber floors and of the very small chamber in height. The proloculus is minute and its size averages from 10 to 20 microns in diameter. The secondary deposits consist of simple and slightly asymmetrical obtuse-triangle forms. Their maximum development is shown in the chambers of the last volution, but original features of the early volutions are obscure perhaps by their resorption. The aperture is rather low and is situated at the base of the apertural face.

The spirotheca is thin in the early volutions but the outermost one becomes very thick and is clearly divisible through its light color band which corresponds to the diaphanotheca of fusulinellid wall structure. The septa of the same structure as the spirotheca, are nearly plane and comparatively long and their length is three-fourh of the height of chambers.

The coiling is plectogyroid and the distortional angle between the last two volutions reaches about 35 to 40 degrees. Examining of the horizontal axial section, some sutures of the outermost wall are not rhythmical but nearly plane. Mature shells show three to five volutions and are 0.17 to 0.28 mm in diameter.

Remarks:- This new species resembles *Plectogyra plectogyra* E. J. ZELLER, but the former differs from the latter in its small shell, little secondary deposits and three layered wall structure and larger total angular distortion. *Paraplectogyra masanae* has important character that some chambers of the last volution are not inflated but nearly smooth. This new form differs also from the other species of *Paraplectogyra* in its

character.

Occurrence:- Common in the *Plectogyra primaeva* zone, the second fossil zone of this area. The type specimen was collected from the locality of MA 09 in the Morikuni-Kodani type section. It is associated with *Granuliferella plectula* E. J. ZELLER, *G. pauciseptata*, sp. nov., *Plectogyra primaeva* (RAUSER-CHERNOUSSOVA), *P.* cf. *trachida* E. J. ZELLER, *Paraplectogyra longiseptata*, sp. nov.

Geologic age:- Probably Osagian, to Meramecian?

Paraplectogyra longiseptata, sp. nov.

Pl. 33, Fig. 1, Pl. 35, Fig. 7 and Pl. 36, Fig. 13.

Description:- The shell is small and discoidal and umbilicate on one side only. The chambers are of small size and are weakly swollen between the sutures or some specimen is rather smooth periphery. The proloculus is minute and spherical and averages from 10 to 15 microns in diameter. Secondary deposits are poorly developed on the chamber floors. The aperture is low and is situated at the apertural face. The coiling is plectogyroid but the total angular distortion is small and some directional specimen appears to be nearly planispiral.

The spirotheca is moderately thick even in the outermost wall, consisting of a tectum, which is very thin, less dense structureless clear band which corresponds to diaphanotheca of fusulinellid wall and lower tectorium which is also referred to that of fusulinid.

The septa are nearly plane and are very long, reaching nearly to the chamber floors. The tunnel is very low. Mature shells show three and one-half to five volutions and are 0.3 to 0.6 mm in diameter.

Remarks:- The septal length of this new species are the largest among the species of *Paraplectogyra*. *Paraplectogyra longiseptata* differs from *P. masanae* in its long septa, poor secondary deposits and thin outermost wall. This new form differs from any species of *Plectogyra* in its three layered wall. *Paraplectogyra longiseptata* differs from *P. gigantea*, sp. nov. in its smooth periphery, smaller size and poor secondary deposits.

Vertical axial section of this new species resembles the sagittal section of genus *Endothyra*, but the former differs clearly from the latter in its three layered wall and plectogyroid coiling.

Occurrence:- *Paraplectogyra longiseptata* occurs through the *Plectogyra primaeva* zone, especially in abundance from its upper part. The holotype comes from the locality of MA 11 in the Morikuni-Kodani type section and it is associated with *Paraplectogyra masanae* OKIMURA, *Granuliferella pauciseptata*, sp. nov., *G. plectula* E. J. ZELLER and *Plectogyra primaeva* (RAUSER-CHERNOUSSOVA).

Geologic age:- Probably Osagian?

Paraplectogyra gigantea, sp. nov.

Pl. 34, Fig. 12, and Pl. 35, Figs. 9 and 12.

Description:- The shell is large, subdiscoidal and umbilicate on one side only. The chambers are strongly swollen between the sutures, especially on the poller end and the last volution expanded abruptly.

The shell in the sliced sections is variable in shape because of the large total angular distortion. The proloculus is minute, spherical and averages from 10 to 20 microns in diameter.

The secondary deposits are thick and broad, asymmetrical and they are well developed in the early volutions. The secondary deposits of the last volution are limited on the chamber floors, although in the early volutions they are large and fill up one-fifth to a quater of a chamber. The wall is thick and consists of tectum, diaphanotheca and lower tectorium which corresponds to that of fusulinellid wall. The aperture is very low and is situated at the base of apertural face. The septa which are loosely spaced are long, nearly plane and slightly directed to anterior. The coiling is plectogyroid and shows large total angular distortion. The shells of adult stage consist of three or four volutions. The mature shells have a diameter of 0.3 to 0.5 mm.

Remarks:- *Paraplectogyra gigantea* differs from *P. longiseptata* in its broad and thick secondary deposits and its larger total angular distortion, the chambers of the former are larger in its last volution and smaller in its early volution than those of the latter.

It differs also from *Paraplectogyra masanae* in its strong umbilicate on one side only. This new form differs from *Paraplectogyra masanae* and *P. longiseptata* in its long, thick and nearly plane septa. The remarkable, irregular secondary deposits are important character for the purpose of distinguishing it from other species of *Paraplectogyra.*

Paraplectogyra gigantea is never similar to any species of *Plectogyra*, because of the existing of diaphanotheca which is shown as clear band.

Occurrence:- This new species is abundant in the upper part of *Endothyra spiroides* zone. The holotype is obtained from the locality of MA 05 in the Morikuni-Kodani type section and is associated with abundant *Endothyra spiroides* E. J. ZELLER.

Geologic age:- Probably Meramecian.

Genus *Granuliferella* E. J. ZELLER, 1957

Granuliferella pauciseptata, sp. nov.

Pl. 32, Figs. 12, 13 and 17.

Description:- The shell is discoidal and umbilicate on one side only. The chambers are strongly swollen between the sutures and the swollen shape is more rhythmical than *Plectogyra*'s. The septa are long and anteriorly directed and almost attain to the chamber height, but septal counts are a few, four to five in the outermost volution.

The aperture is low and is situated on the base of the apertural face. The secondary deposits on the chamber floors are slight. The wall consists of a single layer and the wall of the last volution is thicker in proportion to the thickness of that of juvenile

stage, but some forms which have the thick dense layer in the early volutions are not measured with its thickness, for both layers are of the same structureless single layer. The proloculus is minute. The shell of adult stage consists of two or three volutions.

The diameter of mature shells averages from 0.2 to 0.3 mm. The coiling is plectogyroid and shows a large total angular distortion.

Remarks:- *Granuliferella pauciseptata* differs from any other species of *Granuliferella* in its small shell and slightly dense layer and its longer, thiner and less numerous septa.

Occurrence:- *Granuliferella pauciseptata* is associated with *Granuliferella plectula* E. J. ZELLER, *Plectogyra communis* (RAUSER-CHERNOUSSOVA) and *P. primaeva* (RAUSER-CHERNOUSSOVA), and occurs only in the lower two zones of endothyroid Foraminifera.

The holotype comes from the locality of MA 11 which is situated above 65 meters from the base of Morikuni-Kodani type section.

Geologic age:- Probably Osagian?

Genus *Plectogyra* E. J. ZELLER, 1950

Plectogyra communis (RAUSER-CHERNOUSSOVA)

Pl. 33, Figs. 9 and 10.

1940. *Endothyra primaeva* N.E. CHERNYSHEVA: *Soc. Nat. Moscou, Bull., Moscou, n. s., tome 48 (sect. geol., tome 18), no. 5-6*, p. 124, Pls. 1 and 2.

Description:- The shell is small, discoidal and highly umbilicate on one side only. The chambers are strongly swollen between the sutures and are moderately expansible. The wall is of double layers with a thin and dark layer on the outside and a thicker and lighter one on the inside. The septa are the same structure as the wall and become rather thickening which is noticeable at the end of septa. The proloculus is of moderate size and averages from 20 to 30 microns in diameter.

Secondary deposits are observed in both vertical and horizontal axial sections and their well development are on the chamber floors of the last volution which occupies almost one-third of the chambers. Secondary deposits are single and show slightly irregular forms. These features are probably ascribed to the resorption in the early volutions of shell. The aperture is rather high and narrow and situated at the base of apertural face. The coiling is plectogyroid and shows large total angular distortion. Adult shells consist of three to four volutions. The diameter of mature shells is 0.5 to 0.6 mm.

Remarks:- The present samples closely resemble *Endothyra communis* (RAUSER-CHERNOUSSOVA) from the Lower Tournaisian of Makarovski district, South Ural, Russia, though the latter secondary deposits show a form of two ridges bordering the aperture for the former ones. This difference, however, may be due to the change by the resorption.

From the principle of E. J. ZELLER's classification, this species is emended the genus

Plectogyra because of the plectogyroid coiling and two layered wall as stated above.

This species differs from any other species of *Plectogyra* in its small thickenings which are noticeable at the end of septa.

Occurrence:- The present samples come from the lowest fossil zone of the Atetsu plateau and their localities are B. L. B, MA 07, MA 08, MA 09 and NB 01. They are associated with *Plectogyra primaeva* (RAUSER-CHERNOUSSOVA), *Granuliferella plectula* E. J. ZELLER and *G. pauciseptata* OKIMURA in the upper part of *Plectogyra communis* zone.

Geologic age:- *Plectogyra communis* (RAUSER-CHERNOUSSOVA) has been reported from the Lower Tournaisian of South Ural, Russia, but that of the Atetsu district may be of the later age as discussed in chapter 5: Probably Tournaisian.

Plectogyra primaeva (RAUSER-CHERNOUSSOVA)

Pl. 33, Figs. 5, 6 and 7.

1940. *Endothyra primaeva* N. E. CHERNYSHEVA: *Soc. Nat. Moscou, Bull., Moscou. n. s., tome 48 (sect. geol., tome 18), no. 5-6*, p. 124, Pls. 1 and 2.

Description:- The shell is minute, discoidal and umbilicate on one side only. The chambers of the last volution are strongly swollen between the sutures, but that of the early volutions are not almost rhythmical. The proloculus is minute and its size is more than 30 microns in diameter. Secondary deposits are almost lacking, but in the last volution of some specimen are rather distinctive on the chamber floors. The aperture is rather high and situated at the base of the apertural face. The wall consists of both layers of dark thin and light thick. The septa which are of the same structure as the wall, are comparatively short and slightly curved in the direction of anterior.

The coiling is plectogyroid and the total angular distortion is small. Through examining of the horizontal axial section, the septal count in the last volution does not exceed 7. Mature shells have two to three volutions and are 0.3 to 0.4 mm in diameter.

Remarks:- *Plectogyra primaeva* (RAUSER-CHERNOUSSOVA) described from the Lower Tournaisian of Makarovski district, South Ural, may be undoubtedly referred to the rich present specimens from the second fossil zone in the Atetsu plateau, though the septa of the latter are slightly long.

This species resembles closely to *Granuliferella plectula* E. J. ZELLER, but the former wall is of two layers against the single layered one of the latter. *Plectogyra primaeva* (RAUSER-CHERNOUSSOVA) differs from any other species of *Plectogyra* in its small shell and in its laking of the secondary deposits.

Occurrence:- The rich present specimens are collected from the second fossil zone of their localities which are listed in chapter 2 and associated with *Paraplectogyra masanae* OKIMURA, *P. longiseptata* OKIMURA, *Granuliferella plectula* E. J. ZELLER and *G. Pauciseptata* OKIMURA.

Geologic age:- Probably Tournaisian.

Plectogyra aff. *omphalota* (RAUSER-CHERNOUSSOVA & REITLINGER)

Pl. 34, Fig. 1.

1936. *Endothyra omphalota* RAUSER-CHERNAUSSOVA & REITLINGER: *Akad. Nauk. U. S. S. R., Polanaia Komissia, Trudy, Leningrad, fasc. 28*, p. 211.

1940. *Endothyra omphalota* RAUSER-CHERNOUSSOVA & REITEINGER: *Neftianyi geologo-razvedochnyi Inst., Trudy, Leningrad, fasc.* 7, p. 42, Pls. 7 and 8.

Description:- The shell is medium, discoidal and slightly umbilicate on one side only. The chambers are swollen between the sutures, but some specimen show slightly inflated chambers. The wall is not ascertained to be minutely granular and poorly preserved, though it is probably of double layers. The septa are long in proportion to the height of chamber and sometimes are slightly tapering toward the end. The septa through the shell are usually curved a little in the direction of anterior, and formed almost a right angle with the wall of the shell.

Secondary deposits are slightly developed on the chamber floors, but their forms are less distinctive. The aperture is rather low and situated at the base of apertural face. The coiling differs between the juvenile and adult stages, the former is plectogyroid but the latter is planispiral. Mature shells are of three to four volutions and their diameter averages from 0.5 to 0.8 mm.

Remarks:- As described above the present specimen is referred to *Plectogyra omphalota* (RAUSER-CHERNOUSSOVA & REITLINGER) with some questions; the Atetsu specimens differ slightly from the type specimen of *Plectogyra omphalota* from Samara Bend, U. S. S. R., in the latter large shell, rounded periphery and distinctive dense materials.

Occurrence:- The present specimens are associated with *Endothyra symmetrica* E. J. ZELLER, *E. spiroides* E. J. ZELLER, *E.* aff. *radiata* BRADY var. *tateana* HOWCHIN, *Paraplectogyra gigantea* OKIMURA, *Atetsuella imamurai* OKIMURA and *A. meandera* OKIMURA and *Profusulinella* spp. A and B.

Genus *Endothyra* PHYLLIPS emend. E . J. ZELLER, 1950

Endothyra discoidea (IGO)

Pl. 36, Fig. 8.

1957. *Millerella discoidea* IGO: *Tokyo Univ. Education, Sci. Rep., Sec. C, vol. 5*, pp. 177-179, Pl. 2.

Description:- The shell is minute, completely discoidal and strongly umbilicate on both sides. The chambers may be slightly swollen between the sutures. The septa are comparatively long and show only slight anterior direction. The coiling is plannispiral, but some forms show rather concave on one side. The proloculus is approximately 30 microns in diameter. Secondary deposits or dense materials are observable in the early volutions. The spirotheca consists of two layers, the outer tectum and the inner lower tectorium which may correspond to those of Fusulinidae. The coiling showing moderate expansion is planispiral and slightly closed in the early volutions. Adult

shells are about 0.5mm wide and 0.05 mm. long, and usually counted from five to seven volutions.

Remarks:- The present specimens are probably referred to *Millerella discoidea* IGO from Fukuji of the Hida massif, except for the description of upper tectorium. But the upper tectorium is probably no original layer of wall because of lacking it in the outermost wall. This species therefore must belong to the genus *Endothyra* which have been classified by E. J. ZELLER (1950). This species differs from any other species of *Endothyra* in its umbilicated form through the shell.

Occurrence:- The present specimens were collected from localities of ME05 and coral beds which yield some elements of Onimaru type corals. It is observable with *Endothyra spiroides* E. J. ZELLER, *Paraplectogyra* cf. *masanae* OKIMURA, and rich coral fossils.

Endothyra aff. *radiata* BRADY var. *tateana* HOWCHIN

Pl. 35, Fig. 2.

1888. *Endothyra radiata* BRADY var. *tateana* HOWCHIN: *Roy. Micr. Soc. London, Jour., London, England*, p. 542, Pl. 9.

Description:- The shell is large, discoidal and is nearly circular in peripheral outline. The chambers are narrow, numerous, being countable to about 20 in the last volution and are swollen between the sutures. The spirotheca consists of double layers which correspond to the tectum and lower tectorium of Fusulinidae. The septa may be the same structure as the spirotheca, showing of often considerable irregularity in arrangement on exterior surface and comparatively anterior direction. The coiling is planispiral and it is moderately expansible except for the last volution rather inflated. The proloculus is moderate size, averaging 30 to 40 microns in diameter. The dense material in the middle stage is seen and the wall thickness of the early and the later stages is thin in proportin to that of the middle stage. Mature shells show 5 volutions and are measured from 0.8 to 1.0 mm in diameter.

Remarks:- The present specimen is referred to the type specimen of *Endothyra radiata* BRADY var. *tateana* HOWCHIN from Southwestern Northumberland, England, with a little question that the latter septal count is 25 to 40.

Occurrence:- The present specimen comes from the *Atetsuella meandera* zone (locality of KA16) and is associated with *Endothyra symmetrica* E. J. ZELLER, *E. spiroides* E. J. ZELLER, *Atetsuella imamurai* OKIMURA, *A. meandera* OKIMURA and *Profusulinella* spp. A. and B.

Endothyra spiroides E. J. ZELLER

Pl. 32, Fig. 1.

1957. *Endothyra spiroides* E. J. ZELLER: *Jour. Paleont. vol. 31*, p. 702, pls. 75, 76 and 80.

Description:- The shell is discoidal, involute and the outline of the last volution is nearly rounded periphery. The wall consists of two layers with dark and thin tectum of outside and thick lower tectorium which correspond to those of fusulinid. The septa are the same in structure as wall, are of medium length and they show moderate anterior direction. The proloculus is minute, spherical and averages 18 microns in diameter.

Secondary deposits are only observed in the last volution and its form shows a low and small hamurus one. The coiling is slightly closed in the rate of expansion. The septal count from the first to the fourth and one half volution is 6 or 7, 9, 11, 12, 6, respectively. The diameter of shell averages 0.4 mm, but some specimens reach about 0.5 mm.

Remarks:- *Endothyra spiroide*s E. J. ZELLER was described originally from the *Endothyra spiroides* zone of the Cordilleran region, North America and it is considered to be referable to a certain species of *Parastaffella* from the Middle Viséan of Russia. As stated in the above description, the present specimens are undoubtedly referred to *Endothyra spiroides* E. J. ZELER from the *Endothyra spiroides* zone of the Cordilleran region of North America.

Occurrence:- The present samples were obtained from all sampling localities of *Endothyra spiroides*, *E. symmetrica* and *Atetsuella meandera* zone, but those from the *Atetsuella meandera* zone are only a few in number.

Endothyra symmetrica E. J. ZELLER

Pl. 32, Figs. 3 and 4.

1957. *Endothyra symmetrica* E. J. ZELLER: *Jour. Paleont. vol. 31*, pp. 701-702, pls. 75, 78 and 80.

Description:- The shell is discoidal and is planispiral and involute form in coiling. The chambers are slightly swollen between the sutures. The spirotheca consists of double layers with a thin and dark one on the outside, and a lighter and thicker one on the inside. The septa of the same structure as spirotheca are about as high as half of the chamber, and slightly directed to the anterior. The proloculus is spherical and ranges 27 to 32 microns in diameter.

Secondary deposits are only recognized in the last chamber, though in some specimens they are very slightly developed on the chamber floors of the last one half volution. The septal count from the first to the fourth volution is 6 or 7, 8 or 9, 10, 11, respectively. The coiling is moderately expansible.

The diameter of shell reaches approximately 0.4 to 0.5 mm.

Remarks:- The present specimens are identical with *Endothyra symmetrica* E. J. ZELLER and are similar to ZELLER's original specimens from the Cordilleran region, North America.

Occurrence:- The present specimens are very abundantly collected from the locality of MA01, accompanying with *Endothyra spiroides* E. J. ZELLER, *E.* spp. B and C,

Paraplectogyra spp. B and C, and *Plectogyra* cf. *omphalota* (RAUSER-CHERNOUSSOVA & REITLINGER). The fact that the present species occurs throughout the *Atetsuella meandera* zone can not be overlooked for solving the correlation problem of the Mississippian Nagoe formation.

Postscript

Although *Hexaphyllia* sp. and all indefinable species of endothyroid and fusulinid Foraminifera are figured in the accompanying plates, the writer wishes to postpone their descriptions untill more sufficient materials are obtaind.

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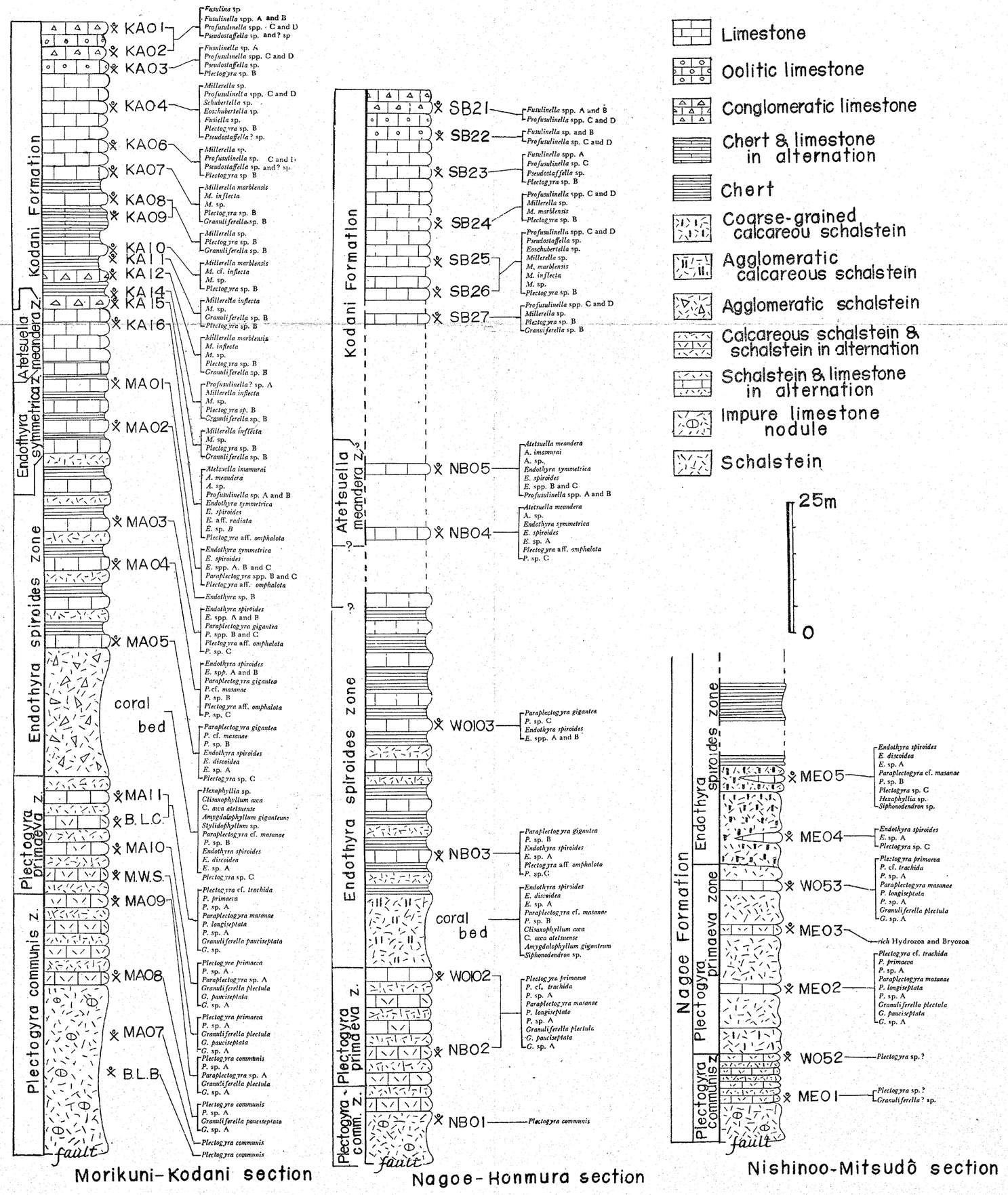
* Unfortunately, the writer had no opportunity of reading these original publications on the stratigraphical occurrences of Russian endothyroid Foraminifera, but regarding the outlines of them, he referred to the translated abstracts in ZENTRALBLATT (FÜR GEOLOGIE UND PALÄONTOLOGIE, Teil 2, Heft 1/2, September 1957) and РЕФЕРАТИВНЫ ЖУРНАЛ (ГЕОЛОГИЯ РЕФЕРАТЫ), No. 6, 1956 and No.8, 9, 11 and 12, 1957.



PL. 30 Three columnar Sections of the Carboniferous rocks of the Atetsu plateau, showing the stratigraphic distribution of foraminifers.
(Each bed of alternation facies is idealized in its thickness.)

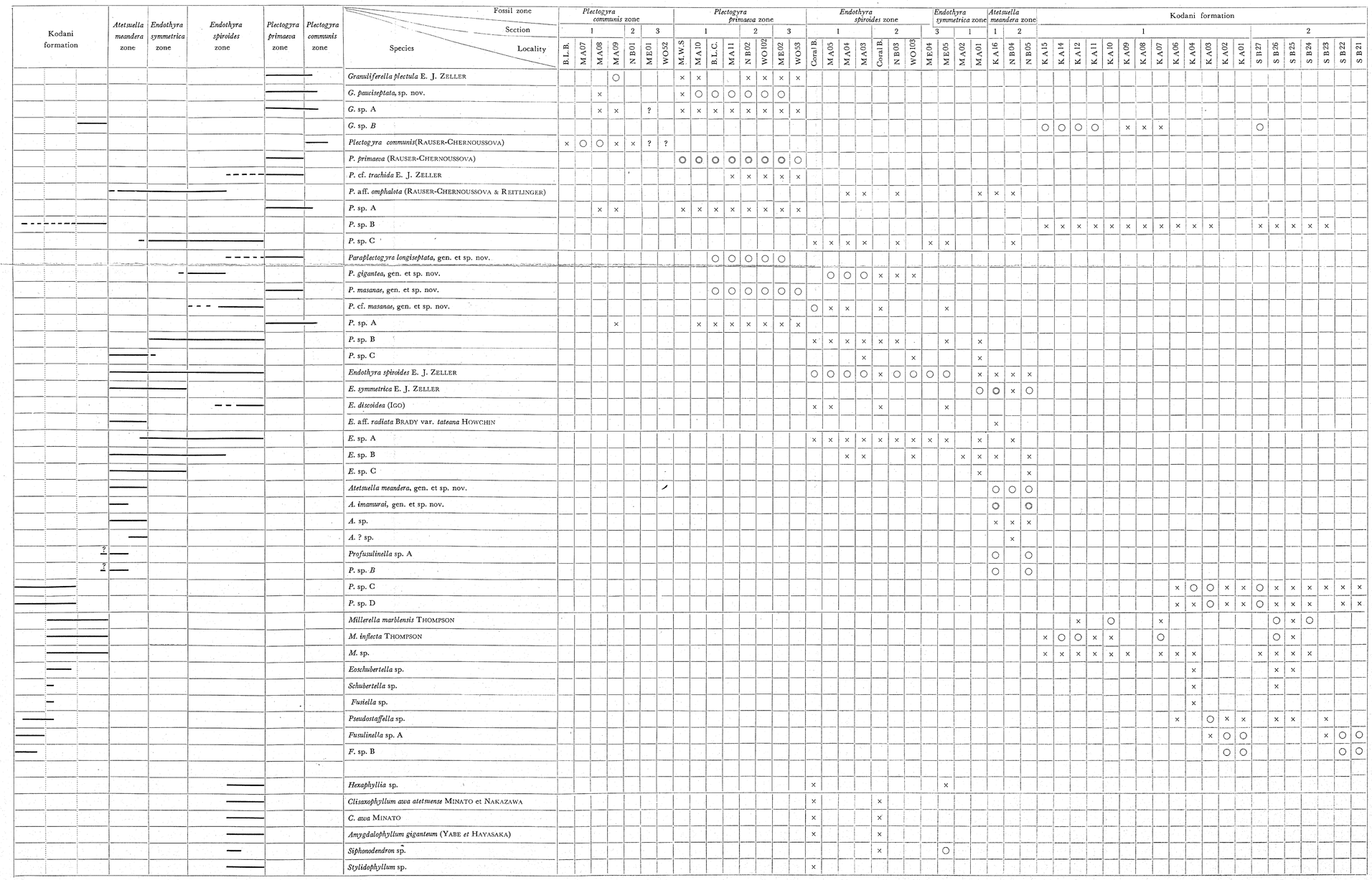


PLATE 30. DISTRIBUTION OF SPECIES COLLECTED FROM THE LOCALITIES BELONGING TO THE THREE SECTIONS OF 1. MORIKUNI-KODANI, 2. NAGOE-HONMURA AND 3. NISHINOO-MITSUDÔ.

○ *abundant* ○ *common* × *rare*

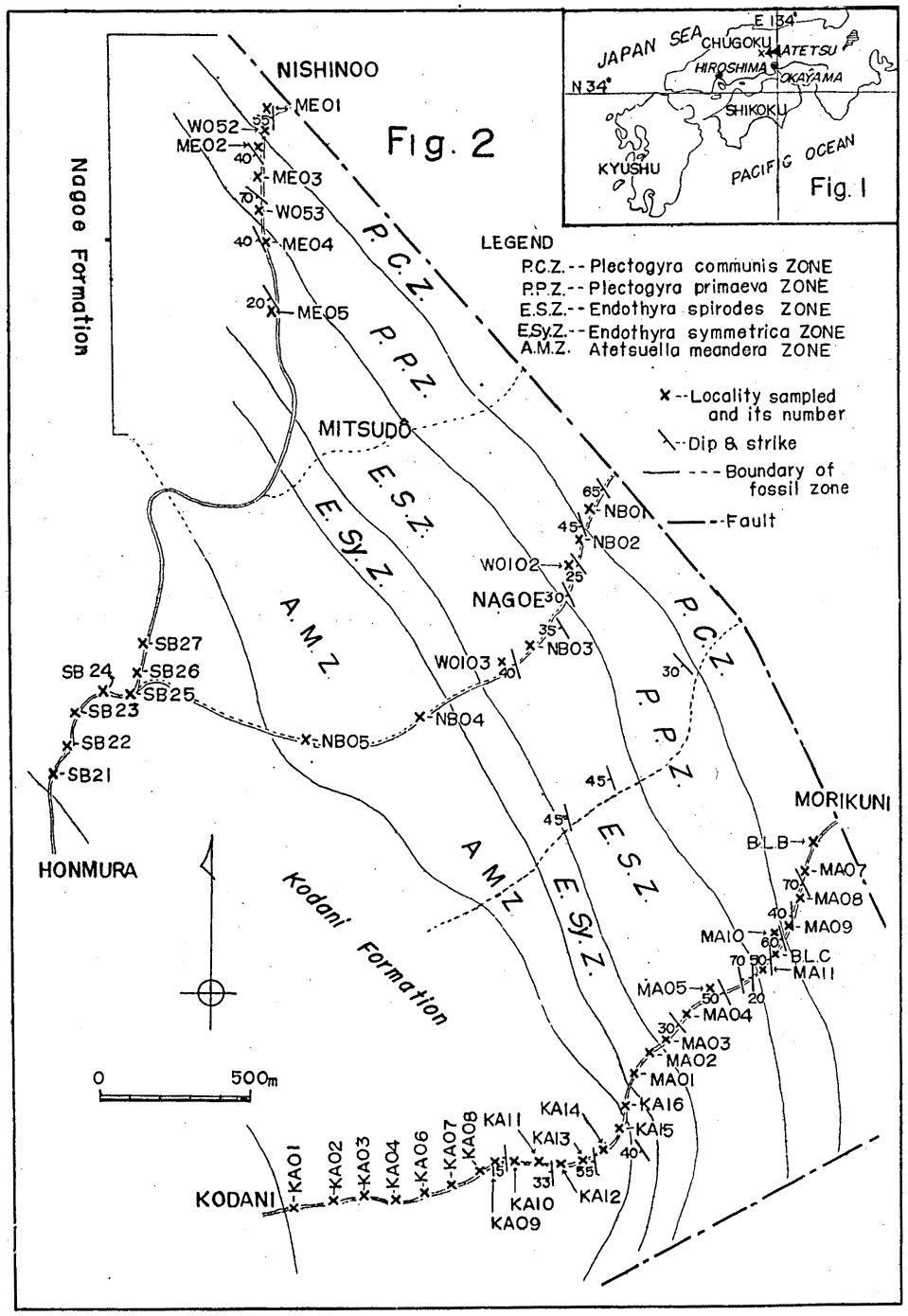


Fig. 1 Location map.
Fig. 2 Sample lacality map.

Yuji OKIMURA

Biostratigraphical and Paleontological Studies on the Endothyroid Foraminifera from the Atetsu Limestone Plateau, Okayama Prefecture, Japan

PLATES 32–36

EXPLANATION OF PLATE 32

ALL FIGURES × 100

FIG. 1- *Endothyra spiroides* E. J. ZELLER. Axial section, coral bed, type section.

2,6 and 8- *Endothyra* sp. All axial section. 2. coral bed, type section. 6. MA01, type section. 8. MA05, type section.

3 and 4-*Endothyra symmetrica* E. J. ZELLER. Both axial section, MA01, type section.

5- *Endothyra*? sp. Axial section, coral bed, type section.

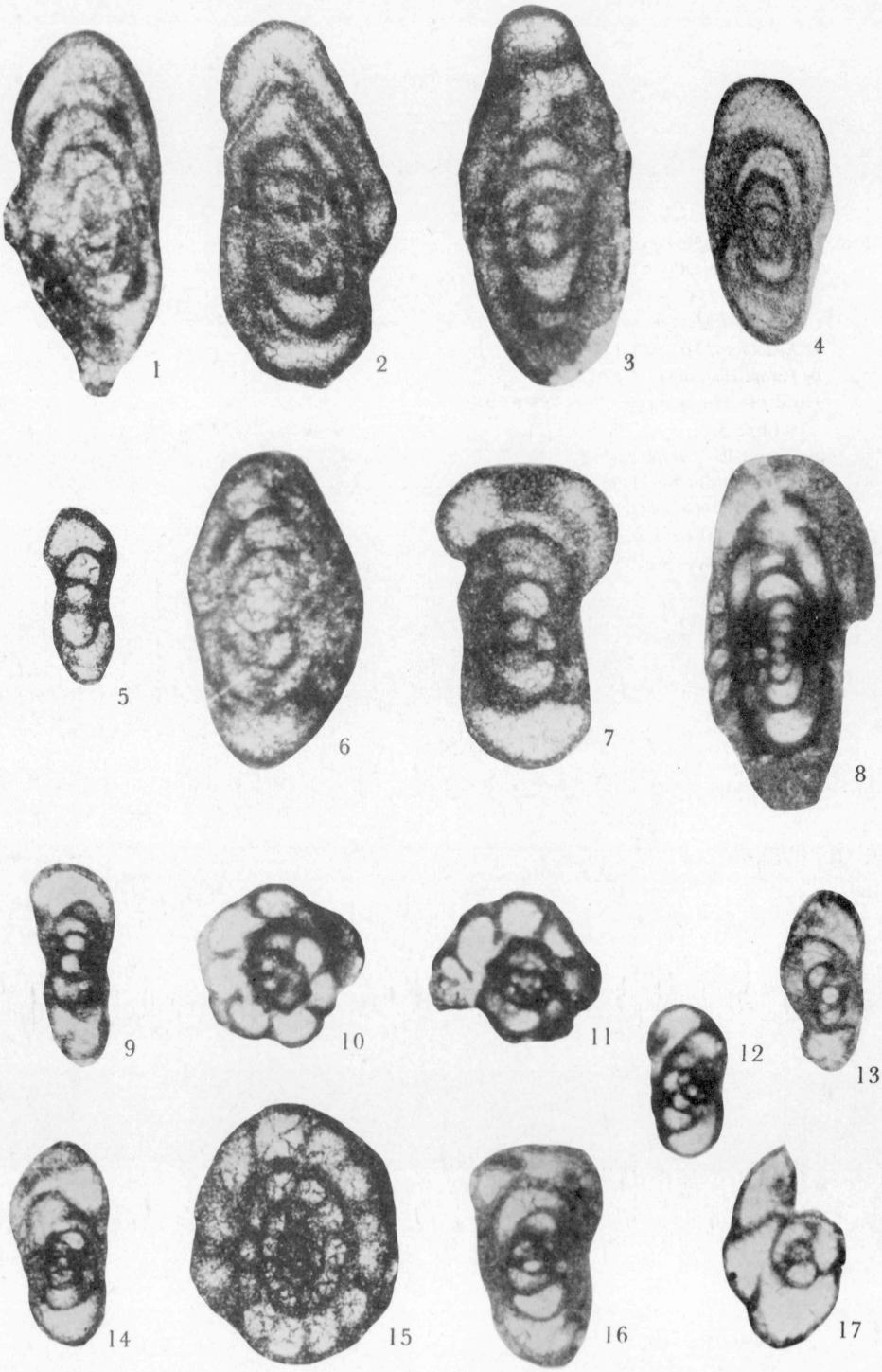
7- *Paraplectogyra* sp. Vertical axial section, coral bed, type section.

9 and 14- *Plectogyra* sp. Both vertical axial section. 9. KA10, type section. 14. KA14, type section.

10, 11 and 16- *Paraplectogyra masanae* n. sp. 10 and 11. horizontal axial section, and 16. vertical axial section, Ma11, type section: 11 is the holotype.

12, 13 and 17- *Granuliferella pauciseptata* n. sp. 12 and 13. Vertical axial section, and 17. horizontal axial section, MA09, type section: 17 is the holotype.

15- *Millerella* sp. Sagittal section, KA14, type section.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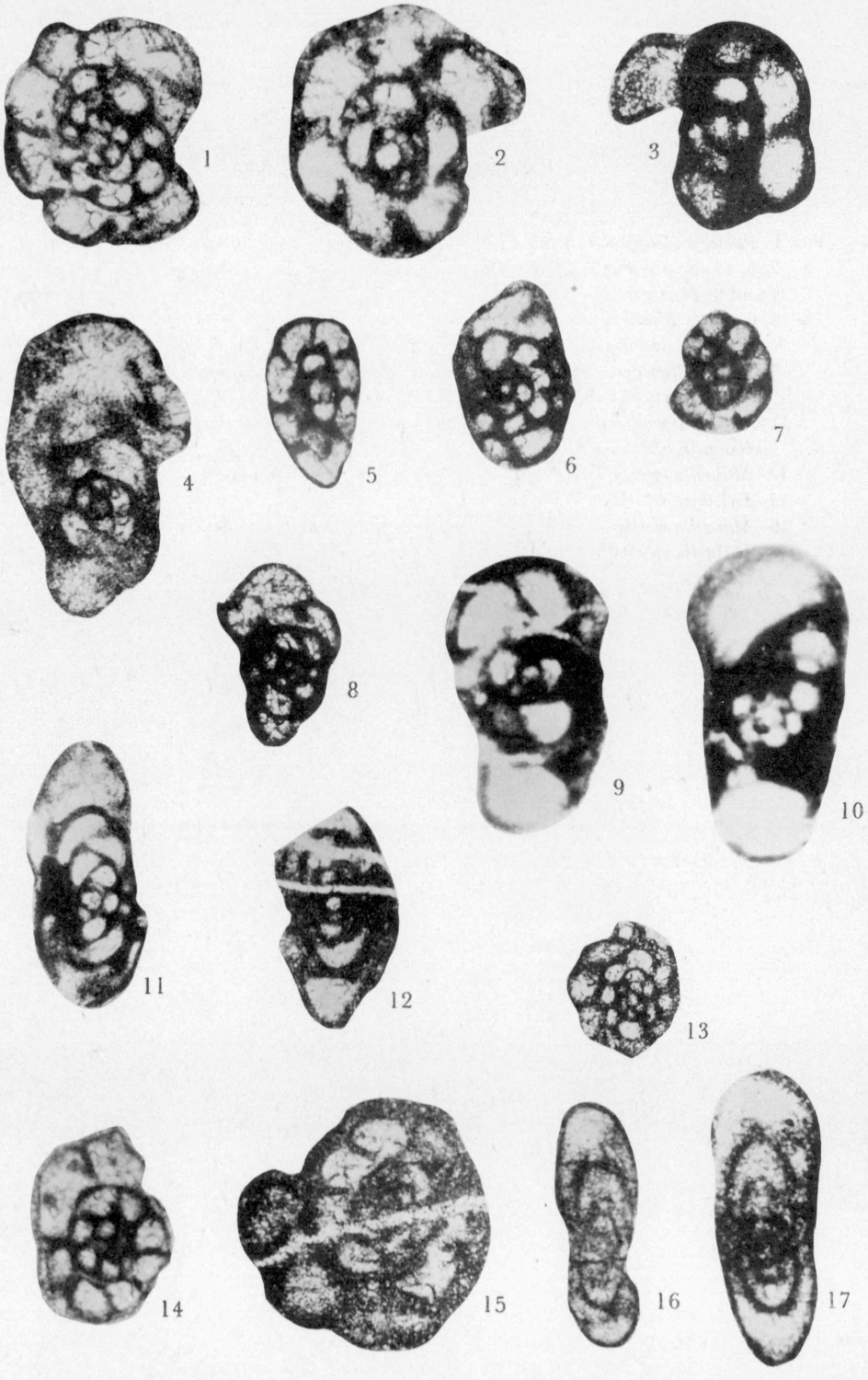
EXPLANATION OF PLATE 33

ALL FIGURES × 100

FIG. 1– *Plectogyra longiseptata* sp. nov. Holotype, horizontal axial section, MA11, type section.
2, 3, 14 and 15– *Plectogyra* sp. All horizontal axial section. 2, 3 and 14. MA12, type section.
4 and 8– *Plectogyra* sp. Both vertical axial section. 4. KA15, and 8 KA14, type section.
5, 6 and 7– *Plectogyra primaeva* (RAUSER-CHERNOUSSOVA). All horizontal axial section. 5 and 7. MA10, and 6. MA11, type section.
9 and 10– *Plectogyra communis* (RAUSER-CHERNOUSSOVA). 9. nearly horizontal axial section, and 10. vertical axial section, MA08, type section.
11 and 13– *Granuliferella* sp. 11. vertical axial section, KA12, type section. 13. horizontal axial section. KA07, type section.
12– *Millerella inflecta* THOMPSON. Axial section, KA15, type section.
15– *Endothyra* sp. Sagittal section, KA12, type section.
16– *Millerella marblensis* THOMPSON. Axial section, SB26, Nagoe-Honmura section.
17– *Millerella* sp. Parallel section, KA15, type section.



EXPLANATION OF PLATE 34

ALL FIGURES × 100, unless otherwise indicated

FIG. 1– *Plectogyra* aff. *omphalota* (RAUSER-CHERNOUSSOVA and REITLINGER). Horizontal axial section, MA04, type section.

2 and 9– *Atetsuella imamurai*, gen. et sp. nov. 2. vertical axial section, KA16, type section. 9. horizontal axial section, NB05, Nagoe-Honmura section: 2 is the genotype and holotype.

3– *Atetsuella* sp. Vertical axial section, NB04, Nagoe-Honmura section.

4– *Paraplectogyra longiseptata*, gen. et sp. nov. Vertical axial section, MA11, type section.

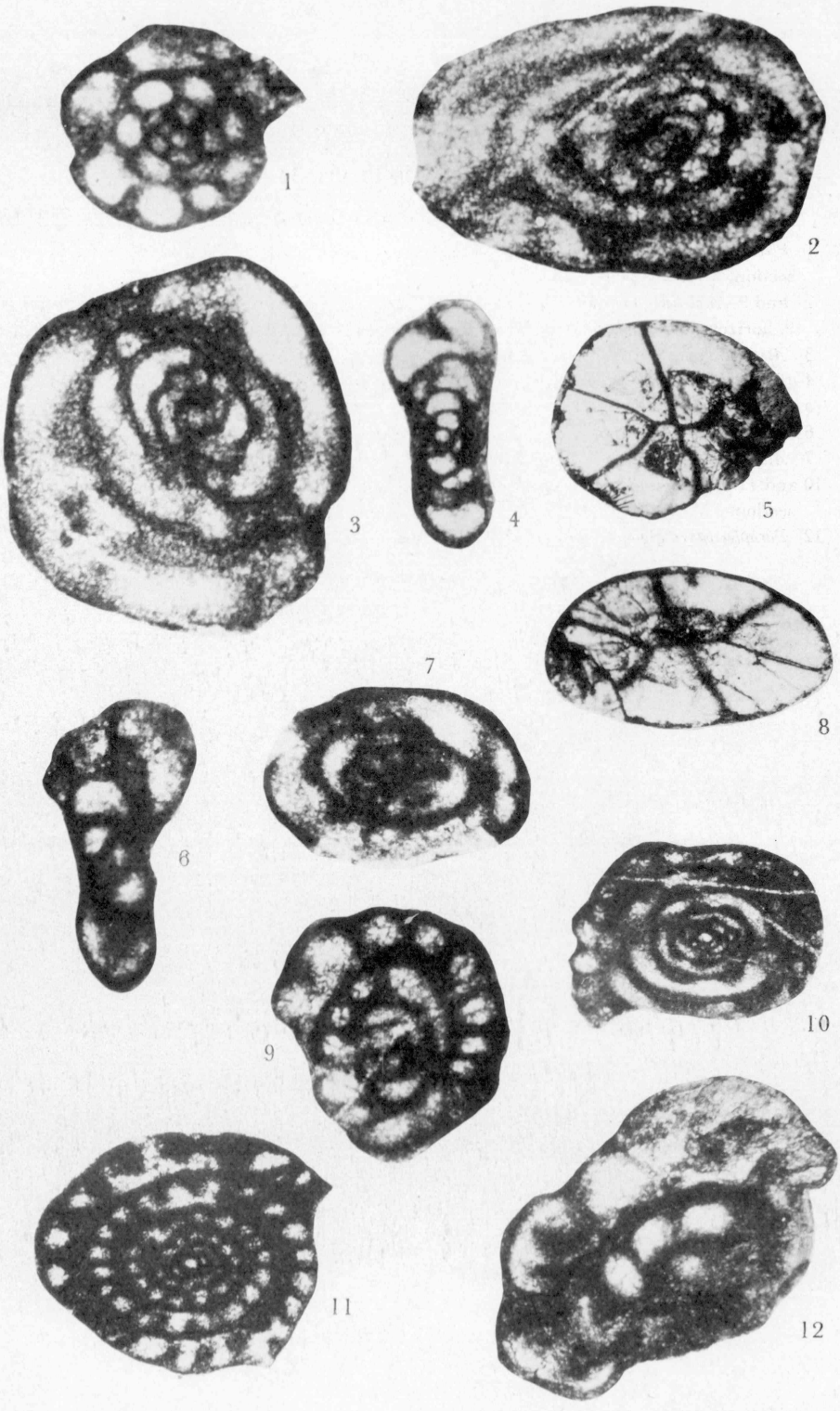
5 and 8– *Hexaphyllia* sp. Transverse section, coral bed, Nishinoo-Mitsudô section; × 50.

6– *Paraplectogyra* cf. *masanae* gen. et sp. nov. Vertical axial section, MA05, type section.

7– *Atetsuella meandera*, gen. et sp. nov. Vertical axial section, NB05, Nagoe-Honmura section.

10 and 11– *Profusulinella* sp. 10. axial section, and 11. sagittal section, NB05, Nagoe-Honmura section.

12– *Paraplectogyra gigantea*, gen. et sp. nov. Oblique section, MA04, type section.



EXPLANATION OF PLATE 35

ALL FIGURES × 100, unless otherwise indicated

FIG. 1 and 3– *Profusulinella* sp. Axial section, NB05, Nagoe-Honmuta section.

2– *Endothyra* aff. *radiata* BRADY var. *tateana* HOWCHIN. Sagittal section, KA16, type section.

4 and 10– *Atetsuella meandera*, gen. et sp. nov. 4. oblique section, KA16, type section. 10. horizontal axial section, NB05, Nagoe-Honmura section.

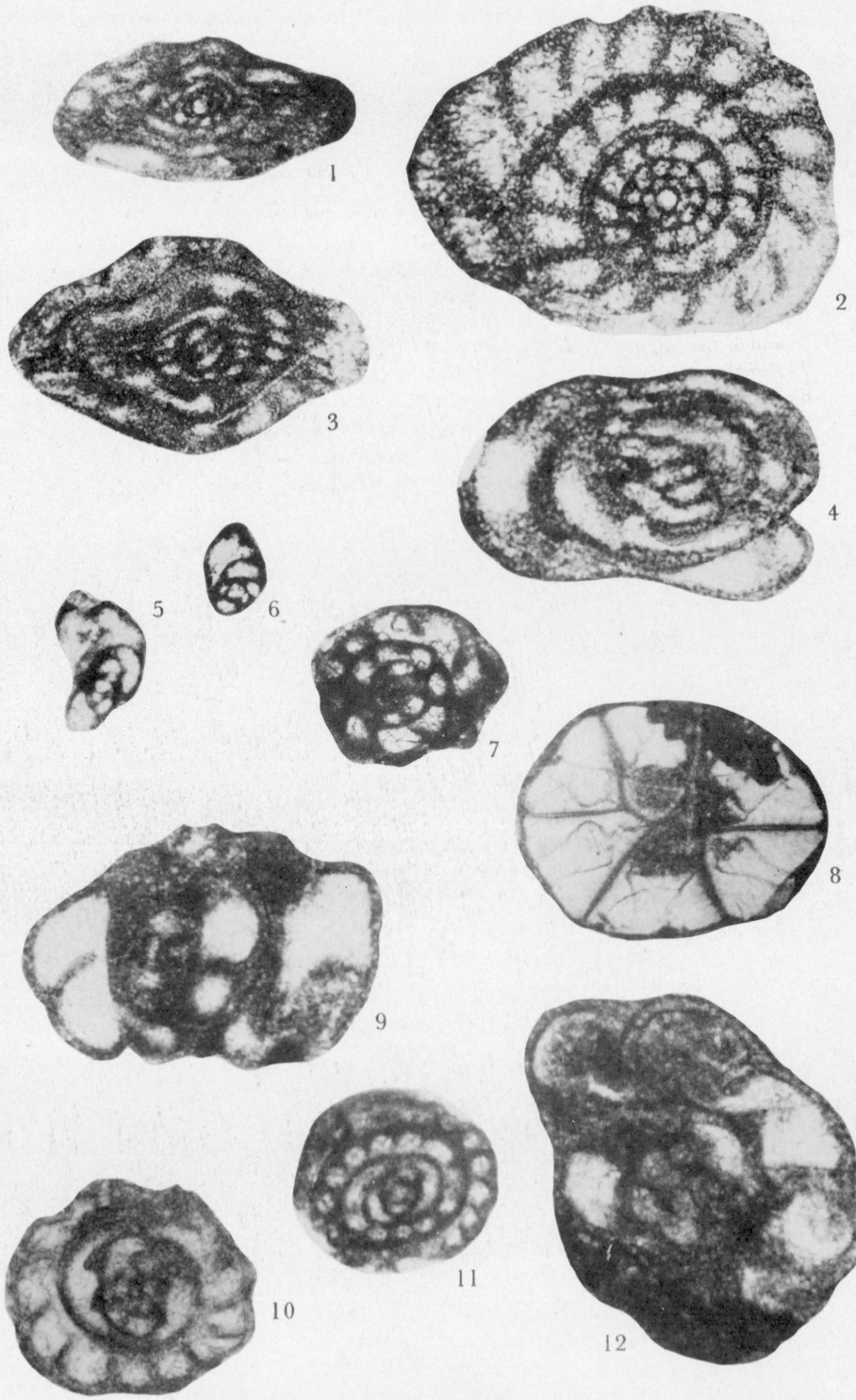
5 and 6– *Granuliferella* sp. Both vertical axial section, KA14, type section.

7– *Paraplectogyra longiseptata*, gen. et sp. nov. Horizontal axial section, MA11, type sectino.

8– *Hexaphyllia* sp. Transverse section, ME05, Nishinoo-Mitsudô section.

9 and 12– *Paraplectogyra gigantea*, gen. et sp. nov. 9. oblique section, MA03, type section. 12. holotype, horizontal axial section, MA04, type section.

11– *Atetsuella*? sp. Horizontal axial section, NB04, Nagoe-Honmura section.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EXPLANATION OF PLATE 36

ALL FIGURES × 100, unless otherwise indicated

FIG. 1 and 7– *Atetsuella meandera*, gen. et sp. nov. 1. vertical axial section, and 7. transverse axial section, NB05, Nagoe-Honmura section: 1 is the holotype.

2– *Granuliferella plectula* E. J. ZELLER. Horizontal axial section, MA09, type section.

3 and 10– *Profusulinella* sp. Axial section, KA16, type section; × 50.

4,5 and 11– *Atetsuella imamurai*, gen. et sp. nov. 4 and 11. transverse axial section, NB05, Nagoe-Honmura section. 5. transverse axial section, KA16, type section.

6– *Atetsuella imamurai* gen. et sp. nov. Enlarged photograph showing wall structure in vertical axial section, KA16, type section; × 250.

8– *Endothyra discoidea*, (IGO). Axial section, coral bed, type section.

9– *Profusulinella* sp. Oblique section, KA16, type section.

12– *Atetsuella*? sp. Horizontal axial section, NB04, Nagoe-Honmura section.

13– *Paraplectogyra longiseptata*, gen. et sp. nov. Oblique section, MA11, type section.