Miocene Microbiostratigraphy of West Honshû, Japan

By

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with 2 Text-figures, 34 Tables, and 7 Plates

ABSTRACT Stratigraphical and paleontological studies of geographically isolated Neogene areas in West Honshû, Japan, has lead to the establishment of two large provinces, each of which is subdivided into subprovinces from their respective characteristics. Detail field and laboratory work on each of the areas revealed that the frequency and faunal displacement of the smaller Foraminifera yielded from the respective characteristic lithological units are widespread and exhibit a sequence expressible in the form of stages, zones and faunules, which are introduced and described in this article.

The recognized time-rock units as well as lithologic units and their respective smaller foraminiferal faunas are described, discussed and applied to the Neogene deposits of West Honshû, and are compared with known similar domestic units and the results are brought into comparison with the Tertiary sequence of Northwest America and the Indo-Pacific region with which correlation is attempted. Although differences in the respective smaller Foraminifara of the three remote regions just mentioned exist, there are found remarkable coincidences in their sequence, characteristic features reflected by them, and noteworthy similarity in the association or assemblage elements of the respective regions.

Periods of volcanicity as related with the lithological units and differentiation during the faunal sequence and the whole as associated with the growth of the respective sedimentary basins studied by the writer in West Honshû, reveal that there exists intimate relationship with the establishment and significance of the respective time-rock units introduced in this work.

The new species of smaller Foraminifera obtained during the past few years are described and illustrated in this work, and with regard to previously known forms records of their occurrences from the respective lithological and time-rock units are given in table form.

CONTENTS

LIST OF ILLUSTRATIONS

Y. TAI

INTRODUCTION

It is generally accepted by Japanese geologists and paleontologists that the early Neogene formations are a product of the marine transgression in the Japanese Islands during the early part of the "Mizuho Period" first established by YABE (1924, 1935). The marine sedimentary provinces introduced by the Mizuho Sea in West Japan have been divided into four by IKEBE (1957), namely, the San'in, Setouchi, Hokuriku, and Nankai Provinces. Of these four, the San'in Province includes the areas in the Chûgoku District along the Japan Sea coast and the Setouchi Province the Miocene formations distributed in basins scattered along the southern foreland of the Chûgoku Mountain Range which forms the southern boundary of the San'in Province. The Neogene deposits of both provinces just mentioned have since 1949 been studied litho- and volcanostratigraphically, under the leadership of Professor S. IMAMURA by the members of the San'in Neogene Research Group of the Institute of Geology and Mineralogy of Hiroshima University. As some results, it has became clear that the San'in Province includes the larger part of the western part of the so-called "Green-Tuff" regions along the Japan Sea coast and has a marginal character of the geosynclinal basin, and that the western Setouchi Province was formed in a common sedimentary basin in the early stage of development of the San'in Province.

In this report, the Neogene smaller Foraminifera from the San'in and Setouchi Provinces are dealt with biostratigraphically and paleontologically by the writer, and included are remarks on those from other provinces in West Honshû, Japan. The majority of the foraminiferal samples reported here were collected by the writer during his field work as a member of the San'in Research Group.

As the first step, some Miocene smaller Foraminifera were studied by the writer, during the course of paleontological research carried on in the Institute of Geology and Paleontology, Tohoku University, during years 1953–1955 under the instruction of Professor K. ASANO. Some results of this investigation have been reported by the writer (1953, 1954, 1955). Until these publications, little has been known of the Neogene smaller Foraminifera from the Chûgoku District, although are a few publications on the larger Foraminifera (YABE, 1918, 1934, 1935; HANZAWA, 1932, 1935).

Subsequent works in the field and laboratory have provided more additional background, particularly for a microbiostratigraphic study. The writer established six microbiostratigraphic units in the San'in and Setouchi Neogene deposits and outlined these in Japanese in some reports during 1956–1958. The present paper is a summary presentation of the data on which the microbiostratigraphic conclusions are based. Most of the work was done in the Hiroshima University, but the descriptions of the new species of the smaller Foraminifera was carried out in the Tohoku University.

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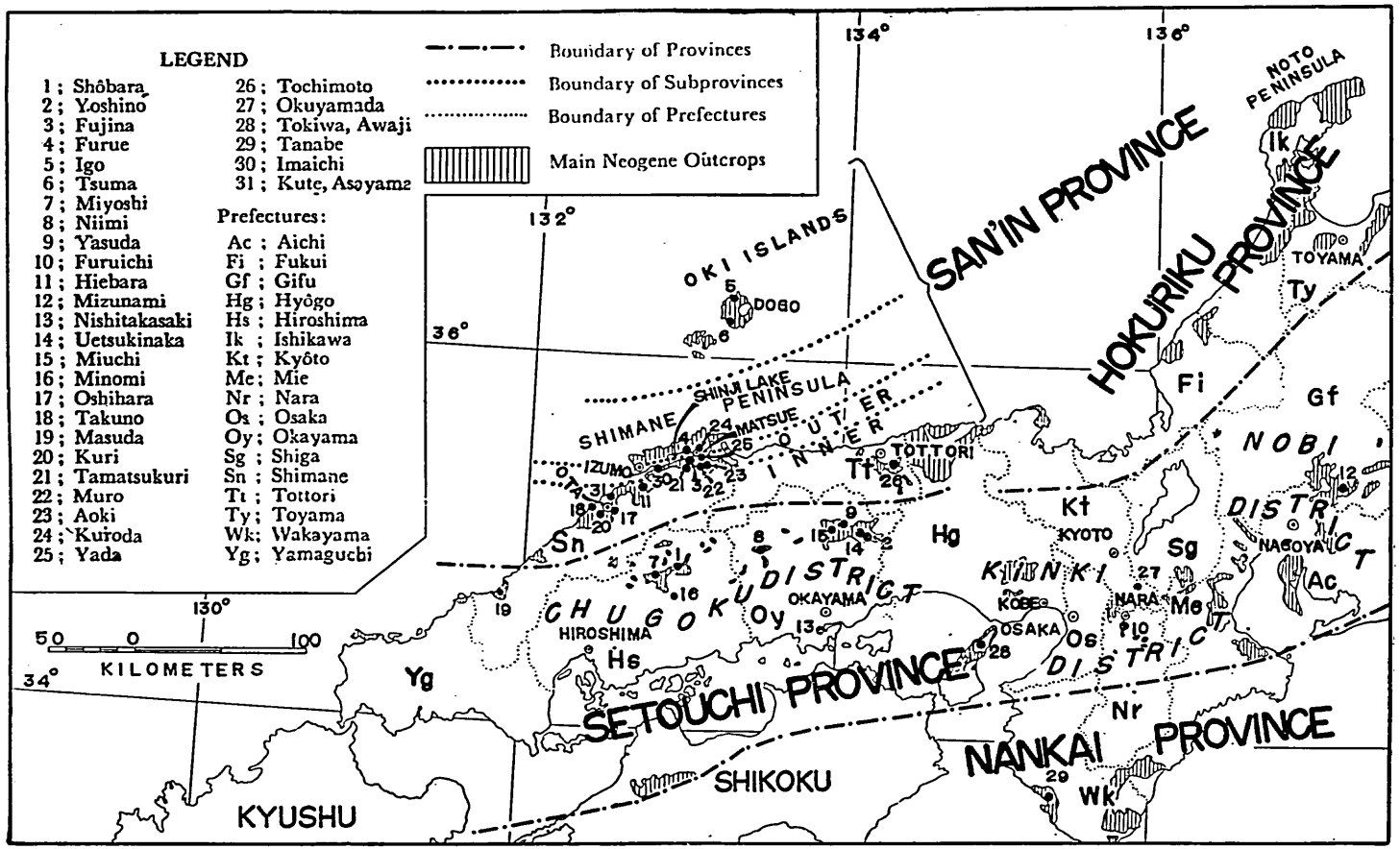


FIG. 1 Index map showing locations having relations with the obtained Neogene foraminiferal data and the distribution of the outcropping Neogene deposits, in the West Honshû, Japan. (Y. TAI, 1959)

CHAPTER I

General Stratigraphy of the Miocene Deposits of West Honshû

From the litho-, volcano-, and biostratigraphic sequences and crustal movements during the Miocene age, the following four sedimentary provinces may be recognized in the West Honshû Miocene, as already classified by N. Ikebe (1957), namely, the San'in-, Setouchi-, Hokuriku-, and Nankai Provinces. Of these, the Setouchi and San'in Provinces are dealt with in the present chapter. From both field and laboratory works, the writer (1957) subdivided the San'in Province into four subprovinces; Inner-, Outer-, Shimane Peninsula-, and Oki Islands Subprovinces. Briefly and later in detail, each province or subprovince is a grouping of the localities having sediments with similar geologic characteristics, forming a belt-like area roughly parallel with the geographic E–W trend of the Chûgoku District. These are shown in Figure 1. The geology of each of these provinces or subprovinces may be summarized as follows.

A. Setouchi Province

The Miocene geology of the Setouchi Province may be summarized for convenience sake from west to east in the following order; Chûgoku-, Kinki-, and Nôbi Districts.

1. *Chûgoku District* (*Western Setouchi Province*). Since 1895, there have been published some valuable reports by several authors*. S. Imamura and the writer (1950) reported on the outline of the Miocene stratigraphy of the northern part of Hiroshima Prefecture, and subsequently S. Imamura (1953) established the lithostratigraphical sequence of the same area.

The Miocene sediments which unconformably cover the basement rocks, mainly of granitic rocks and Paleozoic formations, occupy such basins as the Miyoshi, Shôbara, Saijô, Tôjô, Niimi, and Tsuyama; these are distributed along the southern slope of the Chûgoku Mountain Range. The sediments show a sedimentary cycle and have horizontal or slightly inclined structure. They are situated about from 150 m. to 800 m. above sea-level. These sediments, about 100 m. in thickness, may be divided into two parts in this District, namely, the Shiomachi formation which comprises a lake facies and the Bihoku group of marine origin, the former underlies the latter with parallel unconformity showing a slightly erosion surface.

The lower or Shiomachi formation consists of coarse-grained sediments intercalating thin tuff layers, with lignite seams and such plant fossils as, *Hemitrapa Yokoyamae*, *Liquidambar formosana*, *Metasequoia japonica*, and *Nelumbo uncifera*, while the upper or Bihoku group which yields abundant Foraminifera, is subdivided into two formations, namely, the lower or Yamaga Sandstone and upper or Yatsugi Shale. The former consists mainly of coarse-grained sediments with important marine fossils as, *Miogypsina kotoi*, *Operculina complanata japonica*, *Anadara daitokuensis*, *Batillaria tateiwai*, *B. yamanarii*, *Dosinia suketoensis*, *Siratoria siratoriensis*, and *Turritella kiiensis*, while the upper comprises very fine-grained sediments, yielding some molluscan remains (*Acila submirabilis* and *Propeamussium* cf. *tateiwai*).

The sequence of the Bihoku group is everywhere uniform throughout where it is developed, but the Shiomachi formation is quite variable in its development and distribution in the present district.

From the megafossils mentioned above, the age of these marine formations now is considered to be middle Miocene.

* S. Otsuka (1895), B. Suzuki (1896), T. Ogura (1921), T. Takeyama (1930), H. Yabe and S. Mabuchi (1934), and Y. Otuka (1938).

2. *Kinki District (Central Setouchi Province)*. The Nara basin may be taken up as a representative Miocene locality of the District. The Miocene sediments in this basin were first studied by J. MAKIYAMA (1931), who introduced the name of Fujiwara formation. He considered its age to probably late Miocene. Subsequently, R. SAKAMOTO (1955) made a detail stratigraphical study of the same area and his results of the stratigraphic sequence of the younger Cenozoic deposits in the Nara basin, may be summarized in descending order, as follows;

	Thickness in meters
Sirakawaike formation	100
Bluish muddy or sandy facies in the upper part; grading downwards into conglomeratic facies, with abundant plant fossils as, *Cunninghamia Konishii, Hammamelis parrotioidea, Menyanthes trifoliata*, and *Metasequoia disticha* etc.	
unconformity	
FUJIWARA GROUP ... or MAKIYAMA's "Fujiwara formation" (1931)	300
Toyoda formation	150
Bluish tuffaceous fine-grained sandstone or sandy mudstone, with coarse-grained tuff in the upper part, with abundant smaller Foraminifera and molluscan fossils as, *Cardium ogurai, Crassatellites makiyamai, Cyclocardia ferruginea, C. siogamensis, Macoma optiva, Nuculana (Saccella) kongiensis, Phaxas izumoensis, Yoldia sagittaria, Acteon nipponensis, Calyptraea mammilaris, Nassarius simizui, Protorotella yuantaniensis*, and *P. isizumensis* etc.; this grades downwards into coarse-grained sandstone.	
conformity	
Iwabuchi formation	150
Poor sorted conglomerate consisting mainly of cobbly granitic and dioritic rocks; grading upwards into an alternation of mud and sandstone facies, with some whitish tuff, thin lignite seams, and plant remains as, *Fagus ferruginea, Hemitrapa borealis, Metasequoia* sp., and *Leguminocarpa Sakamotoi* etc.	
unconformity	
BASEMENT ROCKS	
Injection gneiss, gneissose granite, and diorite.	

As to the age of the Fujiwara group, R. SAKAMOTO considered it to be middle Miocene from the molluscan fossils mentioned above.

Details of the smaller Foraminifera from this group have been reported by the writer (1957), and an outline is given in Chapter II.

3. *Nôbi District (Eastern Setouchi Province)*. A area in the vicinity of Mizunami City, Gifu Prefecture, may be taken up as a representative marine Miocene locality of the Nôbi District. The Miocene stratigraphical sequence of the locality may be summarized in descending order, as follows;

	Thickness in meters
MIZUNAMI GROUP	
Oidawara Mudstone member, or "Oidawara formation" (FUJITA and OGOSE, 1951), or a mudstone facies of "Ichihara formation" (WATANABE and IWAHORI, 1952)	50
Gray-whitish, tuffaceous mudstone, with abundant smaller foraminiferan fossils.	
conformity	
Shukunohora Sandstone member, or "Shukunohora formation" (FUJITA and OGOSE, 1951), or "Hiyoshi subformation" (WATANABE and IWAHORI, 1952)	15

Bluish coarse-grained sandstone facies in the upper part; grading downwards into conglomeratic facies, *Miogypsina* and *Operculina*, and abundant molluscan fossils as, *Siratoria*, *Vicaryella*, *Nassarius*, *Cerithium*, *Conus*, *Turbo*, *Babylonia*, *Chlamys*, and *Glycymeris* etc.

~~~~~~~~~~ unconformity ~~~~~~~~~~

Yamanouchi Mudstone member, or "Togari formation" (FUJITA and OGOSE, 1951), or "Yamanouchi formation" (WATANABE and IWAHORI, 1952) 25

Bluish, tuffaceous, and noduliferous mudstone facies; grading downwards into somewhat sandstone facies, which yielded a Desmostylid mammalian fossil from its equivalent horizon, and with abundant molluscan fossils as, *Fulgoraria*, *Venericardia*, *Cultellus*, *Nuculana*, *Acila*, and *Yoldia* etc.

———— conformity ————

Togari Sandstone member, or "Tsukiyoshi formation (Tu_2)" (FUJITA and OGOSE, 1951), or "Togari formation" (WATANABE and IWAHORI, 1952)..... 20

Bluish, tuffaceous, fossiliferous, and noduliferous medium-grained sandstone facies, which yielded *Desmostylus japonicus*, and abundant molluscan fossils as, *Protorotella*, *Katelysia*, *Diplodonta*, *Dosinia*, and *Turritella* etc.

———— conformity ————

Tsukiyoshi Sandstone member, or "Tsukiyoshi formation (Tu_1)" (FUJITA and OGOSE, 1951), or "Tsukiyoshi subformation" (WATANABE and IWAHORI, 1952) 10

Bluish tuffaceous, coarse-grained sandstone, with molluscan fossils as, *Vicarya*, *Vicaryella*, *Dosinia*, *Cardium*, *Ostrea*, *Sanguinolaria*, and *Cyclina* etc.

~~~~~~~~~~ unconformity ~~~~~~~~~~

BASEMENT ROCKS

Nakamura formation which is a lacustrine deposit with coal seams, or granitic rocks.

Details of the smaller Foraminifera from this group have been reported by the writer (1958), and an outline is given in Chapter II.

B. San'in Province

1. *Inner Subprovince.* The Subprovince includes the larger part of the so-called Green Tuff region of Shimane Prefecture, and since 1949 it has been studied in detail under the leadership of Prof. S. IMAMURA by the San'in Neogene Research Group of the Institute of Geology and Mineralogy, Faculty of Science, Hiroshima University. Many valuable results of some phases of the investigation, have been reported by the San'in Group, on the occasion of the respective annual meetings of the Geological Society of Japan, and the meetings of the West Japan Branch of the same society.

According to these results and recent investigations of the San'in Group, the Miocene sediments and volcanics exposed within this Subprovince, may be summarized in descending order, as follows, though it should be mentioned that minor changes occur at different places owing to the difference in the sedimentary conditions.

IZUMO GROUP	Thickness in meters
Matsue formation ..... unexposed	
Fujina formation	750
Fujina Mudstone member or TOMITA and SAKAI's "Lower Huzina bed" (1938 a)	500

Bluish massive and somewhat soft silty sandstone or mudstone, with abundant molluscan

fossils as, *Acila* cf. *submirabilis*, *Clinocardium shiobarense*, *Cultellus izumoensis*, *Dosinia kaneharai*, *D. nomurai*, *Glycymeris gorokuensis*, *Lyropecten kagamianus*, *Macoma optiva*, *Mercenaria chitaniana*, *Patinopecten kimurai matsumoriensis*, *Pecten* (*Patinopecten*) *murayamai*, *Pitar itoi*, *Serripes fujinensis*, *S. pauperculus*, and *Shichiheia japonica*; this grades downwards into medium to coarse-grained brownish sandstone.

——— conformity ———

Kimachi Sandstone member or TOMITA and SAKAI's "Kimati bed" (1938 a) 250

Dark bluish or grayish blue, medium to coarse-grained sandstone with some tuff layers and megafossils as, *Chlamys cosibensis*, *Lyropecten kagamianus*, *Protothaca* aff. *tateiwai*, and shark-'s teeth, in the upper part, and an alternation of coarse-grained sandstone and conglomerate consisting mainly of pebbles of andesitic rocks in the lower part.

~~~~~~~~~~ unconformity ~~~~~~~~~~

IWAMI GROUP

Omori formation, or TOMITA and SAKAI's "Omori bed" (1938 a) .....?

Volcanic materials showing a sequence from the lower or basic to the upper or acidic: i. e., basaltic or gabbroic rocks, two-pyroxene-andesite, dacite, and two-pyroxene-leuco-andesite, intercalating sandstone facies with marine molluscan fossils as, *Chlamys* cf. *meisensis*, *Lyropecten* cf. *kagamianus*, and *Patinopecten* cf. *kimurai* etc., and shale facies with fossil as *Propeamussium* cf. *tateiwai* etc.

~~~~~~~~~~ unconformity ~~~~~~~~~~

Kuri formation, or "Upper Tamatsukuri formation" or "Upper Kawai formation" of the San'in Group till 1956 300-400

Hard black shale with abundant smaller Foraminifera; poor arenaceous fauna in the upper part; abundant calcareous and arenaceous forams in the lower part, intercalating partly greenish tuffs, tuff breccias, and flows of two pyroxene-andesite and plagiorhyolite. It also contains rarely molluscan remains (*Acila* sp., *Nucula* sp., *Propeamussium tateiwai*, and *Yoldia* sp. etc.), and grades downwards into a coarse-grained facies.

——— conformity ———

Kawai formation, or "Lower Tamatsukuri formation" or "Lower Kawai formation" of the San'in Group till 1956 250

Bluish medium to coarse-grained sandstone, with abundant molluscan fossils as, *Anadara valentula*, *Chlamys cosibensis*, *C. heteroglyptus*, *Lyropecten kagamianus*, *Patinopecten kimurai*, *Siratoria siratoriensis*, *Shichiheia japonica*, *Pugilina sazanami*, and *Protorotella* cf. *yuantaniensis* etc.: grading downwards into conglomerate consisting mainly of granitic rocks.

~~~~~~~~~~ unconformity ~~~~~~~~~~

HATA (KIMITANI or KOKUBU) SUBGROUP or "Pre-Kokubu Volcanic Rocks" or "Hata Group" or "Nabeyama Group" or "Kimitani Group" of the San'in Group till 1956 ..... 900+

A volcanic complex consisting mainly of basalt, two-pyroxene-andesite, dacite, rhyolite, and its pyroclastics, with shale facies bearing coal seams and plant fossils in its upper part (*Cinnamomum* sp., *Dryophyllum dewalqui*, *Metasequoia japonica*, *Myrica Naumanni*, *Quercus dryme-ja*, and *Zelkova Ungeri* etc.)

~~~~~~~~~~ unconformity ~~~~~~~~~~

BASEMENT ROCKS

Granitic rocks, diorites, and schists.

As to the microfossils from this Subprovince, the smaller Foraminifera from the Kawai and Kuri formations combined here as from the "Tamatsukuri group" in the area south of Izumo City, Shimane Prefecture, was reported by K. OKAMOTO and Y. TAI (1956). The result may be summarized in Chapter II. The newly obtained

data from the Subprovince are described in Chapter III.

2. *Outer Subprovince.* As shown in Figure 1, this Subprovince occupies the northern side of the Inner Subprovince mentioned above. The geologic condition of the former is similar to that of the latter, but differs from it in the non-development of the Hata subgroup or its equivalent which is the lowermost of the San'in Miocene sequence and in lacking the lower two microbiostratigraphic units described in Chapter IV.

The narrow belt area along the southern borders of Lake Shinji may be taken as the representative area characterizing this Subprovince. According to the study of T. TOMITA and E. SAKAI (1938a) and the recent investigations by the Research Group of the San'in Tertiary, the Miocene stratigraphic sequence of this area may be summarized in descending order, as follows;

	Thickness in meters
IZUMO GROUP	
Matsue formation, or TOMITA and SAKAI's "Upper Huzina bed", "Olivine-trachybasalts", "Tuda bed", "Hornblende-trachybasalts", and "Matue bed" combined (1938a)	
The details are given in the description of the Shimane Peninsula Subprovince.	
——— conformity ———	
Fujina formation	900+
Fujina Mudstone member, or TOMITA and SAKAI's "Lower Huzina bed" (1938a)	700
Bluish massive and somewhat soft silty sandstone or mudstone, with abundant smaller Foraminifera and important megafossils as, *Desmostylus japonicus*, *Cardium shinjiense*, *Cultellus izumoensis*, *Lyropecten kagamianus*, *Natica janthostoma*, and *Serripes fujinensis* etc.	
——— conformity ———	
Kimachi Sandstone member, or TOMITA and SAKAI's "Kimati bed" (1938a)	200
Dark bluish or grayish blue coarse-grained sandstone with molluscan fossils as, *Cardium shinjiense*, *Dosinia* cf. *kaneharai*, and *Serripes fujinensis* etc.; grades downwards into a conglomeratic facies.	
~~ unconformity ~~~~~	
IWAMI GROUP	450+
Omori formation, or TOMITA and SAKAI's "Omori bed" (1938a)	200+
A volcanic complex with two-pyroxene-andesite in the uppermost and basalt flow in the lowermost, intercalating tuff and volcanic conglomerate in the middle part.	
~~ unconformity ~~~~~	
Tamatsukuri formation, or TOMITA and SAKAI's "Tamatukuri bed" (1938a)	250
Hard black shale, intercalating plagiorhyolite lava-flow and its vitric tuff layers and containing marine megafossils as, *Lima goliath*, *Propeamussium tateiwai*, and *Yoldia* aff. *kikuchii* etc.; grades downwards into coarse-grained sandstone and conglomerate.	
~~ unconformity ~~~~~	
BASEMENT ROCKS	
Granites, granodiorites, and granite-aplites.	

As to the smaller Foraminifera, those from the Fujina formation was reported by the writer (1955), and the details are described in Chapter II. The newly obtained data from the Subprovince are described in Chapter III.

3. *Shimane Peninsula Subprovince.* As shown in Figure 1, this Subprovince includes the whole Shimane Peninsula. Since 1949, the writer studied the geology of this Peninsula, and has presented some phases of the investigations on the occasion of

the respective annual meetings of the Geological Society of Japan, and at the meetings of the West Japan Branch of the same society. Recently, he has established the lithostratigraphic sequence of the central area of this Peninsula, and pointed out that it shows a sedimentary cycle from middle Miocene to lower Pliocene (TAI, 1952, 1953, 1955, 1956, 1957).

The stratigraphic sequence of the Subprovince may be summarized in descending order, as follows;

SHINJI GROUP	Thickness in meters
Matsue formation	800
Kuroda Sandstone member, or TOMITA and SAKAI's "Matue bed" (1938a)	150
Bluish, loose, coarse to medium-grained sandstone, containing lignite seams and tuffaceous materials, rarely yielding molluscan fossils as, *Cerithium* sp., *Ostrea* sp., and *Cultellus izumoensis* etc.	
~~ apparent unconformity ? ~~~~~	
Kawazu Tuff member, or TOMITA and SAKAI's "Hornblende-trachybasalts", "Olivine-trachybasalts", and "Tuda bed" combined (1938a), or "Kawazu bed" (1938b)	550+
A volcanic complex consisting mainly of olivine-trachybasalts, hornblende-trachybasalts, pyroxene-andesite, and their pyroclastics with molluscan fossils as, abundant *Turritella nipponica, Glycymeris* n. spp., *Anadara ogawai, Chlamys cosibensis, C. namigataensis, Placopecten* cf. *akihoensis, Pitar itoi*, and *Cultellus izumoensis* etc., intercalating laterally variable volcanic conglomerate and yellowish, loose, coarse to medium-grained sandstone.	
——— conformity ———	
Terazu Sandstone member, or TOMITA and SAKAI's "Upper Huzina bed" (1938a)	100
Bluish or yellowish, loose, coarse to medium-grained sandstone, containing lignite seams and molluscan fossils as, abundant *Cultellus izumoensis* and *Turritella saishuensis*, and some *Cerithium* sp., and *Ostrea* sp. etc.; passes downwards into silty sandstone or mudstone.	
——— conformity ———	
Furue formation	1400
Furue Mudstone member, or TOMITA and SAKAI's "Hurue bed" (1938b)	1000
Dark bluish or grayish, massive, and somewhat soft mudstone, containing abundant arenaceous smaller Foraminifera and some molluscan fossils; passes downwards into hard black shale facies.	
——— conformity ———	
Ushikiri Alternation member	100
An alternation consisting of dark grayish andesitic tuff, tuffaceous sandstone, and hard black shale, containing arenaceous smaller Foraminifera and megafossils as, *Cyclammina incisa, C.* spp., *Propeamussium* cf. *tateiwai*, Fish scales and Echinoid spines.	
——— conformity ———	
Jôsôji Shale member	300
Hard black shale, intercalating bluish, coarse-grained tuff or tuffaceous sandstone and containing smaller Foraminifera and some molluscan fossils as, *Cyclammina japonica, Eathyamussium* sp., *Megayoldia* sp., *Nuculana* sp., "*Palliolum*" n. sp., *Propeamussium* cf. *tateiwai, Solemya* sp., and *Yoldia* sp. etc.	
——— conformity ———	
Koura formation	600
Koura Tuff member	500
A tuffaceous complex consisting mainly of volcanic conglomerate, rhyolitic tuff, and tuffaceous sandstone with plant remains as, *Berchemia racemosa, Cinnamomum Scheuchzeri,*	

Glyptostrobus europaeus, Laurus cf. *primigenius, Metasequoia japonica, Planera Ungeri, Quercus* cf. *glauca, Q.* sp., and *Ulmus* sp., etc. and abundant *Corbicula* sp., intercalating some rhyolite lave-flows.

——————— conformity ———————

Koura Shale member, or TOMITA and SAKAI's "Koura bed" (1938b) 100

A fine-grained, fresh-water sediment, consisting mainly of hard, bluish tuffaceous shale with abundant molluscan fossils as, *Corbicula, Cuneopsis, Hyriopsis, Lamprotula, Parreysia, Semisulcospira,* and *Viviparus* etc. and some plant remains, with some volcanic conglomerate layers in the lower part.

..... unknown .....

BASEMENT ROCKS ..... unexposed

The smaller Foraminifera from this Subprovince were reported by S. MURATA (1951) and the writer (1955).

4. *Oki Islands Subprovince.* This Subprovince includes the whole Oki Islands in the Japan Sea, as shown in Figure 1. T. TOMITA (1936), from a geological and petrological point of view, had studied the Dôgo, Oki Islands and established a representative volcanic sequence. According to the stratigraphic observations in 1952–1953 by S. IMAMURA, M. MUKAE, and the writer, TOMITA's sequence may be revised and summarized in descending order, as follows;

Thickness in meters

Hotokedani formation, or TOMITA's "Hotokedani group (T_5)", "First trachybasalts (TB_1)", "Basalt (B)", and "Trachyandesite (TA)" combined (1936).

Conglomerate, sandstone, and clayey shale occur in the upper part, and basalts, trachybasalts, and trachyandesites in the lower part.

~~~~~~~~ unconformity (?) ~~~~~~~~

Dôgo formation or TOMITA's "Dôgo group" (T_4) (1936)

Marine sediments yielding smaller Foraminifera, mollusca, and diatoms.

Tsuma Sandstone member, or TOMITA's "Tuma beds" (1936) ..... 150+

Grayish fine to medium-sandstone with molluscan fossils as, *Cardium, Crenella, Mya, Pecten,* and *Natica* etc., intercalating conglomerate and conglomeratic sandstone layers.

.....relation unknown .....

Igo Mudstone member, or TOMITA's "Igo beds" (1936) ..... 50+

A massive grayish clayey mudstone with calcareous smaller Foraminifera and mollusca as *Chrysodomus.*

~~~~~~~~ unconformity (?) ~~~~~~~~

Ochi formation, or TOMITA's "Nakayama group" and "Oti group" combined (1936)

Tuffaceous coarse-grained sediments consisting of pyroxene-andesite, andesitic green tuff and tuffite, tuffaceous sandstone and conglomerate, containing coal seams and plant fossils as, *Acer, Ficus, Juglance, Liquidambar, Osmunda, Quercus, Salix,* and *Ulmus* etc.

~~~~~~~~ unconformity (?) ~~~~~~~~

Suki formation, or TOMITA's "Suki group" (1936)

Rhyolite and pyroxene-andesite flows, andesitic tuff and tuffiite, and shale with plant remains as, *Carpinus, Castanea, Liquidambar, Planera, Populus,* and *Salix* etc. in the upper part, and arkose sandstone with conglomerate and shale containing *Sequoia* leaves in the lower part.

~~~~~~~~ unconformity ~~~~~~~~

BASEMENT ROCKS

Oki gneisses and granitic intrusives.

As to the smaller Foraminifera of the Subprovince, that from the Dôgo formation was reported by the writer (1956), and is summarized in Chapter II.

CHAPTER II

HISTORICAL SUMMARY OF THE NEOGENE FORAMINIFERA

The previous records of the Foraminifera from the marine Neogene sediments developed in West Honshû, Japan, are found in the following references.

1918

1. YABE, H., 1918, Notes on *Operculina*-Rocks from Japan, with Remarks on "*Nummulites*" *cumingi* CARPENTER: *Sci. Rep. Tohoku Imp. Univ.*, ser. 2, vol. 4, no. 3, pp. 105-126, pl. 17.

1931

2. IMAMURA, S., 1931, On the Occurrence of *Operculina* near Yatsuo, Toyama: *Jour. Geol. Soc. Tôkyô*, vol. 38, pp. 541-542 (in Japanese).

1932

3. HANZAWA, S., 1932, Localities of *Operculina* and *Miogypsina* in Japan: *Jour. Geol. Soc. Tôkyô*, vol. 39, no. 470, pp. 723-724 (in Japanese).

1934

4. YABE, H. and MABUCHI, S., 1934, Some Geological Observations in Nariwa District, Bittyû: *Jour. Geol. Soc. Tôkyô*, vol. 41, no. 487, pp. 161-168 (in Japanese).

1935

5. YABE, H., 1935, New Find of *Miogypsina* in the Tertiary of Mino: *Proc. Imp. Acad. Tôkyô*, vol. 11, no. 4, pp. 144-145, text figs. 1-5.
6. HANZAWA, S., 1935, Some Fossil *Operculina* and *Miogypsina* from Japan, and Their Stratigraphical Significance: *Sci. Rep. Tohoku Imp. Univ.*, ser. 2, vol. 18, no. 1, pp. 1-29, pls. 1-3.

1949

7. MORISHIMA, M., NAKASEKO, K., MARUHASHI, M., and INOUE, H., 1949, Micropalcontological Studies on the Tertiary Formations in Western Toyama (Part 1): *Jour. Jap. Assoc. Petr. Tech.*, vol. 14, no. 1, pp. 2-8 (in Japanese).
8. IKEBE, N., 1949, Tertiary Stratigraphy of Western Toyama and Eastern Ishikawa Prefectures: *Sci. Earth*, vol. 1, no. 1, pp. 14-26 (in Japanese).

In this report, IKEBE proposes the following six faunizones in ascending order, namely, *Miogypsina kotoi*-, *Nodosaria insecta*-, *Martinottiella* cf. *communis*-, *Epistominella pulchella*-, OST-, and *Polystomellina discorbinoides* zones. The former five faunizones occur in the Yokawa group, and the latter one in the Himi group. Both groups are distributed in western Toyama and eastern Ishikawa Prefectures. He also established the following four stages in ascending order, namely, Onomian, Kamishoan, Tonamian, and Onman, based on the mentioned faunizones. The details of these stages and faunizones is discussed in the following report (NAKASEKO, 1952).

1950

9. CHIJI, M., and NAKASEKO, K., 1950, New Species of Neogene Foraminifera from the Toyama Basin,

Japan: *Jour. Geol. Soc. Japan*, vol. 56, pp. 519–522.

1951

10. MURATA, S., 1951, Miocene *Cyclammina* in the Vicinity of Matsue City, Shimane Prefecture: *Jour. Geol. Soc. Japan*, vol. 57, pp. 509-510 (in Japanese).

1952

11. MURATA, S., 1952, Smaller Foraminifera from the Miocene Deposits of the Miyosi and Tuyama Basins, Tyûgoku, West Japan: *Jour. Geol. Soc. Japan*, vol. 58, pp. 491-492 (in Japanese).
12. NAGAHAMA, M., 1952, Applied Micropaleontological Studies on the Tertiary Formation of the Sekidô Mountainland on the Ishikawa-Toyama Frontier: *Misc. Rep. Res. Inst. Nat. Res.*, no. 25, pp. 46–51 (in Japanese).
13. NAKASEKO, K., 1952, On the Microbiostratigraphy of the Yokawa Group of the Western "Toyama Basin": *Sci. Rep. Sou. Nor. Coll. Osaka Univ.*, no. 1, pp. 73-79 (in Japanese).

NAKASEKO deals with the Foraminifera from the Miocene Yokawa group distributed in the western part of the "Toyama Basin", Toyama and Ishikawa Prefectures. He distinguished the following five microbiostratigraphical units or zones in ascending order, namely, *Miogypsina kotoi*-, *Nodosaria insecta*-, *Martinottiella* cf. *communis*-, *Epistominella pulchella*-, and OST zones.

(1) *Miogypsina kotoi* zone. - This zone is said to occur in a coarse-grained sedimentary facies of the lower Yokawa group, and is characterized by a varied assemblage which contains characteristic and dominant species as: *Miogypsina kotoi*, *Operculina complanata*, *Robulus lucidus*, *Rotalia* cf. *beccarii*, *Amphistegina radiata*, *Gyroidina soldanii*, *Eponides umbonatus* etc.

(2) *Nodosaria insecta* zone. - This zone occurs in a mudstone or very fine-grained sedimentary facies of the lower Yokawa group and contains the largest number of individuals and species of the zones above mentioned. It possesses a fairly uniform assemblage with the following characteristic and dominant species: *Angulogerina angulosa*, *Bolivina* cf. *robusta*, *Nodosaria insecta*, *Gyroidina soldanii*, *Nonion pompilioides*, *Rotalia* cf. *japonica*, *Robulus yoshitakiensis*, *Cassidulina* cf. *laevigata*, *C. subglobosa depressa*, *Vaginulina* cf. *boso*, *Sigmoilina* cf. *schlumbergeri*, *Eponides frigidus*, *Cyclammina* spp. etc.

(3) *Martinottiella* cf. *communis* zone. - This zone occurs in a uniform mudstone of the middle Yokawa group and is characterized with arenaceous foraminiferal genera and other microfossils, such as *Martinottiella*, *Cyclammina*, *Ammodiscus*, *Makiyama*, Diatom, and Radiolaria. The individual number of the calcareous Foraminifera and pelagic forms as *Globigerina* become very rare compared with the underlying *Nodosaria insecta* zone.

(4) *Epistominella pulchella* zone. - This zone shows an increase in the individual number of the calcareous Foraminifera and the genus *Globigerina*. The zone is a mudstone facies of the middle Yokawa group and has yielded the following characteristic and dominant species: *Epistominella pulchella*, *Nonion pompilioides*, *N. scaphum*, *Cassidulina subglobosa*, *C. yabei*, *Eponides umbonatus*, *Uvigerina canariensis*, *U. pygmaea*, *Cyclammina* sp., and *Martinottiella* cf. *communis* etc.

(5) OST zone. - This zone is characterized by a siliceous microfossil which is considered to probably belong to the radiolarian Family Challengeridae, and for this Radiolaria-like microfossil the tentative name of OST has been proposed. Foraminifera are very rare. According to the classification of stages proposed by IKEBE (1949), the *Miogypsina kotoi-* and *Nodosaria insecta* zones above corresponds to the Onomian stage, and the *Martinottiella* cf. *communis-* and *Epistominella pulchella* zones to the Kamishoan, and the OST zone to the Tonamian.

1953

14. ASANO, K., 1953, Miocene Foraminifera from the Noto Peninsula, Ishikawa Prefecture: *Short Papers, IGPS*, no. 5, pp. 1-12, pls. 1-3.

In this report, ASANO deals with the Miocene Foraminifera collected by K. MASUDA from both the upper part of the Higashi-innai and Najimi formations, a siltstone facies that conformably overlies the *Miogypsina-Operculina* zone in Noto Peninsula. The latter zone is distributed in the northern part of Noto Peninsula, Ishikawa Prefecture, West Japan. He concluded that the Noto microfauna is similar to that of Kar Nicobar or Fiji Islands and that a certain part of the siltstone facies of Noto Peninsula is definitely middle Miocene in age.

15. TAI, Y., 1953, Miocene Foraminifera from the Shôbara Basin, Hiroshima Prefecture: *Jour. Sci. Hiroshima Univ.*, ser. c, vol. 1, no. 3, pp. 1-9.

In this paper, TAI deals with the Miocene smaller Foraminifera from the Middle and Upper formations distributed along the southern side of the Saijô River, northwest of the Shôbara Railway Station in the Shôbara basin, Hiroshima Prefecture. Since IMAMURA's stratigraphic classification (1953) of the deposits, the Middle formation in this paper is called the "Lower Sandstone" and the Upper formation is the "Upper Shale", and both members are included into the "Bihoku group". Details concerning this group are given in Chapter I.

The foraminiferal samples collected by the writer are from seven horizons (A-G) from the Lower Sandstone which also yields *Operculina* and *Vicarya*, and three (H-J) from the Upper Shale. The Foraminifera from the washed samples were distinguished into 14 families, 35 genera, and 87 species excluding the pelagic forms; these are given in Table I. The molluscan fossils are also listed together with the Foraminifera in this paper.

TABLE I

Check List of the Miocene Foraminifera from the Bihoku Group in the Shôbara Basin, Hiroshima Prefecture

Species \ Horizons	A	B	C	D	E	F	G	H	I	J
Bathysiphon sp.	—	—	—	—	—	—	2	4	—	—
Bathysiphon? sp.	—	—	—	—	—	—	—	—	—	1
Haplophragmoides sp.	—	—	—	—	—	4	2	3	17	—

Species \ Horizons	A	B	C	D	E	F	G	H	I	J
Haplophragmoides? sp.	—	—	—	—	—	6	—	7	1	17
Cribrostomoides cf. *kyushuense* Asano	—	—	—	—	—	—	1	—	—	—
Cyclammina incisa (Stache)	—	—	—	—	—	—	—	—	1	—
Cyclammina cf. *incisa* (Stache)	—	—	—	—	—	—	—	4	6	—
Cyclammina pusilla Brady	—	—	—	—	—	—	—	—	6	—
Cyclammina sp.	—	—	—	—	—	—	—	1	1	2
Cyclammina? sp.	—	—	—	—	—	—	—	—	5	2
Gaudryina (*Pseudogaudryina*) *ishikiensis* Asano	—	—	—	—	—	45	10	—	—	—
Gosella? sp.	—	—	—	—	—	—	—	—	—	1
Martinottiella communis (d'Orbigny)	—	—	—	—	—	2	1	12	34	—
Martinottiella? sp.	—	—	—	—	—	—	—	1	—	—
**Sigmoilina* sp.	—	—	—	—	—	—	—	2	9	—
**Sigmoilina*? sp.	—	—	—	—	—	—	—	1	—	—
Robulus cf. *nikobarensis* (Schwager)	—	—	—	—	—	—	2	—	—	—
Robulus pseudorotulatus Asano	—	—	—	—	—	—	1	1	—	1
Robulus cf. *pseudorotulatus* Asano	—	—	—	—	—	4	—	—	—	—
Robulus sp.	—	18	—	—	—	49	57	15	—	132
Robulus? sp.	—	—	—	—	—	—	1	—	—	—
Lenticulina? sp.	—	—	—	—	—	—	2	—	—	1
Marginulina masudai Asano	—	—	—	—	—	5	11	4	—	—
Marginulina sp.	—	—	—	—	—	1	—	—	—	—
Dentalina emaciata Reuss	—	—	—	—	—	—	7	1	—	1
Dentalina cf. *emaciata* Reuss	—	—	—	—	—	—	1	—	—	—
Dentalina subsoluta (Cushman)	—	—	—	—	—	—	1	1	2	1
Dentalina sp.	—	—	—	—	—	6	1	—	—	2
Dentalina? sp.	—	—	—	—	—	—	2	1	—	—
**Nodosaria* sp. A	—	—	—	—	—	2	4	2	—	—
**Nodosaria* sp. B	—	—	—	—	—	—	2	—	—	—
**Nodosaria* sp. C	—	—	—	—	—	1	3	—	2	1
Lagenonodosaria cf. *scalaris sagamiensis* Asano	—	—	—	—	—	—	4	—	—	—
Lagenonodosaria sp.	—	4	—	—	—	6	7	5	1	—
Lagenonodosaria? sp.	—	—	—	—	—	—	—	1	—	—
Saracenaria sp.	—	—	—	—	—	—	1	—	—	—
Saracenaria? sp.	—	—	—	—	—	1	—	—	—	—
Vaginulina bradyi Cushman	—	2	—	—	—	1	8	13	4	—
Guttulina irregularis (d'Orbigny)	—	—	—	—	—	1	15	1	—	—
Guttulina cf. *kishinouyi* Cushman and Ozawa	—	—	—	—	—	—	2	—	—	—
Guttulina(*Sigmoidina*) *pacifica*(Cushman and Ozawa)	—	—	—	—	—	—	1	—	—	—
Guttulina cf. *problema* d'Orbigny	—	—	—	—	—	—	2	—	—	—
Guttulina cf. *sadoensis* (Cushman and Ozawa)	—	—	—	—	—	—	3	—	—	—
Guttulina sp.	—	—	—	—	—	3	—	2	—	—
Guttulina? sp.	—	—	—	—	—	—	2	—	1	—
Globulina? sp.	—	—	—	—	—	—	2	1	—	—
Nonion japonicum Asano	11	—	13	1	—	1	4	—	—	—
Nonion cf. *japonicum* Asano	—	—	—	—	1	—	—	—	—	—
Nonion sp.	—	—	—	—	—	—	3	—	—	—
Nonion? sp.	—	—	—	—	—	1	1	—	—	—
Elphidiella momiyamaensis Uchio	—	—	—	—	—	—	1	—	—	—
Operculina complanata japonica Hanzawa	—	368	—	—	—	—	—	—	—	—
Plectofrondicularia sp.	—	—	—	—	—	4	—	—	—	—
Plectofrondicularia? sp.	—	—	—	—	—	—	—	1	—	—
Bulimina striata d'Orbigny	—	—	—	—	—	7	11	1	—	—

Species \ Horizons	A	B	C	D	E	F	G	H	I	J
Bulimina sp.	—	—	—	—	—	—	2	—	—	—
Bolivina marginata Cushman	—	—	—	—	—	—	—	1	—	11
Uvigerina crassicostata Schwager	—	—	—	—	—	14	8	9	4	—
Uvigerina nitidula Schwager	—	—	—	—	—	—	1	—	—	—
Uvigerina cf. *nitidula* Schwager	—	—	—	—	—	3	—	—	—	7
Uvigerina cf. *subperegrina* Cushman and Kleinpell	—	—	—	—	—	—	—	—	—	48
Uvigerina sp.	—	—	—	—	—	3	12	—	11	1
Uvigerina? sp.	—	—	—	—	—	—	1	—	—	—
Ellipsonodosaria lepidula (Schwager)	—	—	—	—	—	79	24	10	10	2
Ellipsonodosaria sp.	—	—	—	—	—	—	—	—	—	2
Discopulvinulina sp.	—	—	—	—	—	—	1	—	—	—
Eponides tanai Uchio	—	—	—	—	—	—	—	—	1	—
Eponides cf. *tanai* Uchio	—	—	—	—	1	—	—	—	—	—
Eponides cf. *umbonatus* (Reuss)	—	—	—	—	—	—	—	—	5	5
Eponides sp.	1	—	—	—	—	18	21	8	33	27
Eponides? sp.	—	—	—	—	—	2	22	—	—	5
Rotalia inflata (Seguenza)	—	—	—	—	—	16	22	—	—	—
Rotalia tochigiensis Uchio	—	28	—	—	—	—	5	—	—	—
Rotalia sp.	5	2	30	—	—	14	1	—	—	—
Baggina sp.	—	—	—	—	—	—	6	5	—	—
Cassidulina laevigata carinata Cushman	—	—	—	—	—	—	28	—	46	3
Cassidulina sp.	—	—	—	—	—	—	7	6	—	—
Cassidulina? sp.	—	—	—	—	—	—	3	1	—	—
Planulina wuellerstorfi (Schwager)	—	—	—	—	—	—	1	—	—	—
Planulina cf. *wuellerstorfi* (Schwager)	—	—	1	—	—	—	—	—	—	—
Hanzawaia tagaensis Asano	—	—	—	—	—	—	3	—	—	—
Hanzawaia sp.	—	—	—	—	—	3	—	—	—	—
Hanzawaia? sp.	—	—	—	—	—	—	3	—	—	—
Cibicides cf. *floridanus* (Cushman)	—	—	—	—	—	7	—	—	—	—
Cibicides pseudoungerianus (Cushman)	—	—	3	—	—	27	12	20	11	13
Cibicides sp.	—	—	—	—	2	6	—	6	23	42
Cibicides? sp.	—	—	—	—	—	—	6	—	—	—
The total number of specimens (benthonic Foram.)	17	422	47	1	4	342	367	151	234	328
Globigerina spp.	—	—	—	—	—	—	20	80	250	—

Ten samples (A-J), each weighing 200 grams, were first washed, sieved and then dried in an incubator. The dried materials were respectively divided into eight equal parts, and one-eighth part of each sample was examined under the binocular microscope for individual counting of the Foraminifera. As a result of quantitative analysis of the foraminiferal fauna from each sampling horizon, the species and their individual number are indicated in the Table.

Horizons:

A- Stratigraphically 18.5m. above the base of the Lower Sandstone (the Middle formation in this reference), the lower division of the Bihoku group, distributed along the southern side of the Saijô River, Shôbara basin, Hiroshima Prefecture.

B- Stratigraphically 21.5m. above the base of the Lower Sandstone.

C- Stratigraphically 24.5m. above the base of the Lower Sandstone.

D- Stratigraphically 27.0m. above the base of the Lower Sandstone.

E- Stratigraphically 31.0m. above the base of the Lower Sandstone.

F- Stratigraphically 33.5m. above the base of the Lower Sandstone.

G- Stratigraphically 37.5m. above the base of the Lower Sandstone.
H- Stratigraphically 40.5m. above the base of the Lower Sandstone, or 1.5m. above the base of the Upper Shale (the Upper formation in this reference).
I- Stratigraphically 42.5m. above the base of the Lower Sandstone, or 3.5m. above the Upper Shale.
J- Stratigraphically 45.5m. above the base of the Lower Sandstone, or 6.5m. above the Upper Shale.
*: *Sigmoilina* sp.=*S. imamurai* Tai; *Sigmoilina*? sp.=*S.* sp.; *Nodosaria* sp. A=*N. notoensis* Asano; *Nodosaria* sp. B=*Lagenonodosaria scalaris sagamiensis* Asano; *Nodosaria* sp. C=*N. pyrula* d'Orbigny; *Baggina* sp. =*B. notoensis* Asano (TAI, 1954).

1954

16. TAI. Y., 1954, Miocene Smaller Foraminifera from the Tsuyama Basin, Okayama Prefecture, Japan: *Jour. Sci. Hiroshima Univ.*, ser. c, vol. 1, no. 4, pp. 1-24, pl. 1.

In this report, TAI treats the smaller Foraminifera from the northern cliff (Lat. 35°03′48″N., long. 134°09′46.4″E.) of the Yoshino Primary School, which is situated about 14km. east of Tsuyama City in the Tsuyama basin, Okayama Prefecture. The sediments exposed here are referred to the Bihoku group which contains *Miogypsina-Operculina-Vicarya* fauna in its lower part. The Foraminifera were studied both quantitatively and microbiostratigraphically. According to current usage, the Sandstone member and the Shale member are referred to the Lower Sandstone and the Upper Shale respectively of S. IMAMURA (1953).

Smaller Foraminifera of the Tsuyama Miocene are listed in Table II.

TABLE II
Check List of the Miocene Foraminifera from the Bihoku Group of the Northern Cliff of the Yoshino Primary School in the Tsuyama Basin, Okayama Prefecture

Species \ Horizons	D	E	F	G	H	I
Bathysiphon sp.	—	—	16	2	—	3
Haplophragmoides trullissatum (Brady)	—	—	20	16	—	2
Haplophragmoides sp.	—	—	2	23	6	—
Haplophragmoides? sp.	—	—	1	5	2	8
Cribrostomoides kyushuense Asano	—	—	—	1	—	—
Cribrostomoides? sp.	—	—	1	—	—	—
Cyclammina incisa (Stache)	—	—	3	42	6	4
Cyclammina cf. *incisa* (Stache)	—	—	—	2	—	—
Cyclammina incisa? (Stache)	—	—	—	1	—	—
Cyclammina sp.	—	—	3	20	2	—
Cyclammina? sp.	—	—	—	—	2	—
Gaudryina (*Pseudogaudryina*) *ishikiensis* Asano	—	—	97	84	2	96
Gaudryina sp.	—	—	201	21	—	12
Gaudryina? sp.	—	—	36	6	—	5
Martinottiella communis (d'Orbigny)	—	—	92	114	25	63
Sigmoilina imamurai Tai	—	—	48	—	—	32
Sigmoilina sp.	—	—	11	4	—	—
Sigmoilina? sp.	—	1	—	—	—	—
Robulus calcar (Linnaeus)	—	—	1	—	—	—
Robulus lucidus (Cushman)	—	—	86	2	—	14

Species \ Horizons	D	E	F	G	H	I
Robulus nikobarensis (Schwager)	—	—	69	—	—	1
Robulus nikobarensis? (Schwager)	—	—	4	—	—	—
Robulus notoensis Asano	—	—	13	2	—	—
Robulus pseudorotulatus Asano	—	—	35	14	23	8
Robulus cf. *pseudorotulatus* Asano	—	—	—	—	—	2
Robulus sp.	—	—	173	53	72	82
Robulus? sp.	—	—	33	—	5	11
Lenticulina asanoi Tai	—	—	1	—	—	—
Lenticulina sp.	—	—	1	2	—	2
Lenticulina? sp.	—	—	—	2	—	2
Marginulina aculeata Neugeboren	—	—	2	—	5	2
Marginulina cf. *glabra* d'Orbigny	—	—	26	—	—	2
Marginulina masudai Asano	—	—	4	12	8	2
Marginulina cf. *masudai* Asano	—	—	21	—	—	—
Marginulina sp.	—	—	4	—	—	2
Dentalina emaciata Reuss	—	—	60	34	—	5
Dentalina cf. *soluta* Asano	—	—	9	2	16	9
Dentalina spinosa d'Orbigny	—	—	2	—	—	—
Dentalina sp.	—	—	4	—	2	2
Dentalina? sp.	—	—	—	—	—	2
Nodosaria cf. *longiscata* d'Orbigny	—	—	18	8	—	12
Nodosaria notoensis Asano	—	—	45	24	—	—
Nodosaria pyrula d'Orbigny var.	—	—	13	2	1	—
Nodosaria pyrula? d'Orbigny	—	—	—	—	—	1
Nodosaria cf. *vertebralis* (Batsch)	—	—	6	—	—	1
Nodosaria sp.	—	—	2	—	—	—
Lagenonodosaria scalaris (Batsch)	—	—	22	—	11	2
Lagenonodosaria cf. *scalaris sagamiensis* Asano	—	—	34	22	5	9
Lagenonodosaria sp.	—	—	33	24	8	24
Lagenonodosaria? sp.	—	—	5	—	—	1
Vaginulina bradyi Cushman	—	—	179	38	12	18
Vaginulina sp.	—	—	6	—	—	—
Lagena laevis (Montagu)	—	—	6	11	—	2
Lagena sp.	—	—	—	—	2	—
Lagena? sp.	—	—	—	—	—	2
Guttulina irregularis (d'Orbigny)	—	—	21	4	—	—
Guttulina sadoensis? (Cushman)	—	—	1	—	—	—
Guttulina sp.	—	—	—	8	8	4
Guttulina? sp.	—	—	—	4	5	—
Globulina? sp.	—	—	—	—	—	1
Nonion japonicum Asano	—	2	41	161	88	43
Nonion nicobarense Cushman	—	—	1	—	3	—
Nonion sp.	—	7	8	—	—	—
Nonionella miocenica Cushman	—	2	20	2	—	—
Plectofrondicularia japonica Asano	—	—	21	—	—	—
Bulimina inflata Seguenza	—	—	4	—	—	—
Bulimina striata d'Orbigny	—	—	8	5	—	—
Bulimina striata notoensis Asano	—	—	13	26	—	56
Bulimina sp.	—	—	4	—	—	5
Bulimina? sp.	—	—	3	—	—	—
Bolivina marginata Cushman	—	—	4	—	—	24
Bolivina marginata masudai Asano	—	—	—	—	—	10

Species \ Horizons	D	E	F	G	H	I
Bolivina sp.	—	—	2	—	—	—
Uvigerina crassicostata Schwager	—	—	53	26	—	28
Uvigerina crassicostata? Schwager	—	—	2	—	—	—
Uvigerina hootsi Rankin	—	—	—	106	—	—
Uvigerina cf. *hootsi* Rankin	—	—	72	35	—	2
Uvigerina nitidula Schwager	—	—	—	15	—	—
Uvigerina cf. *subperegrina* Cushman and Kleinpell	—	—	2	5	—	—
Uvigerina sp.	—	—	8	23	—	11
Uvigerina? sp.	—	—	—	—	4	4
Siphogenerina? sp.	—	1	—	—	—	—
Ellipsonodosaria japonica Ishizaki	—	—	10	10	—	2
Ellipsonodosaria lepidula (Schwager)	—	—	29	108	2	78
Ellipsonodosaria sp.	—	—	—	2	—	1
Ellipsonodosaria? sp.	—	—	2	—	—	—
Gyroidina soldanii d'Orbigny	—	—	53	8	—	—
Gyroidina cf. *soldanii* d'Orbigny	—	—	2	—	—	—
Gyroidina soldanii? d'Orbigny	—	2	—	—	—	—
Gyroidina sp.	—	—	2	1	—	—
Gyroidina? sp.	—	2	—	—	—	—
Eponides haidingerii d'Orbigny	—	—	36	2	—	2
Eponides cf. *haidingerii* d'Orbigny	—	—	—	2	—	—
Eponides praecinctus (Karrer)	—	—	33	5	—	—
Eponides subpraecinctus (Karrer)	—	—	2	4	—	—
Eponides umbonatus (Reuss)	—	—	32	—	—	5
Eponides sp.	—	—	23	2	9	—
Eponides? sp.	—	—	14	—	—	—
Rotalia inflata (Seguenza)	—	—	86	22	18	5
Rotalia tochigiensis Uchio	757	206	—	—	—	—
Rotalia sp.	—	6	35	—	6	4
Rotalia? sp.	—	—	12	—	—	—
Baggina notoensis Asano	—	—	8	22	—	14
Baggina sp.	—	—	3	—	—	—
Baggina? sp.	—	—	3	—	—	—
Cassidulina laevigata carinata Cushman	—	—	8	71	6	—
Cassidulina sp.	—	—	8	12	—	4
Cassidulina? sp.	—	—	9	—	—	—
Planulina nipponica Asano	—	—	6	2	—	—
Planulina cf. *nipponica* Asano	—	—	82	16	—	—
Planulina sp.	—	—	13	—	1	—
Hanzawaia tagaensis Asano	—	11	108	24	2	1
Hanzawaia sp.	—	—	2	23	6	—
Hanzawaia? sp.	—	—	1	5	2	8
Cibicides pseudoungerianus (Cushman)	—	2	63	4	—	35
Cibicides sp.	—	1	22	16	1	19
Cibicides? sp.	—	4	1	—	—	2
The total number of specimens (benthonic Foram.)	757	247	2441	1377	376	814
Globigerinidae:	—	—	2549	469	113	574

The method for individual counting of the Foraminifera is the same as used in the study of the Shôbara Miocene Foraminifera (Tai, 1953).

Horizons:

D- Stratigraphically 15.0m. above the base of the Lower Sandstone (=Sandstone member in this reference), the lower Bihoku group, exposed at the northern cliff (Lat. 35°03′48″ N., long. 134° 09′46.4″ E.) of the Yoshino Primary School, which is situated about 14km. east of Tsuyama City, Okayama Prefecture.

E- Stratigraphically 2.0m. above horizon D.

F- Stratigraphically 7.5m. above horizon D, or 2.0m. above the base of the Upper Shale (=Shale member in this reference).

G- Stratigraphically 9.5m. above horizon D, or 4.0m. above the Upper.

H- Stratigraphically 11.5m. above horizon D, or 6.0m. above the Upper.

I- Stratigraphically 13.5m. above horizon D, or 8.0m. above the Upper.

For discrimination and correlation of the foraminiferal faunules, see Table X and Plate 38.

1955

17. TAI, Y., 1955, Micropaleontological Study of the Furue formation, Geology of the Tertiary System in Shimane Prefecture, Japan (Part 3): *Jour. Geol. Soc. Japan*, vol. 61, pp. 407–420 (in Japanese).

In this report, the upper Miocene smaller Foraminifera from two members, namely, the type Fujina Mudstone (or TOMITA and SAKAI's "Lower Huzina bed") in the Outer Subprovince and the type Furue Mudstone in the Shimane Peninsula Subprovince, are dealt with both paleo-depositionally and -ecologically as follows;

Field evidence shows that the Fujina Mudstone distributed along the southern side of Shinji Lake and the Furue Mudstone bordering the northern side are obviously contemporaneous and equivalent in their stratigraphic positions. Although both lithologic units consist of very fine-grained sediments, their areas of deposition within the same sedimentary basin are not the same as proved by their contained foraminiferal faunas.

The Fujina Mudstone is characterized by such calcareous foraminiferal genera as, *Uvigerina*, *Cibicides*, *Cassidulina*, and *Epistominella*. On the other hand, the Furue Mudstone is represented by such arenaceous foraminiferal genera as, *Cyclammina*, *Haplophragmoides*, *Martinottiella*, *Goësella*, and *Plectina*. This dissimilar microfauna is quite contrary to what would be expected from a lithologically similar facies.

The contrasting microfauna can be explained by referring to the sedimentary and ecological environments of the two similar lithological units by their contained elements. The Fujina may be regarded to have been deposited in the outer neritic zone and the Furue in the outer bathyal zone. Structurally the Fujina and Furue occupy the southern and northern wings of the same syncline.

By reconstructing the two units to their original positions and referring them to one sedimentary basin, it became evident that the basin configuration must have had a characteristic contour, such as a "graben-trough".

The distribution of the smaller Foraminifera on which the foregoing conclusions are based, are shown in Table III.

In the present paper, TAI also reported some arenaceous Foraminifera from the Miocene Jôsôji Shale- and Ushikiri alternation members, the subjacent ones below the Furue Mudstone, distributed in the central part of the Shimane Peninsula. The Foraminifera obtained from both members are only the following five species, namely, *Cyclammina* cf. *cancellata* Brady, *C. incisa* (Stache), *C. japonica* Asano, *C.* cf. *japonica* Asano, and *C.* sp. This assemblage may be named the *Cyclammina* faunule.

TABLE III

Check List of the Upper Miocene Smaller Foraminifera from the Fujina and Furue Mudstones,
Distributed along the Southern and Northern Sides of Shinji Lake, Shimane Prefecture

	Species \ Members / Samp. Hors.	The Fujina Mudstone															The Furue Mudstone																	
		Upper										Lower					Upper																	Lower
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Calcareous Foraminifera	*Anomalina glabrata* Cushman	—	12	—	3	—	—	3	—	—	2																							
	Bolivina cf. *robusta* Brady	—	—	—	30	—																												
	Bulimina cf. *auriculata* Bailey	2	6	—	1	1																												
	Cassidulina laevigata carinata Cushman	13	26	39	28	—	12	—	—	10	3	1																						
	Cibicides aknerianus (d'Orbigny)	1	1	—	—	1	—	—	1																									
	Cibicides lobatulus(Walker and Jacob)	—	25	6	12	2	4																											
	Cibicides pseudoungerianus (Cushman)	—	46	19	101	38	—	4	—	—	2	1																						
	Cribroelphidium tomitai Tai	5	22	13	23	2	—	—	—	—	—	2	—	—	—	—	1																	
	Cribroelphidium yabei (Asano)	—	3	12	—	1	—	5	—	—	1																							
	Dentalina sp. indet.	—	—	2	2																													
	Elphidium etigoense Husezima and Maruhasi	—	3	1	3	2	—	—	16	—	11	4	—	1																				
	Elphidium sp. indet.	1	1	1	3																													
	Entosolenia marginata (Montagu)	—	7	1																														
	Epistominella pulchella Husezima and Maruhasi	20	52	20	32	12	42	61	17	1	38	152																						
	Eponides frigidus (Cushman)	7	2	20	30	4	—	—	3	2	3	1	—	—	—	—	4	2																
	Guttulina pacifica (Cushman and Ozawa)	—	—	—	—	—	—	—	—	—	—	2																						
	Lagena laevis (Montagu)	—	—	—	1																													
	Lagena sulcata spicata Cushman and McCulloch	1	6	14	3	7	2	7	—	1	—	6																						
	Lagenonodosaria fukushimaensis Asano	—	6	1	—	—	—	—	15	—	89	41	1																						
	Nonion japonicum Asano	1	—	2	—	—	—	—	—	—	7																							
	Nonion umbilicatulum (Montagu)	—	64	8	16	14	11	19	4	1	12	1																						
	Nonionella miocenica Cushman	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3																	
	Pullenia salisburyi R. E. and K. C. Stewart	—	13	17	24	2	—	2	—	—	—	5																						
	Quinqueloculina akneriana d'Orbigny	—	—	—	—	—	—	—	—	—	6																							
	Quinqueloculina vulgaris d'Orbigny	—	—	—	—	—	—	—	1	—	7																							
	Robulus sp. indet.	—	—	—	—	—	—	—	1																									
	Rotalia takanabensis (Ishizaki)	—	1	—	—	—	—	—	—	—	—	126																						
	Uvigerina cf. *hootsi* Rankin	—	11	2	2	—	—	4	2	2	—	7																						
	Uvigerina nitidula Schwager	—	30	27	8	10	—	9	6	7	2	15																						
	Uvigerina segundoensis Cushman and Galliher	—	21	17	8	2	—	—	—	2	1	33																						
	Uvigerina subperegrina Cushman and Kleinpell	—	60	65	7	7	—	177	89	44	75	403	—	1																				
	Uvigerina yabei Asano	—	10	10	—	1	—	5	1	—	3	6																						
	Uvigerina sp. indet.	—	54	18	6	4																												
Arenaceous Foraminifera	*Ammodiscus* sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1									
	Bathysiphon? sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	1														
	Cribrostomoides? sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1							
	Cyclammina cf. *cancellata* Brady	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	15					
	Cyclammina cf. *ezoensis* Asano	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8				
	Cyclammina incisa (Stache)	—	—	—	1	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	21	8	9	17	16		
	Cyclammina japonica Asano	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	5	27	15	12	7	9	
	Cyclammina cf. *japonica* Asano	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11	13				
	Cyclammina pusilla Brady	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	11	5	1	5	—	1	3	1	1	—	5				
	Cyclammina sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	1	—	—	—	3				
	Gaudryina ishikiensis Asano	—	44	12	44	—	7	—	32	3	120	69																						
	Gaudryina cf. *yabei* Asano	—	—	—	—	—	—	—	—	3	4																							
	Goësella schencki Asano	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	1	1	—	—	—	—	1	1	—	—	12	8			
	Haplophragmoides compressum LeRoy	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—				
	Haplophragmoides cf. *emaciatum* (Brady)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2															
	Haplophragmoides trullissatum (Brady)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	12				
	Haplophragmoides sp.	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	3	3	9	6	1	6	2	—	—	—	13	18			
	Martinottiella communis (d'Orbigny)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	16	—	—	—	—	—	—	—	—	—	21	—	31		
	Martinottiella sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1															
	Plectina nipponica Asano	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	3	—	—	4	3	—	—	—	23				
	Plectina sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	13	4	3							
	Quinqueloculina sakaii Tai	—	—	—	—	—	—	—	1	—	—	2																						
	Spiroplectammina niigataensis Asano and Inomata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11					
	Textularia lythostrota (Schwager)	—	—	—	1																													
	Textularia sp.	—	—	1	—	—	—	—	—	—	2																							
	Trochammina sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	5	5	—	—	—	11					
	Total number of specimens (benthonic Foraminifera)	51	526	328	389	110	78	296	189	76	392	877	1	2	1	1	8	2	22	34	10	13	11	5	31	19	6	2	16	174	70	52	24	25
	Globigerina bulloides d'Orbigny	—	27	43	1	—	—	6	4	16	5	7																						
	Globorotalia sp.	—	—	—	—	—	—	—	—	2	—	3																						

33 samples, each weighing 200 grams, were first washed, sieved and then dried in an incubator. The dried materials were respectively divided into two equal parts, and a half part of each sample was examined under the binocular microscope for individual counting of the Foraminifera. As a result of quantitative analysis of the foraminiferal fauna from each sampling horizon, the species and their individual numbers are indicated in this Table.

Sampling horizons:

1- Stratigraphically about 520m. above the base of the type Fujina Mudstone exposed at the cliff of Iwayamae, Tamayu-mura, Yatsuka-gun, Shimane Prefecture.
2- Stratigraphically about 10m. below horizon 1.
3- Stratigraphically about 40m. below horizon 1.
4- Stratigraphically about 60m. below horizon 1.
5- Stratigraphically about 80m. below horizon 1.
6- Stratigraphically about 95m. below horizon 1.
7- Stratigraphically about 115m. below horizon 1.
8- Stratigraphically about 135m. below horizon 1.
9- Stratigraphically about 155m. below horizon 1.
10- Stratigraphically about 185m. below horizon 1.
11- Stratigraphically about 195m. below horizon 1.
12- Stratigraphically about 205m. below horizon 1.
13- Stratigraphically about 235m. below horizon 1.
14- Stratigraphically about 280m. below horizon 1.
15- Stratigraphically about 10m. above the base of the type Fujina Mudstone exposed at the cliff of Iwayamae, Tamayu-mura, Yatsuka-gun, Shimane Prefecture.
16- Stratigraphically about 55m. below the top of the type Furue Mudstone exposed at the cliff of Shinji Lake coast at Terazu, west of Matsue City, Shimane Prefecture.
17- Stratigraphically about 50m. below horizon 16.
18- Stratigraphically about 250m. below horizon 16.
19- Stratigraphically about 275m. below horizon 16.
20- Stratigraphically about 300m. below horizon 16.
21- Stratigraphically about 325m. below horizon 16.
22- Stratigraphically about 350m. below horizon 16.
23- Stratigraphically about 375m. below horizon 16.
24- Stratigraphically about 400m. below horizon 16.
25- Stratigraphically about 425m. below horizon 16.
26- Stratigraphically about 475m. below horizon 16.
27- Stratigraphically about 500m. below horizon 16.
28-31- These four sampling horizons are considered to represent about the middle part of the Furue Mudstone, although the exact stratigraphic position of each could not be determined owing to disturbance by faults, foldings, and weathering.
32- Stratigraphically about 130m. above the base of the Furue Mudstone exposed at Noma, NW of Matsue City, Shimane Prefecture. Locality; Lat. 35°30′0″N., long. 133°0′ 40″E.
33- Stratigraphically about 20m. above the base of the type Furue Mudstone exposed along the road cliff at Ushikiri, NW of Matsue City, Shimane Prefecture. Locality; Lat. 35° 29′50.4″ N., long. 132°59′58.4″E.

From the distribution of the Foraminifera shown in Table III, the Fujina microfauna is subdivided into two foraminiferal faunules, namely, *Uvigerina-Epistominella-Cibicides-Cassidulina-Gaudryina-*, and *Haplophragmoides-Elphidium*-faunules. The former occurs in the upper horizons (1–11) of the Fujina Mudstone member, and the latter in its lower horizons(12–15).

On the other hand, the Furue microfauna can also be subdivided into two faunules,

namely, *Eponides*-, and *Cyclammina-Haplophragmoides-Plectina*-faunules. The former occurs in the upper horizons (16–17) of the Furue Mudstone member, and the latter in its lower horizons (18–33).

Of the faunules mentioned above, the lower faunule of the Furue Mudstone may correspond to the lower and upper faunules of the Fujina Mudstone. As described in Chapter IV, these Fujina faunules just mentioned represent the greater part of the Fujinan stage.

18. CHIJI, M., 1955, On the Microbiostratigraphy of the Yatsuo Group in the Yatsuo District of Toyama Prefecture: *Jour. Geol. Soc. Japan*, vol. 61, pp. 162–172 (in Japanese).

1956

19. TAI, Y., 1956, Miocene Smaller Foraminifera from Dôgo, Oki Islands: *Jour. Geol. Soc. Japan*, vol. 62, pp. 212-213 (in Japanese).

In this short paper, TAI treats the upper Miocene smaller Foraminifera from the Tsuma Sandstone and Igo Mudstone, distributed respectively on the southern and northern coasts of Dôgo, Oki Islands, Shimane Prefecture. He concluded that the Dôgo microfauna is correlative with that of the type Fujina Mudstone distributed along the southern coast of Shinji Lake, Shimane Prefecture. Smaller Foraminifera from both units are listed in Table IV.

TABLE IV

Check List of the Upper Miocene Smaller Foraminifera from the Igo Mudstone and Tsuma Sandstone Distributed in Dôgo, Oki Islands, Shimane Prefecture

Species	Igo	Tsuma
Angulogerina cf. *hughesi* (Galloway and Wissler)	1	
Angulogerina kokozuraensis Asano	3	
Anomalina sp.		1
Bulimina sp. indet.	2	
**Cassidulina laevigata carinata* Cushman	3	
Cassidulina margareta Karrer	2	3
Cassidulina cf. *subglobosa* Brady		4
Cassidulina sp. indet.	1	6
**Cibicides aknerianus* (d'Orbigny)		1
**Cibicides lobatulus* (Walker and Jacob)		64
**Cibicides pseudoungerianus* (Cushman)	3	7
Cibicides n. sp.		5
Cibicides sp. indet.	1	1
**Cribroelphidium tomitai* Tai	1	
Cribrostomoides cf. *kyushuense* Asano	1	
**Cyclammina pusilla* Brady	6	
Discopulvinulina cf. *bertheloti* (d'Orbigny)		1
**Epistominella pulchella* Huseзima and Maruhasi	24	
**Eponides frigidus* (Cushman)	1	
Eponides sp. indet.		1
**Globigerina bulloides* d'Orbigny	3	15
Globobulimina sp. indet.	9	
Guttulina sp. indet.	21	
Lagena striata (d'Orbigny)	1	
Martinottiella sp. indet.	1	

Species	Igo	Tsuma
Nonion pompilioides (Fichtel and Moll)	28	
Nonion cf. *pompilioides* (Fichtel and Moll)		1
Nonionella sp. indet.	8	
**Pullenia salisburyi* R. E. and K. C. Stewart	2	
Pullenia sp. indet.	3	
Robulus sp. indet.	1	
Trochammina sp. indet.	1	
**Uvigerina* cf. *hootsi* Rankin	1	
**Uvigerina nitidula* Schwager	29	
**Uvigerina segundoensis* Cushman and Galliher	14	
**Uvigerina subperegrina* Cushman and Kleinpell	45	
**Uvigerina yabei* Asano	11	
Uvigerina sp. indet.	7	
Valvulineria sp. indet.	2	2

24 samples including 22 others that yielded no Foraminifera, each weighing 200 grams, were first washed, sieved and then dried in an incubator. The dried materials were respectively divided into two equal parts, and a half part of each sample was examined under the binocular microscope for individual counting of the Foraminifera. As a result of quantitative analysis of the foraminiferal fauna from each sampling locality, the species and their individual numbers are indicated in Table IV.

Sampling localities:

Igo- Igo locality (Lat. 36°19′30″ N., long. 133°16′06″ E.) A mudstone facies of the type Igo Mudstone exposed at the beach cliff of Igo, Naka-mura, Suki-gun, Dôgo, Oki Islands, Shimane Prefecture.

Tsuma- Tsuma locality (Lat. 36°11′15.5″ N., long. 133°14′30″ E.) A fossiliferous sandstone facies of the type Tsuma Sandstone exposed at the beach cliff of Kamaya, Tsuma-mura, Oti-gun, Dôgo, Oki Islands, Shimane Prefecture.

* : Species in common with of the Fujina Mudstone mentioned above.

20. TAI, Y., 1956, On the Microbiostratigraphy of the Cenozoic Strata in Chûgoku and Kinki Districts: *Earth Science* (*Chikyu-kagaku*), no. 30, pp. 9–18 (in Japanese).

In this report, TAI established tentatively five microbiostratigraphic units or zonules from his previous foraminiferal data of the Chûgoku District. These zonules are in ascending order, as follows;

1) *Miogypsina kotoi-Operculina complanata japonica* Zonule
2) *Lagenonodosaria scalaris-Uvigerina crassicostata* Zonule
3) *Cyclammina* spp.-*Haplophragmoides* spp. Zonule ("PF Zone")
4) *Uvigerina subperegrina-Epistominella pulchella* Zonule
5) *Nonion pacificum-Rotalia* cf. *beccarii* Zonule

These details are discussed in Chapter IV.

1957

21. TAI, Y., 1957, Microbiostratigraphical Study of the Cenozoic Strata of the Western Setouchi Province, Japan: *Geol. Rep. Hiroshima Univ.*, no. 5, pp. 1–58 (in Japanese).

In this report, TAI treats the foraminiferal faunas from the Miocene strata of the Miyoshi, Shôbara, Niimi, and Tsuyama basins in the Chûgoku District (or the western Setouchi Province) and Nara basin in the Kinki District (or the central Setouchi Province).

He discussed the relation between two units, namely, microbiostratigraphical ones based on the foraminiferal assemblages of the faunas, and lithostratigraphical ones, previously established, of the Miocene marine sediments in the same basins.

1) Miyoshi Miocene Foraminifera.

17 foraminiferal samples from the Bihoku group (Lower Sandstone and Upper Shale) exposed at the road cliff of Obara in the Miyoshi basin, Hiroshima Prefecture were washed and the Foraminifera obtained are listed in Table V.

TABLE V

Check List of the Miocene Foraminifera from the Bihoku Group in the Miyoshi Basin, Hiroshima Prefecture

Species \ Samp. hors.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Bathysiphon sp. indet.					4	1	1	15	17	6	19	4					
Haplophragmoides sp. indet.				6			6	13	4	14	4	1					
Haplophragmoides? sp. indet.						2											
Ammobaculites sp. indet.						1		1			1						
Cyclammina incisa (Stache)						1	1			2	1						
Cyclammina cf. *incisa* (Stache)				2				2									
Cyclammina cf. *japonica* Asano				3													
Cyclammina pusilla Brady				2				1	1	3							
Cyclammina sp. indet.				2	2	3			1	2							
Verneuilina sp.					3												
Gaudryina (*Pseudogaudryina*) *ishikiensis* Asano		7	13									2					
Plectina nipponica Asano			1														
Plectina sp. indet.											1						
Gosella schencki Asano								1									
Martinottiella communis (d'Orbigny)				27	11	7	4	4	8	49	19	4			5		
Schenckiella victoriensis (Cushman)					16												
Sigmoilina imamurai Tai					1	10				1	2						
Sigmoilina schlumbergeri Silvestri										6							
Trochammina sp. indet.					1			1									
Robulus cf. *asanoi* Takayanagi			1														
Robulus iotus (Cushman)					1												
Robulus javana simplex (Koch)								1	2	4	1	1					
Robulus lucidus (Cushman)		2	2	1	2	6		6	8	4	3	4					
Robulus nikobarensis (Schwager)					1						1						
Robulus notoensis Asano									1		1						
Robulus cf. *orbicularis* (d'Orbigny)												1					
Robulus cf. *tangens* LeRoy												1					
Robulus yoshitakiensis Chiji and Nakaseko						1											
Robulus cf. *yoshitakiensis* Chiji and Nakaseko			1		1				1		1	6					
Robulus sp. indet.		23	34	53	15	43		26	22	15	23	28					
Marginulina aculeata Neugeboren			7					2			1	1					
Marginulina cf. *glabra* d'Orbigny												1					
Marginulina masudai Asano					4	1		2		1		1					
Marginulina sp. indet.			2					1	1								
Dentalina emaciata Reuss				1	4	3											
Dentalina insecta (Schwager)					3					4	2						
Dentalina soluta Asano			4														
Dentalina subsoluta (Cushman)					1				1		3	1					

Species \ Samp. hors.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Dentalina tauricornis (Schwager)												1					
Dentalina sp. indet.		3		2		3		3	1	1	8	4					
Nodosaria longiscata d'Orbigny			3		4	4		3	3								
Nodosaria notoensis Asano		1		3	15	5		11			3						
Nodosaria pyrula d'Orbigny			3		1				1	4	3						
Nodosaria vertebralis (Batsch)					2			1									
Nodosaria sp. indet.				3				2				1					
Lagenonodosaria scalaris (Batsch)				4					3	3	6	6					
Lagenonodosaria scalaris sagamiensis Asano				1				6	2								
Lagenonodosaria sp. indet.						1		7	2			1					
Saracenaria sp. indet.				1				1			1	1					
Vaginulina bradyi Cushman		1	5	10	8	4		29	3	1	5	9					
Lagena acuticosta Reuss											2						
Lagena cf. *acuticosta* Reuss									2								
Lagena laevis (Montagu)									2								
Lagena cf. *laevis* (Montagu)					1	1				2							
Lagena sulcata spicata Cushman and McCulloch											2	7					
Lagena cf.*sulcata spicata* Csuhman and McCulloch									7								
Lagena sp. indet.				4				1	4	7	13	23					
Guttulina irregularis (d'Orbigny)		2	2														
Guttulina sp. indet.		3	2			1			1								
Nonion japonicum Asano		16	12	1		3											
Nonion nakosoense Asano		3	3	1													
Nonion pompilioides (Fichtel and Moll)										1	1						
Nonion sp. indet.		2															
Nonionella miocenica Cushman		5	5	2	2	1			1								
Elphidium sp.			1														
Elphidium sp. indet.		2															
Operculina complanata japonica Hanzawa			(35)														
Plectofrondicularia japonica Asano		1	2	1	1	1		1			2	1					
Plectofrondicularia sp. indet.									1								
Bulimina striata d'Orbigny					9	3			2	1	1						
Bulimina striata notoensis Asano				1					2	3	2						
Bolivina marginata masudai Asano									1	4	1						
Reussella aculeata Cushman											3						
Uvigerina crassicostata Schwager						13											
Uvigerina nitidula Schwager												2					
Uvigerina sp. indet.								1									
Ellipsonodosaria japonica Ishizaki				2	11				4								
Ellipsonodosaria lepidula(Schwager)				11	31	13		23	17	11	16	13					
Ellipsonodosaria sp.			3														
Ellipsonodosaria? sp. indet.									1								
Discopulvinulina cf. *isabelleana* (d'Orbigny)						2											
Discopulvinulina sp. indet.						3				2							
Gyroidina orbicularis d'Orbigny						4											
Gyroidina soldanii d'Orbigny		2	1		1												
Eponides frigidus (Cushman)					1	7		7	1	7	5	1					
Eponides frigidus calidus Cushman and Cole						1											
Eponides haidingerii (d'Orbigny)			1														
Eponides nipponicus (Husezima and Maruhasi)												1					

Species \ Samp. hors.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Eponides praecinctus (Karrer)				2		3			1	1							
Eponides subpraecinctus Asano					2	1											
Eponides umbonatus (Reuss)		2						12	33	13	10	33					
Eponides sp. indet.		3	4	2	2	3		8	1	2		9					
Rotalia cf. *beccarii* (Linnaeus)		6															
Rotalia inflata (Seguenza)		65	47	8	16	5											
Rotalia takanabensis (Ishizaki)		10	20	1	15	19											
Rotalia cf. *takanabensis* (Ishizaki)										1							
Rotalia tochigiensis Uchio		4	5														
Rotalia sp. indet.		4				2											
Baggina notoensis Asano				1	2												
Amphistegina? sp. indet.									1								
Epistominella sp.											1	1					
Cassidulina laevigata carinata Cushman				9		1				4	3	12					
Pullenia? sp. indet.																	
Sphaeroidina japonica Asano																	
Planulina nipponica Asano		9	5	10							1						
Planulina cf. *subdepressa* Asano					1	1											
Planulina wuellerstorfi (Schwager)			2		1												
Planulina sp. indet.			1						1								
Hanzawaia nipponica Asano									1								
Hanzawaia tagaensis Asano		1		1													
Cibicides lobatulus (Walker and Jacob)		2		2		3		1	2			2					
Cibicides pseudoungerianus (Cushman)		21	8	19	4	13		6	32	21	28	16					
Cibicides sp. indet.								1									
Dyocibicides sp. indet.				1													
Total number of benthonic Foraminifera	0	200	200	200	200	200	12	200	200	200	200	200	0	0	5	0	0
Pelagic forms				7	1	4			12	5	24	14					

17 samples, each weighing 200 grams, were first washed, sieved and then dried in an incubator. In counting the specimens, 200 specimens were taken from each dried sample at random but when numbers were less than 200, all of them are gathered. As a result of such quantitative analysis of the foraminiferal fauna from each sampling horizon, the species and their individual numbers are indicated in this Table. Of the sampling horizons, three (1-3) belong to the Lower Sandstone and the remaining (4-17) to the Upper Shale. Sampling horizons:

1- Stratigraphically about 10m. below the top of the Lower Sandstone, the lower part of the Bihoku group, exposed at the road cliff (Lat. 34°47′54″N., long. 132°53′43.4″ E.) of Obara, 1.5km. east of the Yatsugi Railway Station in the Miyoshi basin, Hiroshima Prefecture.

2- Stratigraphically about 7m. above horizon 1.

3- Stratigraphically about 9m. above horizon 1.

4- Stratigraphically about 1m. above the base of the Upper Shale, or the top of the Lower Sandstone mentioned above.

5- Stratigraphically about 2m. above horizon 4.

6- Stratigraphically about 4m. above horizon 4.

7- Stratigraphically about 6m. above horison 4.

8- Stratigraphically about 8m. above horizon 4.

9- Stratigraphically about 10m. above horizon 4.

10- Stratigraphically about 12m. above horizon 4.
11- Stratigraphically about 14m. above horizon 4.
12- Stratigraphically about 16m. above horizon 4.
13- Stratigraphically about 18m. above horizon 4.
14- Stratigraphically about 20m. above horizon 4.
15- Stratigraphically about 37m. above horizon 4.
16- Stratigraphically about 39.5m. above horizon 4.
17- Stratigraphically about 41m. above horizon 4.

The distribution of the percentage of the dominant genera based upon individual unmbers given in Table V, is also represented as shown in Table VI. Thus, the Miyoshi foraminiferal sequence in ascending order comprises the following four faunules;

1) *Operculina-Rotalia-Nonion* faunule
2) *Robulus-Rotalia-Ellipsonodosaria* faunule
3) *Robulus-Martinottiella-Haplophragmoides-Eponides* faunule
4) *Martinottiella* faunule

Pelagic forms occur in association with the faunules 2) and 3) above.

TABLE VI

Distribution of the Dominant Genera of Miyoshi Foraminifera (Numbers; %)

Faunules / Hor. Nos. / Genera	*Operculina-Rotalia-Nonion* Faunule			*Robulus-Rotalia-Ellipsonodosaria* Faunule			*Robulus-Martinottiella-Haplophragmoides-Eponides* Faunule						*Martinottiella* Faunule				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Bathysiphon					2.0	0.5	8.3	7.5	8.5	3.0	9.5	2.0					
Haplophragmoides				3.0		1.0	50.0	6.5	2.0	7.0	2.0	0.5					
Cyclammina				4.5	1.0	2.0	8.3	1.5	1.0	3.5	0.5						
Gaudryina		3.5	6.5									1.0					
Martinottiella				13.5	5.5	3.5	33.3	2.0	4.0	24.5	9.5	2.0			100.0		
Sigmoilina					0.5	5.0				3.5	1.0						
Robulus		12.5	19.0	27.0	10.0	25.0		16.5	17.0	11.5	15.0	20.5					
Marginulina			4.5		2.0	0.5		2.5	0.5	0.5	0.5	1.5					
Dentalina		1.5	2.0	1.5	4.0	3.0		1.5	1.0	2.5	6.5	3.0					
Nodosaria		0.5	3.0	3.0	11.0	4.5		8.5	2.0	2.0	3.0	0.5					
Lagenonodosaria				2.5		0.5		6.5	3.5	1.5	3.0	3.5					
Vaginulina		0.5	2.5	5.0	4.0	2.0		14.5	1.5	0.5	2.5	4.5					
Lagena				2.0	0.5	0.5		0.5	7.5	4.5	8.5	15.0					
Guttulina		2.5	2.0			0.5			0.5								
Nonion		10.5	7.5	1.0		1.5				0.5	0.5						
Nonionella		2.5	2.5	1.0	1.0	0.5			0.5								
Bulimina				0.5	4.5	1.5			2.0	2.0	1.5						
Uvigerina						6.5		0.5				1.0					
Ellipsonodosaria			1.5	6.5	21.0	6.5		11.5	11.0	5.5	8.0	6.5					
Eponides		2.5	2.5	2.0	2.5	7.5		13.5	18.0	11.5	7.5	22.0					
Rotalia		44.5	36.0	4.5	15.5	13.0				0.5							
Cassidulina				4.5						2.0	1.5	6.0					
Planulina		4.5	4.0	5.0	1.0	0.5			0.5								
Cibicides		11.5	4.0	10.5	2.0	8.0		4.0	17.0	10.5	14.0	9.0					

2) Shôbara Miocene Foraminifera.

As shown in Table I, the smaller Foraminifera from the Shôbara Miocene were listed by the writer from the Shôbara River section (TAI, 1953). Table VII shows the distribution of the percentage of the dominant genera based upon individual numbers shown in Table I.

TABLE VII

Distribution of the Dominant Genera of Shôbara Foraminifera (Numbers; %)

Faunules / Genera / Horizons	*Operculina-Rotalia-Nonion* Faunule					*Robulus-Rotalia-Ellipsonodosaria-Eponides* Faunule		*Robulus-Martinottiella-Uvigerina-Eponides-Cibicides* Faunule		
	A	B	C	D	E	F	G	H	I	J
Bathysiphon							0.5	2.6		0.3
Haplophragmoides						2.9	0.5	6.6	7.7	5.2
Cyclammina								3.3	8.1	1.2
Gaudryina						13.2	2.7			
Martinottiella						0.6	0.3	8.6	14.5	
Sigmoilina								2.0	3.8	
Robulus		33.3				15.5	16.6	10.6		40.5
Marginulina						1.8	3.0	2.6		
Dentalina						1.8	3.3	2.0	0.9	1.2
Nodosaria						0.9	2.4	1.3	0.9	0.3
Lagenonodosaria		7.4				1.8	3.0	4.0	0.4	
Vaginulina		3.7				0.3	2.2	8.6	1.7	
Guttulina						1.2	6.7	2.0	0.4	
Nonion	64.7		27.7	100.0	25.0	0.6	2.2			
Bulimina						2.0	3.5	0.7		
Uvigerina						5.8	6.0	6.0	6.4	17.1
Ellipsonodosaria						23.1	6.5	6.6	4.3	1.2
Eponides	5.9				25.0	5.8	11.7	5.3	16.7	11.3
Rotalia	29.4	55.6	63.8			8.8	7.6			
Cassidulina							10.4	4.6	19.7	0.9
Hanzawaia						0.9	1.6			
Cibicides			6.4		50.0	11.6	4.9	17.2	14.5	17.0

From Table VII, three faunules were distinguished by TAI in ascending order, as follows, namely, 1) *Operculina-Rotalia-Nonion* faunule, containing horizons A-E, 2) *Robulus-Rotalia-Ellipsonodosaria-Eponides* faunule, containing F and G, 3) *Robulus-Martinottiella-Uvigerina-Eponides-Cibicides* faunule, containing H-J. Pelagic Foraminifera occur abundantly in company with the faunules 2) and 3) mentioned above. In other words, it became evident that pelagic forms occur firstly from about the uppermost horizon of the Lower Sandstone in the Shôbara River section. (see Table I).

3) Niimi Miocene Foraminifera.

Ten foraminiferal samples from the Bihoku group exposed at the road cliff of the Daichinji-Muroyama section of Tetsuta-machi, which is situated about 6 km. south of Niimi City, Okayama Prefecture were studied. Foraminifera from the Niimi Miocene are listed in Table VIII.

TABLE VIII

Check List of the Miocene Foraminifera from the Bihoku Group in Tetsuta-machi, South of Niimi City, Okayama Prefecture

Species \ Nos.	1	2	3	4	5	6	7	8	9	10
Rhabdammina sp. indet.							1			
Siphotextularia n. sp.							6			
Gaudryina (*Pseudogaudryina*) *ishikiensis* Asano				1	1	2	5	1	5	8
Gaudryina cf. *yabei* Asano							1		1	
Sigmoilina imamurai Tai							1			
Robulus cf. *iotus* (Cushman)					1			1		
Robulus lucidus (Cushman)		3	3	19	7	2	6	5	5	2
Robulus nikobarensis (Schwager)		18	5	7	3					
Robulus sp. indet.		6	2	16	17	13	14		14	1
Marginulina glabra d'Orbigny							6			1
Marginulina cf. *glabra* d'Orbigny		1			4			4		
Marginulina sp. indet.					5				6	
Lagenonodosaria fukushimaensis Asano							1		2	
Lagenonodosaria scalaris (Batsch)					10	11	12	53	18	30
Lagenonodosaria scalaris sagamiensis Asano							1		1	
Vaginulina cf. *awaensis* Asano							1			
Vaginulina yoshihamaensis Inoue and Nakaseko							2		2	
Lagena sulcata (Walker and Jacob)									5	
Lagena sulcata spicata Cushman and McCulloch					1					11
Lagena cf. *sulcata spicata* Cushman and McCulloch								27		
Guttulina irregularis (d'Orbigny)				1			2		2	
Guttulina kishinouyi Cushman and Ozawa							1			
Guttulina sp. indet.					1	2		1		
Nonion grateloupi (d'Orbigny)							2		1	2
Nonion japonicum Asano		5	3		4	2		8		3
Nonion nakosoense Asano		1	1		4		1			1
Nonion nicobarense Cushman							1	2	1	
Nonion scaphum (Fichtel and Moll)		4	1	2	6	3	12	3	3	5
Nonion umbilicatulum (Montagu)							2		1	
Nonion sp. indet.					2					
Nonionella miocenica Cushman		10	9	5	13	16	4	1	3	7
Nonionella sp. indet.		5								
Elphidium advenum (Cushman)							1			
Elphidium cf. *advenum* (Cushman)			2							
Elphidium etigoense Husezima and Maruhasi					1		3	1		
Elphidium cf. *tsudai* Chiji and Nakaseko		4	1							
Elphidium sp. indet.		1								
Elphidiella momiyamaensis Uchio		11	8	12						
Plectofrondicularia japonica Asano					1	1	1			
Bulimina striata d'Orbigny							1	2	1	1
Bulimina striata notoensis Asano							1	5	2	3
Bulimina sp.							4		3	3
Bolivina marginata Cushman							2	2	10	3
Bolivina marginata masudai Asano					2		1	3	3	11
Bolivina robusta Brady							4	3	5	7
Bolivina cf. *robusta* Brady					1	13	1			5
Bolivina n. sp.							6			
Bolivina sp. indet.					1	1				
Reussella aculeata Cushman							3		3	
Reussella cf. *aculeata* Cushman						1				
Reussella spinulosa (Reuss)						2	2		3	1
Uvigerina crassicostata Schwager					8			1	2	7

Species \ Nos.	1	2	3	4	5	6	7	8	9	10
Uvigerina cf. *hootsi* Rankin					1		1		1	2
Uvigerina nitidula Schwager					10	10	12	29	15	10
Uvigerina cf. *subperegrina* Cushman and Kleinpell						1		1		3
Uvigerina cf. *yabei* Asano					1		1		1	
Angulogerina kokozuraensis Asano					1	1	2	5	4	7
Ellipsonodosaria lepidula (Schwager)					4	3	9		11	
Discopulvinulina sp. indet.					2					
Gyroidina soldanii d'Orbigny						2	2		2	3
Eponides frigidus (Cushman)					5	2	3	3	4	3
Eponides frigidus calidus Cushman and Cole		1			1	3	3	3	5	3
Eponides haidingerii (d'Orbigny)			1	10	1					
Eponides cf. *haidingerii* (d'Orbigny)		1								
Eponides nipponicus (Huseзima and Maruhasi)							1			
Eponides praecinctus (Karrer)			1	23	1	4	1	1		2
Eponides subpraecinctus Asano				12	1					
Eponides cf. *tanai* Uchio							2		2	
Eponides sp. indet.			1	7	4	4		4		2
Rotalia beccarii (Linnaeus)		44	48	14			8		3	4
Rotalia cf. *beccarii* (Linnaeus)						5				
Rotalia beccarii hatatatensis Takayanagi							4		4	
Rotalia takanabensis (Ishizaki)		11	17	19	7	6				
Potalia tochigiensis Uchio		68	88	42						
Baggina notoensis Asano		1		1		1	7	1	6	2
Amphistegina sp. indet.						3	1			
Epistominella japonica (Asano)					20	21	8	7	10	7
Cassidulina laevigata carinata Cushman						1				1
Cassidulina margareta Karrer							1	1		
Cassidulina pacifica Cushman							1		1	
Cassidulina subglobosa Brady					2	2	2	1	8	7
Planulina nipponica Asano						2	1			4
Planulina wuellerstorfi (Schwager)					4					
Planulina sp. indet.					1	2				
Hanzawaia nipponica Asano						18	11	9	11	11
Hanzawaia tagaensis Asano		4	9	9	32	13	5	2	4	7
Cibicides aknerianus (d'Orbigny)							1			
Cibicides lobatulus (Walker and Jacob)					2	11	2		2	5
Cibicides pseudoungerianus (Cushman)		1			7	15	3	10	4	5
Cibicides sp.							2			
Dyocibicides sp. indet.						1				
Total number of benthonic Foraminifera	0	200	200	200	200	200	200	200	200	200
Pelagic forms					2	2	20	54	34	82

The method for individual counting of the Foraminifera picked from the washed samples, is the same as used in the study of the Miyoshi Miocene Foraminifera (see the footnote of Table V). Of ten sampling horizons, four (1-4) belong to the Lower Sandstone and the remaining (5-10) to the Upper Shale.

Sampling horizons:

1- Stratigraphically about 14.5m. above the base of the Lower Sandstone, the lower division of the Bihoku group, exposed at the road cliff (Lat. 34°55′36″ N., long. 133°28′1.4″ E.) of the Daichinji-Muroyama section, Tetsuta-machi, which is situated about 6km. south of Niimi City, Okayama Prefecture.

2- Stratigraphically about 2m. above horizon 1.

3- Stratigraphically about 2.5m. above horizon 1.
4- Stratigraphically about 3.5m. above horizon 1.
5- Stratigraphically about 14m. above horizon 1, or 3.5m. above the base of the Upper Shale or the top of the Lower Sandstone.
6- Stratigraphically about 4m. above horizon 5.
7- Stratigraphically about 5m. above horizon 5.
8- Stratigraphically about 6m. above horizon 5.
9- Stratigraphically about 7m. above horizon 5.
10- Stratigraphically about 8m. above horizon 5.

Table IX represents the distribution of the percentage of the dominant genera based upon individual numbers shown in Table VIII.

TABLE IX

Distribution of the Dominant Genera of Niimi Foraminifera (Numbers; %)

Faunules / Genera \ Hor. Nos.	*Rotalia-Robulus-Elphidiella* Faunule				*Lagenonodosaria-Robulus-Uvigerina-Hanzawaia* Faunule					
	1	2	3	4	5	6	7	8	9	10
Gaudryina				0.5	0.5	1.0	3.0	0.5	3.0	4.0
Robulus		13.5	5.0	21.0	14.0	7.5	10.0	3.0	9.5	1.5
Marginulina		0.5			4.5		3.0	2.0	3.0	0.5
Lagenonodosaria					5.0	5.5	7.0	26.5	10.5	15.0
Vaginulina							1.5		1.0	
Lagena					0.5			13.5	2.5	5.5
Guttulina				0.5	0.5	1.0	1.5	0.5	1.0	
Nonion		5.0	2.5	1.0	8.0	2.5	9.0	6.5	3.0	5.5
Nonionella		7.5	4.5	2.5	6.5	8.0	2.0	0.5	1.5	3.5
Elphidium		2.5	1.5		0.5		2.0	0.5		
Elphidiella		5.5	4.0	6.0						
Bulimina							3.0	3.5	3.0	3.5
Bolivina					2.0	7.0	4.0	4.0	9.0	13.0
Reussella						1.5	2.5		3.0	0.5
Uvigerina					10.0	5.5	7.0	15.5	9.5	11.0
Angulogerina					0.5	0.5	1.0	2.5	2.0	3.5
Ellipsonodosaria					2.0	1.5	4.5		5.5	
Gyroidina					1.0	1.0	1.0		1.0	1.5
Eponides		1.0	1.5	26.0	6.5	6.5	5.0	5.5	5.5	5.0
Rotalia		61.5	76.5	37.5	3.5	5.5	6.0		3.5	2.0
Baggina		0.5		0.5		0.5	3.5	0.5	3.0	1.0
Epistominella					10.0	10.5	4.0	3.5	5.0	3.5
Cassidulina					1.0	1.5	2.0	1.0	4.5	4.0
Planulina					2.5	2.0	0.5			2.0
Hanzawaia		2.0	4.5	4.5	16.0	15.5	8.0	5.5	7.5	9.0
Cibicides		0.5			4.5	13.0	4.0	5.0	3.0	5.0

The sequence of the foraminiferal assemblages in ascending order are the following two faunules; 1) *Rotalia-Robulus-Elphidiella* faunule, and 2) *Lagenonodosaria-Robulus-Uvigerina-Hanzawaia* faunule. Pelagic forms occur in company with faunule 2).

In the Niimi section, the Lower Sandstone is characterized with faunule 1) and the Upper Shale with faunule 2).

4) Tsuyama Miocene Foraminifera.

In a previous report (TAI, 1954), the writer treated the Miocene Foraminifera from the Bihoku group exposed at the northern cliff of the Yoshino Primary School, Shoô-machi, Katsuta-gun, Okayama Prefecture. At the same time, 117 species were listed from the Yoshio Miocene as shown in Table II. Table X shows the distribution of the percentage of the dominant genera based upon individual numbers of these species (see Table II). The sequence of the foraminiferal assemblages in ascending order are the following two faunules; namely, 1) *Operculina-Rotalia* faunule, containing horizons D and E, and 2) *Robulus-Nonion-Gaudryina-Uvigerina* faunule, containing F-I. Pelagic Foraminifera occur very abundantly in company with faunule 2). In the Yoshino section in the central Tsuyama basin, the Lower Sandstone is characterized with faunule 1), and the Upper Shale with faunule 2). The microbiostratigraphical position of the two Yoshino faunules within the Tsuyama basin is discussed in the following pages.

TABLE X

Distribution of the Dominant Genera of Tsuyama Foraminifera (Yoshino Area) (Numbers; %)

Genera \ Faunules / Hors.	*Operculina-Rotalia* Faunule		*Robulus-Nonion-Gaudryina-Uvigerina* Faunule			
	D	E	F	G	H	I
Haplophragmoides			0.9	3.2	2.1	1.2
Cyclammina			0.3	4.7	2.7	0.5
Gaudryina			13.7	8.1	0.5	13.9
Martinottiella			3.8	8.3	6.6	7.7
Sigmoilina		0.4	2.4	0.3		3.9
Robulus			17.0	5.2	26.6	14.5
Marginulina			2.3	0.9	3.5	0.9
Dentalina			3.0	2.6	4.8	2.2
Nodosaria			3.4	2.5	0.3	1.7
Lagenonodosaria			3.9	3.3	6.4	4.4
Vaginulina			7.6	2.8	3.2	2.2
Guttulina			0.9	1.1	3.5	0.5
Nonion		3.6	2.0	11.7	24.2	5.3
Bulimina			1.3	2.3		7.5
Bolivina			0.3			4.2
Uvigerina			5.6	15.3	1.1	5.5
Ellipsonodosaria			1.7	8.7	0.5	10.0
Gyroidina		1.6	2.3	0.7		
Eponides			5.7	1.1	2.4	0.9
Rotalia	100.0	85.8	5.4	1.6	6.4	1.1
Baggina			0.5	1.8		1.8
Cassidulina			1.0	6.0	1.6	0.5
Planulina			4.1	1.3	0.3	
Hanzawaia		4.5	4.5	3.8	2.7	1.1
Cibicides		2.8	3.5	1.5	0.3	6.9

The writer, because of additional foraminiferal data from the Tsuyama basin, again treats the Bihoku group distributed at Yasuda, Tsuyama City, Okayama Prefecture. The 74 species of Foraminifera picked from the washed seven samples are listed in Table XI.

TABLE XI

Check List of the Miocene Smaller Foraminifera from the Bihoku Group Exposed at Yasuda, Tsuyama City in the Tsuyama Basin, Okayama Prefecture

Species \ Hor. Nos.	1	2	3	4	5	6	7
Bathysiphon sp. indet.	13	9	3	2	3		
Ammodiscoides sp. indet.			1				
Haplophragmoides renzi Asano					1		1
Haplophragmoides sp. indet.	10	13	71	6	11	10	14
Cribrostomoides cf. *kyushuense* Asano							1
Cribrostomoides sp. indet.							20
Cyclammina incisa (Stache)	1	3	1		1		1
Cyclammina pusilla Brady	1		11				
Cyclammina sp. indet.		1	2	1	1	2	1
Plectina nipponica Asano		2	13	15	9		13
Plectina sp. indet.	3		9	59	35	1	26
Goësella schencki Asano			18	11	21		3
Goësella sp. indet.		1		9			
Martinottiella communis (d'Orbigny)	35	32	45	1			
Martinottiella sp. indet.	1					1	1
Schenckiella victoriensis? (Cushman)			1				
Quinqueloculina sp. indet.	5	5					
Spiroloculina communis incisa Cushman		1					
Sigmoilina imamurai Tai	5	9					
Sigmoilina schlumbergeri Silvestri	2						
Trochammina sp. indet.	7	5	25	41	25	12	34
Arenaceous Foraminifera ge. et sp. indet.				55	93	24	85
Robulus cf. *iotus* (Cushman)	1						
Robulus javana simplex (Koch)	1						
Robulus lucidus (Cushman)	7	4					
Robulus cf. *nikobarensis* (Schwager)		1					
Robulus sp. indet.	18	16					
Marginulina aculeata Neugeboren	1	1					
Marginulina cf. *glabra* d'Orbigny		4					
Marginulina sp. indet.	1	1					
Dentalina subsoluta (Cushman)	1						
Nodosaria longiscata d'Orbigny	1						
Nodosaria cf. *longiscata* d'Orbigny		1					
Nodosaria pyrula d'Orbigny		2					
Nodosaria cf. *pyrula* d'Orbigny	1						
Lagenonodosaria scalaris (Batsch)	8	9					
Vaginulina? sp. indet.	2						
Lagena striata (d'Orbigny)	1						
Lagena sulcata spicata Cushman and McCulloch	1	2					
Lagena sp. indet.	1	2					
Guttulina sp. indet.	1						
Nonion pompilioides (Fichtel and Moll)	2	9					
Nonionella miocenica Cushman		1					
Nonionella sp. indet.		2					
Elphidium cf. *clavatum* Cushman	2	1					
Cribroelphidium sp. indet.	1						
Bulimina striata notoensis Asano	3						
Entosolenia sp. indet.		1					
Virgulina sp. indet.		1					
Uvigerina cf. *proboscidea* Schwager		1					
Angulogerina kokozuraensis Asano		1					
Angulogerina sp. indet.	1						

Species \ Hor. Nos.	1	2	3	4	5	6	7
Ellipsonodosaria lepidula (Schwager)	3	3					
Discopulvinulina sp. indet.		3					
Valvulineria sp. indet.		1					
Eponides frigidus (Cushman)	3	2					
Eponides frigidus calidus Cushman and Cole		2					
Eponides haidingerii (d'Orbigny)	3						
Eponides praecinctus (Karrer)	8	3					
Eponides subpraecinctus Asano	5						
Eponides tanai Uchio	3						
Eponides sp. indet.	2	2					
Rotalia sp. indet.		1					
Baggina notoensis Asano		1					
Epistominella sp. indet.		2					
Cassidulina laevigata carinata Cushman	8	6					
Cassidulina subglobosa Brady	1	3					
Cassidulina sp. indet.		3					
Planulina nipponica Asano	3	2					
Planulina sp. indet.	1						
Hanzawaia tagaensis Asano	1	1					
Cibicides cf. *aknerianus* (d'Orbigny)		7					
Cibicides lobatulus (Walker and Jacob)	9	5					
Cibicides pseudoungerianus (Cushman)	10	11					
Cibicides sp. indet.	2	1					
Total number of benthonic Foraminifera	200	200	200	200	200	50	200
Pelagic forms	425	4			1		

The method for individual counting of the Foraminifera is the same as used in the study of the Miyoshi Miocene Foraminifera (see the footnote of Table V). All sampling horizons (1-7) here belong to the Upper Shale, the upper division of the Bihoku group. Unfortunately, the Lower Sandstone, the lower division of the same group, yielded no Foraminifera.

Sampling horizons:

1- Stratigraphically about 13m. above the base of the Lower Sandstone, or 2m. above the base of the Upper Shale, exposed at Yasuda, Tsuyama City in the Tsuyama basin, Okayama Prefecture. Locality; (Lat. 35°6′54″ N., long. 134°1′35.9″ E.)
2- Stratigraphically about 1m. above horizon 1.
3- Stratigraphically about 60m. above horizon 1.
4- Stratigraphically about 61m. above horizon 1.
5- Stratigraphically about 62m. above horizon 1.
6- Stratigraphically about 66m. above horizon 1.
7- Stratigraphically about 67m. above horizon 1.

Table XII shows the distribution of the percentage of the dominant genera based upon individual numbers given in Table XI.

TABLE XII

Distribution of the Dominant Genera of Tsuyama Foraminifera (Yasuda Area) (Numbers; %)

Genera \ Faunules / Hor. Nos.	*Martinottiella-Robulus-Eponides-Cibicides* Faunule		*Plectina-Trochammina-Haplophragmoides* Faunule				
	1	2	3	4	5	6	7
Bathysiphon	6.5	4.5	1.5	1.0	1.5		
Haplophragmoides	5.0	6.5	35.5	3.0	6.0	20.0	7.5
Cyclammina	1.0	2.0	7.0	0.5	1.0	4.0	1.0
Plectina	1.5	1.0	11.0	37.0	22.0	2.0	19.5
Goëssella		0.5	9.0	10.0	10.5		1.5
Martinottiella	18.0	16.0	22.5	0.5		2.0	0.5
Sigmoilina	3.5	4.5					
Trochammina	3.5	2.5	12.5	20.5	12.5	24.0	17.0
Robulus	13.5	10.5					
Marginulina	1.0	3.0					
Nodosaria	1.0	1.5					
Lagenonodosaria	4.0	4.5					
Lagena	1.5	2.0					
Nonion	1.0	4.5					
Ellipsonodosaria	1.5	1.5					
Eponides	12.0	4.5					
Cassidulina	4.5	6.0					
Planulina	2.0	1.0					
Cibicides	10.5	12.0					

From Table XII, the sequence of the foraminiferal assemblages in ascending order are the following two faunules; 1) *Martinottiella-Robulus-Eponides-Cibicides* faunule, and 2) *Plectina-Trochammina-Haplophragmoides* faunule. Pelagic Foraminifera occur remarkably in company with faunule 1) above. In other words, pelagic forms occur from about the base of the Upper Shale in the Yasuda section.

As to the relation between the two Yoshino faunules recognized previously (Table X) and the present two faunules, the writer concludes that microbiostratigraphically the present two faunules are superposed conformably above the two of the Yoshino. Permitting the four faunules, the two Yoshino faunules plus the two of Yasuda, for the whole Tsuyama microfaunal sequence, this foraminiferal sequence corresponds with the four faunules recognized from a cliff in the Miyoshi basin.

5) Nara Miocene Foraminifera.

The foraminiferal samples examined are from the Miocene Fujiwara group exposed along the southern cliffs in the Fujiwara Rifle-Range of Furuichi, Nara City, Nara Prefecture. Smaller Foraminifera picked from the washed samples are listed in Table XIII.

TABLE XIII

Check List of the Miocene Smaller Foraminifera from the Fujiwara Group in Furuichi, Nara City, Nara Prefecture

Species \ Hor. Nos.	1	2	3	4	5	6	7	8	9	10
Cyclammina incisa (Stache)		1	1							1
Textularia lythostrota (Schwager)										1

Species \ Hor. Nos.	1	2	3	4	5	6	7	8	9	10
Gaudryina (*Pseudogaudryina*) *ishikiensis* Asano					1	4	8	1	10	5
Gaudryina (*Pseudogaudryina*) cf. *oga* Asano							1			
Gaudryina yabei Asano									2	
Gaudryina cf. *yabei* Asano								2		
Gaudryinella tsuchidai Uchio										1
Spiroloculina communis incisa Cushman									1	4
Spiroloculina sp. indet.									2	
Sigmoilina imamurai Tai									1	
Sigmoilina tenuis (Czizek)									1	1
Sigmoilina sp. indet.					1					
Pyrgo sp. indet.									1	
Trochammina? sp. indet.	1									
Robulus bicostatus Asano										1
Robulus calcar (Linnaeus)									1	1
Robulus cf. *iotus* (Cushman)									3	3
Robulus javana simplex (Koch)							1		5	5
Robulus lucidus (Cushman)		4			2	6	2	5	6	2
Robulus nikobarensis (Schwager)	2	8	3			1	2	2	4	4
Robulus cf. *notoensis* Asano										2
Robulus pseudorotulatus Asano									7	5
Robulus cf. *surugaensis* Asano					1					
Robulus yoshitakiensis Chiji and Nakaseko										1
Robulus n. sp. α					2					3
Robulus n. sp. β										5
Robulus sp. indet.		4	5			1	10	15	6	
Marginulina aculeata Neugeboren					1					
Marginulina cf. *glabra* d'Orbigny										1
Marginulina masudai Asano									1	
Marginulina sp. indet.					1					
Dentalina insecta (Schwager)										1
Dentalina cf. *soluta* Asano									2	
Dentalina sp. indet.					1					
Nodosaria longiscata d'Orbigny								1		
Nodosaria cf. *longiscata* d'Orbigny										1
Nodosaria notoensis Asano			1						3	3
Nodosaria pyrula d'Orbigny									2	
Nodosaria vertebralis (Batsch)										3
Nodosaria sp. indet.					1				1	1
Lagenonodosaria fukushimaensis Asano					2					
Lagenonodosaria scalaris (Batsch)								1		
Lagenonodosaria scalaris sagamiensis Asano						1			4	4
Lagenonodosaria sp. indet.									1	
Saracenaria akitaensis Iwasa and Kikuchi									4	
Saracenaria sp. indet.						1				
Vaginulina cf. *yoshihamaensis* Inoue and Nakaseko						1	6	5	3	
Vaginulina sp. indet.										1
Lagena acuticosta Reuss									5	
Lagena laevis (Montagu)									3	
Lagena cf. *laevis* (Montagu)						2		1		1
Lagena perlucida (Montagu)									2	1
Lagena striata (d'Orbigny)										4
Lagena sulcata spicata Cushman and McCulloch									1	1
Lagena sp. indet.									2	
Guttulina irregularis (d'Orbigny)								1	1	
Guttulina cf. *kishinouyi* Cushman and Ozawa									1	
Guttulina sp. indet.						1				
Nonion japonicum Asano					3	4				
Nonion nakosoense Asano					1	4			3	

Species \ Hor. Nos.	1	2	3	4	5	6	7	8	9	10
Nonion scaphum (Fichtel and Moll)					1	1		2	1	
Nonion umbilicatulum (Montagu)					1					1
Nonion sp. indet.						1				
Nonionella miocenica Cushman					11	3	2		3	2
Nonionella sp. indet.					1					
Elphidium tsudai Chiji and Nakaseko					1					
Elphidium sp. indet.					1					
Elphidiella momiyamaensis Uchio					1					
Bolivina cf. *robusta* Brady					3	1			1	3
Reussella sp.										1
Uvigerina crassicostata Schwager					9	67	4	4	7	5
Uvigerina cf. *hootsi* Rankin										1
Uvigerina nitidula Schwager					6	23	1	5	3	3
Uvigerina subperegrina Cushman and Kleinpell					6		1	2	2	2
Uvigerina yabei Asano						12				
Hopkinsina sp. indet.				1						
Angulogerina cf. *occidentalis* (Cushman)							1			
Angulogerina sp. indet.						1				
Ellipsonodosaria lepidula (Schwager)						1			1	1
Ellipsonodosaria sp. indet.					1	1		1		
Discorbis cf. *opercularis* (d'Orbigny)									2	
Discopulvinulina? sp. indet.					1					
Valvulineria sadonica Asano					2					
Valvulineria? sp. indet.						1				
Gyroidina soldanii d'Orbigny									4	5
Gyroidina sp. indet.					1					
Eponides frigidus (Cushman)					4	13		1	1	4
Eponides frigidus calidus Cushman and Cole							2	10	1	1
Eponides praecinctus (Karrer)										2
Eponides n. sp. α									2	1
Eponides n. sp. β										1
Eponides sp. indet.					1				3	
Rotalia beccarii hatatatensis Takayanagi									2	1
Rotalia inflata (Seguenza)						1	4			
Rotalia cf. *inflata* (Seguenza)								3		
Rotalia takanabensis (Ishizaki)					3	2	3		6	3
Rotalia tochigiensis Uchio					2	1				1
Rotalia sp. indet.							1			
Baggina notoensis Asano										3
Epistominella japonica (Asano)										5
Epistominella cf. *japonica* (Asano)									3	
Cassidulina margareta Karrer					1				2	1
Cassidulina pacifica Cushman									2	
Cassidulina subglobosa Brady									19	18
Pullenia quinqueloba (Reuss)									1	
Planulina nipponica Asano									1	
Planulina wuellerstorfi (Schwager)					4	12		4		
Planulina sp. indet.						4		1	2	
Hanzawaia nipponica Asano					4	7	9	2	6	11
Hanzawaia tagaensis Asano					2	6		1		2
Hanzawaia cf. *tagaensis* Asano							1			
Hanzawaia sp. indet.						3				
Cibicides lobatulus (Walker and Jacob)				1	9	2		13	4	10
Cibicides pseudoungerianus (Cushman)					9	11		25	31	44
Dyocibicides biserialis Cushman and Valentine									1	
Dyocibicides perforata Cushman and Valentine										1
Total number of benthonic Foraminifera	3	17	10	2	102	200	59	108	200	200
Pelagic forms					2	23	14	3	246	307

The method for individual counting of the Foraminifera, is the same as used in the study of the Miyoshi Miocene Foraminifera (see the footnote of Table V). All sampling horizons belong to the Toyoda formation, the upper division of the Fujiwara group.

Sampling horizons:

1- A sandstone of the Toyoda formation exposed at the floor of the stream about 150m. NNE of the cliff (Lat. 34°39′3″ N., long. 135°51′10.4″ E.), at the southeast corner of the Fujiwara Rifle-Range in Furuichi, Nara City, Nara Prefecture.
2- Stratigraphically about 10m. above horizon 1.
3- Stratigraphically about 15m. above horizon 1.
4- A very fine-grained sandstone of the Toyoda formation, the upper division of the Fujiwara group, exposed at the same locality as the cliff of the Fujiwara Rifle-Range mentioned in horizon 1 above.
5- Stratigraphically about 4m. above horizon 4.
6- Stratigraphically about 10m. above horizon 4.
7- Stratigraphically about 13m. above horizon 4.
8- Stratigraphically about 19m. above horizon 4.
9- Stratigraphically about 39m. above horizon 4.
10- Stratigraphically about 44m. above horizon 4.

Table XIV shows the distribution of the percentage of the dominant genera, based upon individual numbers shown in Table XIII.

The sequence of the foraminiferal assemblages are the following two faunules; namely, 1) *Robulus* faunule below and 2) *Robulus-Cibicides-Uvigerina* faunule above. Of both faunules, the latter is subdivided into two subfaunules, namely, *Hanzawaia-Rotalia-Nonionella* subfaunule below and *Cassidulina-Lagena* subfaunule above. Pelagic Foraminifera first occur from the sampling horizon 5 as shown in Table XIII. This stratigraphic position falls within the lowest horizon of the faunule 2) mentioned above. Unfortunately, the Iwabuchi formation, the lower division of the Fujiwara group, yielded no Foraminifera to the writer.

TABLE XIV

Distribution of the Dominant Genera of Nara Foraminifera (Numbers; %)

Faunules / Hor. Nos. / Genera	*Robulus* Faunule				*Robulus-Cibicides-Uvigerina* Faunule					
					Low. Subf.				Up. Subf.	
	1	2	3	4	5	6	7	8	9	10
Gaudryina					1.0	2.0	15.0	2.7	6.0	2.5
Robulus	66.0	94.0	80.0		5.0	4.0	25.0	20.0	16.0	16.0
Nodosaria			10.0		1.0			0.9	3.0	4.0
Lagenonodosaria					2.0	0.5		0.9	2.5	2.0
Vaginulina						0.5	10.0	4.5	1.5	0.5
Lagena						1.0		0.9	6.5	3.5
Nonion					6.0	5.0		1.8	2.0	0.5
Nonionella					12.0	1.5	3.3		1.5	1.0
Uvigerina					21.0	51.0	10.0	10.0	6.0	5.5
Eponides					5.0	6.5	3.3	10.0	2.5	4.0
Rotalia					5.0	2.0	13.3	2.7	4.0	2.5
Cassidulina					1.0				11.5	9.5
Planulina					4.0	8.0		4.5	1.5	
Hanzawaia					6.0	8.0	16.7	2.7	3.0	6.5
Cibicides				50.0	18.0	6.5		31.5	18.5	27.5

22. OKAMOTO, K. and TAI, Y., 1957, Miocene Smaller Foraminifera from the Tamatsukuri Group in the Area South of Izumo City, Shimane Prefecture: *Jour. Geol. Soc. Japan*, vol. 63, pp. 340-356 (in Japanese).

In this report, the writers discuss the smaller Foraminifera from several horizons of the middle Miocene Tamatsukuri group (=the Kawai and Kuri formations combined) distributed in the area south of Izumo City, Shimane Prefecture. Foraminiferan fossils were collected from the strata transitional from the upper part of the lower Tamatsukuri formation (=the Kawai formation) to the lower part of the upper Tamatsukuri formation (=the Kuri formation), along the Hiebara River in this area.

The fauna is divided into two foraminiferal assemblages, the lower and upper. The lower assemblage is characterized by having a large number of *Rotalia* and, as a whole, a comparatively small number of genera, species, and individuals, and by the pelagic forms.

In the upper assemblage, the family Lagenidae represents the largest number of genera, species, and individuals. In other families, *Baggina*, *Bathysiphon*, *Cibicides*, *Cyclammina*, *Eponides*, *Gaudryina*, *Hanzawaia*, *Haplophragmoides*, *Nonion*, *Rotalia*, *Sigmoilina*, and *Uvigerina* are worth mentioning with regard to the number of species and individuals; pelagic forms also occur in association.

Compared with the microbiostratigraphical units established by TAI (1956) in the Chûgoku District, the lower foraminiferal assemblage seems to correspond to his *Miogypsina kotoi-Operculina complanata japonica* zonule, and the upper one to his *Lagenonodosaria scalaris-Uvigerina crassicostata* zonule.

From the depth analysis of the genera from both assemblages, the sedimentary environments of the transitional sediments above mentioned, evidently represent conditions which gradually change from those of shallow littoral water to those of the open sea or outer neritic region. The fauna flourished under warm thermal conditions.

The writers conclude that the present fauna is very similar to those of the middle Miocene sediments of the Bihoku group of the Shôbara basin, Hiroshima Prefecture, and of the Tsuyama basin, Okayama Prefecture. Further, of the 142 species discriminated among the present fauna, 70 occur in the fauna reported by ASANO (1953) from the upper part of the middle Miocene Higashi-innai and Najimi formations in Noto Peninsula, Ishikawa Prefecture. This large number of species in common between the present and the Noto faunas are considered to indicate remarkable similarity in the conditions of deposition and environments of the foraminiferal faunas of the two geographically separated middle Miocene areas.

Smaller Foraminifera picked from the washed 23 samples are listed in Table XV.

Of 23 sampling horizons, 15 horizons (1–15) belong to the lower Tamatsukuri formation (=the Kawai formation) and the remaining (16–23) to the upper Tamatsukuri formation (=the Kuri formation).

TABLE XV

Check List of the Miocene Smaller Foraminifera from the "Tamatsukuri" Formation
Distributed in the Area South of Izumo City, Shimane Prefecture

Species \ Formation / Horizons	Lower Tamatsukuri Formation															Upper Tamatsukuri Formation							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Bathysiphon sp.								22				4	3	13	2	49	7	50	39	9	18	22	
Bathysiphon? sp.								5				1									2		1
Ammodiscus sp.									1														
Ammodiscus? sp.																							1
Haplophragmoides cf. *trullissatum* (Brady)			1									1					1		4			2	
Haplophragmoides sp.		1		1			7	28	13	2		6	11	13	31	86	79	36	42	49	22	35	
Haplophragmoides? sp.									4	4				12			12	7	10	9		26	
Cribrostomoides kyushuense Asano									1				3										
Cribrostomoides cf. *kyushuense* Asano								9											1		1		
Ammobaculites cf. *catenulatus* Cushman and McCulloch													1										
Ammobaculites sp.								1	1				1			2					1		
Cyclammina cf. *ezoensis* Asano								11	1	1		2			4	3	13		1	9		3	
Cyclammina incisa (Stache)						1		2	16				3	5	3	2	32	1		3	5	8	2
Cyclammina cf. *incisa* (Stache)						15		5	7	1			1	1	4	20			6	4	4	9	
Cyclammina cf. *japonica* Asano		1					3	4	3	2					6	7	1		1	3		4	
Cyclammina sp. indet.		1			1			6						6	11	6	10		2	13	3	10	
Cyclammina? sp.				1								1						1	1	9			
Textularia lythostrota (Schwager)									2														
Textularia sp.									3														
Gaudryina ishikiensis Asano								27	31				23	5	4	5	19	57	3			1	
Gaudryina cf. *oga* Asano																4			1				
Gaudryina cf. *yabei* Asano													1				1	1					
Gaudryina sp. indet.							3		5														
Gaudryina? sp.			1							2													
Plectina nipponica Asano									3				2		3							1	
Plectina cf. *nipponica* Asano						7				1													
Plectina sp. indet.									4						1	3							
Plectina? sp.															4								
Goësella schenzki Asano		1											1										
Goësella? sp.																							1
Martinottiella communis (d'Orbigny)																				1			5
Martinottiella cf. *communis* (d'Orbigny)														1									5
Martinottiella? sp.																2				3			
Quinqueloculina sp. indet.								3										2					

Sigmoilina imamurai Tai								5					6	1	1	1		14	9	13	8	1	
Sigmoilina cf. *imamurai* Tai																	3						
Sigmoilina schlumbergeri Silvestri								16				2	1	1	2	2	44	4	3	7	3	1	2
Spiloroculina communis Cushman and Todd															1								
Spiloroculina communis incisa Cushman								6															
Spiloroculina cf. *communis incisa* Cushman																				1			
Spiloroculina? sp.																			1				
Pyrgo sp. indet.								1										1					
Trochammina sp.															13		11	2	2	8			1
Trochammina? sp.																	1						
Robulus asanoi Takayanagi								2											1				
Robulus cf. *asanoi* Takayanagi																		6					
Robulus cf. *calcar* (Linnaeus)																			1				
Robulus iotus (Cushman)								3						2			2						
Robulus cf. *iotus* (Cushman)																		1					
Robulus izumoensis n. sp. (MS)								4						1	1		1	4	3				
Robulus javana (Koch) var.								170					3	19	12		6	50	22	2	3		
Robulus lucidus (Cushman)								12			1			3	5			19	6	3			1
Robulus cf. *lucidus* (Cushman)														1									
Robulus nikobarensis (Schwager)								14						2	5			2	2				1
Robulus notoensis Asano																		1					
Robulus noziriensis n. sp. (MS)																			2				
Robulus orbicularis (d'Orbigny)								20						5				5	14				
Robulus cf. *orbicularis* (d'Orbigny)													5		1			4					
Robulus pseudorotulatus Asano								4					2	5				2					
Robulus cf. *surugaensis* Asano								6															
Robulus yoshitakiensis Chiji and Nakaseko								1					1										
Robulus cf. *yoshitakiensis* Chiji and Nakaseko																			2				
Robulus sp.														1									
Robulus sp. indet.								33	7			10	11	46	14		2	18	33	35	16		1
Saracenaria sp. indet.								1													1		
Vaginulina yoshihamaensis Inoue and Nakaseko																			1				
Vaginulina sp. indet.															1			1			1		
Marginulina aculeata Neugeboren								15	1				16	3			1	1					
Marginulina cf. *aculeata* Neugeboren															10								
Marginulina masudai Asano																			3				
Marginulina cf. *masudai* Asano																				2			
Marginulina mukaei n. sp. (MS)								21					2	5	6			21	5				2
Marginulina cf. *nakamurai* (Asano)																			1				
Marginulina sendaiensis Asano																			6				

Species \ Formation / Horizons	Lower Tamatsukuri Formation															Upper Tamatsukuri Formation							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Marginulina sp. indet.								7	2				9	1	2		1	5	5	11			
Pseudoglandulina laevigata (d'Orbigny)								6	5				1		1								
Pseudoglandulina sp. indet.														1									
Lagenonodosaria fukushimaensis Asano								2	6			3	2		15			27					
Lagenonodosaria cf. *fukushimaensis* Asano																							1
Lagenonodosaria scalaris (Batsch)																		2					
Lagenonodosaria scalaris sagamiensis Asano								19	110			2	33	21	25			21	4	16			6
Lagenonodosaria sp. indet.					4	2		18	171			2	23	5	50		4	4	21	10	5		9
Lagenonodosaria? sp.			1																				
Nodosaria longiscata d'Orbigny								2											2				
Nodosaria pyrula d'Orbigny								35				1	1	15	10		2	44	12	5	1		1
Nodosaria sp. indet.						1			1			1	1					1	3	1			
Dentalina communis d'Orbigny								1										2					
Dentalina cf. *communis* d'Orbigny														2									
Dentalina subsoluta (Cushman)																		6					
Dentalina cf. *subsoluta* (Cushman)													1					4					
Dentalina tauricornis (Schwager)																			1				
Dentalina sp. indet.				2	1			3	6				14	2	1		1	5			1		1
Dentalina? sp.				1								1						1					
Ellipsonodosaria japonica Ishizaki								1						1				2					
Ellipsonodosaria cf. *japonica* Ishizaki															2		1	1					
Ellipsonodosaria lepidula (Schwager)								2						3				3	1				
Ellipsonodosaria sp. indet.						1									1			3		2			
Ellipsonodosaria? sp.																		1					
Lagena laevis (Montagu)																		5					
Lagena perlucida (Montagu)								4						2	1		1	1					1
Lagena striata (d'Orbigny)								3						3					1				
Lagena cf. *striata* (d'Orbigny)																					1		
Lagena sulcata spicata Cushman and McCulloch																	1	4					
Lagena cf. *sulcata spicata* Cushman and McCulloch														5									
Lagena sp. indet.													4					23	1				
Lagena? sp.																		14					1
Entosolenia cf. *orbignyana* (Seguenza)																	1						
Plectofrondicularia longistriata LeRoy														2				6	4	1	1		
Guttulina cf. *irregularis* (d'Orbigny)														5					2				
Guttulina sp. indet.								36	2				2		7								

Nonion japonicum Asano						1		73	38			2	8	6	11		4	105	41		4		1
Nonion cf. *japonicum* Asano																			3		2		1
Nonion nakosoense Asano								17				1	4				2	32	3				
Nonion cf. *nakosoense* Asano																							1
Nonion scaphum (Fichtel and Moll)								1					1	1				3					
Nonion cf. *scaphum* (Fichtel and Moll)								2							1								
Nonion umbilicatulum (Montagu)								6						1					1				
Nonion sp. indet.						1		12				3	2	1			1	14	8		8		
Nonionella miocenica Cushman								22	2				4	4	1		1	1	1				
Nonionella cf. *miocenica* Cushman																					1		
Nonionella sp. indet.									1						1			4	1				
Nonionella? sp.																		1					
Elphidium advenum (Cushman)								1					1	7	7			3					
Elphidium cf. *advenum* (Cushman)																			3				
Elphidium sp.																							1
Elphidiella momiyamaensis Uchio													3	1									
Bulimina pyrula d'Orbigny																							1
Bulimina sp. indet.																			1				
Bulimina? sp.													1										
Globobulimina perversa (Cushman)																	5						
Globobulimina sp. indet.													1										
Globobulimina? sp.																		28					
Virgulina complanata Egger															1								
Bolivina marginata Cushman																		5					
Bolivina marginata masudai Asano								1										11		2			
Bolivina robusta kusumii n. subsp. (MS)						1		6	1					6			3		8				
Uvigerina crassicostata Schwager								21						1				6	3	3			
Uvigerina cf. *hootsi* Rankin								23					10	34	1			26	4	21	8		1
Uvigerina nitidula Schwager																				1			
Uvigerina cf. *nitidula* Schwager																			1				
Uvigerina proboscidea Schwager								34	1				11		7			27	3				3
Uvigerina segundoensis Cushman and Galliher													1										
Uvigerina subperegrina Cushman and Kleinpell																			3				
Uvigerina cf. *yabei* Asano																		4					
Hopkinsina hispida (Schwager)													1										
Angulogerina kokozuraensis Asano																		5					
Angulogerina sp. indet.									1														1
Discopulvinulina cf. *isabelleana* (d'Orbigny)																		1					
Discopulvinulina sp. indet.															1								
Gyroidina nipponica Ishizaki								1															

Species \ Formation / Horizons	Lower Tamatsukuri Formation															Upper Tamatsukuri Formation							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Gyroidina cf. *nipponica* Ishizaki								1															
Gyroidina soldanii d'Orbigny								32							4		1	56					
Gyroidina cf. *soldanii* d'Orbigny														1									
Eponides cf. *bengarensis* (Schwager)								9											8				
Eponides frigidus (Cushman)						1		54	34				28	59	5		2	11	1	1	1		15
Eponides haidingerii (d'Orbigny)												11						2					
Eponides nipponicus (Husezima and Maruhasi)								9						6			3						
Eponides cf. *nipponicus* (Husezima and Maruhasi)																		1			1		
Eponides praecinctus (Karrer)								6				3	55	2	3			13	2	10	2		
Eponides cf. *praecinctus* (Karrer)																		6					
Eponides umbonatus (Reuss)								3	1					1									
Eponides sp. indet.						2		3				4	3		1		1		1	5	17		1
Potalia cf. *inflata* (Seguenza)						12																	
Potalia takanabensis (Ishizaki)						20		71	7				230	117			4	98	27	8	24		
Rotalia cf. *takanabensis* (Ishizaki)						2			7						71					2			
Potalia sp. indet.						6		1	21					13				4			4		
Cancris auriculus (Fichtel and Moll)								1															
Cancris sp. indet.														1									
Baggina notoensis Asano								28	10			15	62	1	21		3	29	28	6	1		
Baggina sp. indet.								13				2		6	9			11	15	1			
Baggina? sp.																		1		1			
Cassidulina laevigata carinata Cushman									8														
Cassidulina cf. *margareta* Karrer																					1		
Cassidulina cf. *orientale* Cushman								1															
Cassidulina subglobosa Brady								2						1				5	9				
Cassidulina cf. *subglobosa* Brady																				3			
Cassidulina sp. indet.													1										
Cassidulina? sp.												2						1					
Cassidulinoides miuraensis Higuchi								1															
Sphaeroidina japonica Asano																							18
Sphaeroidina sp.								2															1
Anomalina? sp.																							1
Planulina wuellerstorfi (Schwager)								8						9	2			5					
Planulina sp. indet.								1							1				2				
Hanzawaia tagaensis Asano								56						9				39					
Cibicides aknerianus (d'Orbigny)																		1					

Cibicides lobatulus (Walker and Jacob)								14					1	5			1	14	16	2	2		
Cibicides cf. *lobatulus* (Walker and Jacob)								4											6				
Cibicides (?) *omurai* Asano and Inomata																			5				
Cibicides pseudoungerianus (Cushman)								5						7	3			28	36				1
Cibicides cf. *pseudoungerianus* (Cushman)																			1				
Cibicides sp. indet.													1	1				2	3		1		
The total number of specimens (Benthonic Foraminifera)	0	4	3	5	6	73	13	1148	541	13	1	80	617	520	411	192	289	1099	529	295	174	123	90
Globigerinidae:								61						3	1			45	13	6	1		2

23 samples, each weighing 200 grams, were first washed, sieved and then dried in an incubator. The dried materials were respectively divided into two equal parts, and a half part of each sample was examined under the binocular microscope for individual counting of the Foraminifera. As a result of quantitative analysis of the foraminiferal fauna from each sampling horizon, the species and their individual numbers are indicated in this Table.

Sampling horizons:

1- A tuffaceous coarse-grained sandstone of the Lower Tamatsukuri formation (=the Kawai formation) exposed at the floor (Lat. 35°17′6″ N., long. 132°48′16.4″ E.) of Hiebara River in Hiebara, south of Izumo City, Shimane Prefecture.
2- Stratigraphically about 3.5m. above horizon 1.
3- Stratigraphically about 5.5m. above horizon 1.
4- Stratigraphically about 7.5m. above horizon 1.
5- Stratigraphically about 9.5m. above horizon 1.
6- Stratigraphically about 11.5m. above horizon 1.
7- Stratigraphically about 13.5m. above horizon 1.
8- Stratigraphically about 15.5m. above horizon 1.
9- Stratigraphically about 17.5m. above horizon 1.
10- Stratigraphically about 19.5m. above horizon 1.
11- Stratigraphically about 21.5m. above horizon 1.
12- Stratigraphically about 23.5m. above horizon 1.
13- Stratigraphically about 25.5m. above horizon 1.
14- Stratigraphically about 27.5m. above horizon 1.
15- Stratigraphically about 29.5m. above horizon 1.
16- Stratigraphically about 31.5m. above horizon 1.
17- Stratigraphically about 33.5m. above horizon 1.
18- Stratigraphically about 35.5m. above horizon 1.
19- Stratigraphically about 37.5m. above horizon 1.
20- Stratigraphically about 39.5m. above horizon 1.
21- Stratigraphically about 41.5m. above horizon 1.
22- Stratigraphically about 43.5m. above horizon 1.
23- A shale of the upper Tamatsukuri formation (=the Kuri formation) exposed at the floor (Lat. 35°16′36″ N., long. 132°47′9.2″ E.) of Ono River in Mimigu, south of Izumo City, or about southwest 2km. of the locality of the horizon 1, Shimane Prefecture.

From the vertical distribution of the Foraminifera listed in Table XV, four foraminiferal assemblages were distinguished, in ascending order, namely, 1) *Rotalia* faunule, 2) *Robulus-Rotalia-Lagenonodosaria-Eponides* faunule, 3) *Robulus-Haplophragmoides-Lagenonodosaria-Nonion* faunule, and 4) *Haplophragmoides-Cyclammina-Bathysiphon* faunule. Their stratigraphic arrangement is indicated in Plate 38.

1958

23. TAI, Y., 1958, On "the Togarian Stage"——Miocene Microbiostratigraphy of the Setouchi Geologic Province-: *Jour. Geol. Soc. Japan*, vol. 64, pp. 516-525 (in Japanese).

In this report, Y. TAI first treats the Foraminifera from several horizons of the type section of the middle Miocene Mizunami group distributed in the area north of Mizunami City, Gifu Prefecture.

The fauna is divided into five foraminiferal faunules, namely, *Elphidium-*, *Nonion-Elphidium-Eponides-*, *Lagena-Rotalia-Nonion-Elphidium-*, *Miogypsina-Amphistegina-Robulus-*, and *Bulimina-Uvigerina-Ellipsonodosaria-Epistominella-Cibicides*-faunules. The first three faunules occur in the lower part of the Mizunami group, the Tsukiyoshi sandstone, Togari sandstone, and Yamanouchi mudstone combined, and the latter two in the upper part of the same group, the Shukunohora sandstone and Oidawara mudstone combined.

Compared with the microbiostratigraphical units established by TAI (1957) in the Chûgoku District, the *Miogypsina-* faunule above mentioned corresponds to the *Miogypsina kotoi-Operculina complanata japonica* zone, and the *Bulimina-* faunule to the *Lagenonodosaria scalaris-Uvigerina crassicostata* zone. The lower three faunules seem to comprise a new microbiostratigraphical unit lying below the *Miogypsina kotoi-Operculina complanata japonica* zone, and for this new unit the tentative name of "*Nonion-Elphidium*" zone is proposed.

He also discusses the relation between the microbiostratigraphical units based on the foraminiferal assemblages, and the lithostratigraphical units previously established, to the middle Miocene marine sediments in the eight basins in the Setouchi and San'in Provinces, including that of the Mizunami. As a result he concluded that "the Uetukian Stage" (MAKIYAMA, 1932, 1939) is synonymous with the upper of "the Togarian Stage" (MAKIYAMA, 1939).

Smaller Foraminifera picked from the washed 33 samples are listed in Table XVI.

Of 33 sampling horizons, 16 horizons (1-16) belong to the lower part of the Mizunami group, and the remaining (17-33) to the upper part of the same group.

TABLE XVI

Check List of the Miocene Smaller Foraminifera from the Mizunami Group Distributed in the Area North of Mizunami City, Gifu Prefecture

Species \ Zones / Faunules / Form. name / Hors.	"*Nonion–Elphidium*"																*Mio. k.* — *Op. c. j.*			*Lagenonodosaria scalaris-Uvigerina crassicostata*													
	Lower												Upper							Lower													
	Elphidium						*Nonion* *Elphidium* *Eponides*						*Lagena* *Rotalia* *Nonion* *Elphidium*				*Miog.* *Amph.* *Rob.*			*Bulimina* *Uvigerina* *Ellipsonodosaria* *Epistominella* *Cibicides*													
	Tsuki-yoshi			Togari			Yamanouchi										Shuku-nohora			Oidawara													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Gaudryina sp.																	R																
Martinottiella communis d'Orbigny																						F	R	R	R	F	F	R	R		R		
Quinqueloculina elongata Natland																	(R)																
Quinqueloculina sawanensis Asano																	(R)																
Quinqueloculina vulgaris d'Orbigny																	R	R															
Quinqueloculina yezoensis Asano																	(R)																
Quinqueloculina sp.						R	R											R															
Sigmoilina imamurai Tai																														R			
Sigmoilina sp.																														R			
Triloculina tricarinata d'Orbigny																	R																
Triloculina sp.								R	R				R				R																
Robulus calcar (Linnaeus)																						(R)	(R)	(R)	(R)		(R)		(R)				
Robulus lucidus (Cushman)															(R)	R							R										
Robulus nikobarensis (Schwager)																	R	R															
Robulus sp.											R						R	R	R			R					R					R	R
Planularia yabei Asano																	R	R															
Planularia n. sp.																				R													
Marginulinna glabra d'Orbigny																R						(R)	(R)										
Dentalina insecta (Schwager)																						R		R									
Dentalina sp.													R		R	R	R						R				F						
Nodosaria longiscata d'Orbigny																			F	(A)	R	F	R										
Nodosaria pyrula d'Orbigny																				R	R	R	R	R	F		C		F	R	R	R	R
Nodosaria radicula (Linne')														R																			
Nodosaria tosta Schwager																			R	R	R	R	R	R	R		C	R					
Nodosaria vertebralis (Batsch)																								(R)	(R)		(R)		(R)				
Nodosaria sp.																		R							R								
Lagenonodosaria fukushimaensis Asano														(R)	(R)																		
Lagenonodosaria scalaris Batsch																						R		R	R		F		R			R	

Species \ Horizons	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Lagenonodosaria scalaris sagamiensis Asano																						R	R	R	R		R						
Lagenonodosaria sp.											R		R				R		R		R	C	R		R		F						
Saracenaria latifrons (Brady)																						(R)											
Saracenaria sp.																				R					R		R						
Frondicularia foliacea (Schwager)																			R	F		R	F		R			R	R			R	
Frondicularia sp.																								R									
Lagena acuticosta Reuss																				R	R	A	R	F	R		R				R		
Lagena globosa (Montagu)																											(R)						
Lagena hispidula Cushman													R																				
Lagena laevis (Montagu)													R				(R)	(R)				R	R	R									
Lagena perlucida (Montagu)																	R					R	(R)	R			R						
Lagena striata (d'Orbigny)																						R											
Lagena substriata Williamson													(R)														(R)				(R)		
Lagena sulcata laevicostata Cushman and Gray																						R											
Lagena sulcata spicata Cushman and McCulloch																						(C)	R				(R)				(R)	(R)	
Lagena sp.												R								R			R	R			R						
Guttulina irregularis (d'Orbigny)																	R	(R)															
Guttulina kishinouyi Cushman and Ozawa														R																			
Guttulina pacifica (Cushman and Ozawa)																						R											
Nonion grateloupi (d'Orbigny)									(A)	(F)		(R)	(R)				F	R				R		R									
Nonion japonicum Asano							R	A	A	A		C	C				F	R															
Nonion kidoharaense Fukuda										R		(A)	(F)					R															
Nonion nakosoense Asano							R	C	F	F		F					R																
Nonion nicobarense Cushman						F	R	C	(F)	(F)							R		R	A	R	A	F	R	R		A		F		R	F	
Nonion pompilioides (Fichtel and Moll)														R									R				R					R	
Nonion scaphum (Fichtel and Moll)								F	C	F			R					R															
Nonion n. sp.																						F	F					R					
Nonion sp.							R	C	A	F																							
Astrononion sp.									R																								
Pseudononion japonicum Asano										R							R	R															
Pseudononion n. sp.								R																									
Pseudononion sp.									F	R			R							R													
Nonionella miocenica Cushman								A	C	C		F	C			R																	
Nonionella sp.								R																(R)									
Elphidium advenum (Cushman)																				(R)													
Elphidium clavatum Cushman																								(R)									
Elphidium craticulatum (Fichtel and Moll)				R																													

Elphidium etigoense (Husezima and Maruhasi)				R	R		R	R		R												R		R									
Elphidium ozawai Uchio			R	R			R		R			R																					
Elphidium sendaiense Takayanagi									(F)	(R)		R	R		R																		
Elphidium tsudai Chiji and Nakaseko									R																								
Elphidium n. sp. A												A	F																				
Elphidium n. sp. B									R			F	R		F																		
Elphidium n. sp. C												C	F																				
Elphidium sp.							R		R															R									
Cribroelphidium yabei (Asano)															R																		
Elphidiella momiyamaensis Uchio						R	R	R				R	R																				
Plectofrondicularia miocenica Cushman																									R		R			R		R	
Plectofrondicularia sp.										R																							
Bulimina striata d'Orbigny																				R		F					C	R	R			A	R
Bulimina striata notoensis Asano																			R			C	R	R			A	R	R	R	A	A	R
Entosolenia catenulata Williamson																	R					F	R										
Entosolenia hexagona Williamson																				R		R					R		R		R		
Entosolenia marginata (Montagu)																				(F)		C	F	R			C	R	F		R	R	
Entosolenia orbignyana (Seguenza)																				F	R	A	C	F			F	R	R	R			
Entosolenia sp.																	R																
Virgulina complanata Egger																	R																
Bolivina marginata Cushman																				R			R									R	
Bolivina marginata masudai Asano																			R	F		F	R				R		F	R	R	F	
Bolivina robusta Brady													(R)				(R)	(R)		(F)				(R)								(R)	
Reussella spinulosa (Reuss)																	R																
Uvigerina aculeata d'Orbigny																																(R)	
Uvigerina hootsi Rankin																			F	R		A	C	R			R		A	R	R		
Uvigerina multicostata LeRoy																				(R)		(F)	R	(R)									
Uvigerina nitidula Schwager																			F	F		A	F	R			A		R	R	R	F	R
Uvigerina proboscidea Schwager																			R	R		A	R	F	R		A		A		R	R	R
Uvigerina segundoensis Cushman and Galliher																			R	R		R	R		R		R		R		R	R	R
Uvigerina subperegrina Cushman and Kleinpell																						A	R				R	R	R			R	
Uvigerina yabei Asano																				(R)			(R)		(R)		(R)						
Angulogerina kokozuraensis Asano													R							R		C	C	C			R		F		R	R	
Angulogerina occidentalis (Cushman)													R																				
Ellipsonodosaria japonica Ishizaki																						R	(R)	F	(F)		R	(R)	(R)		(R)	(R)	(R)
Ellipsonodosaria lepidula (Schwager)																			F	C	F	C	F	R	R		F		R		R	R	
Ellipsonodosaria sp.															R					R	R		R	R									
Discorbis australensis Heron-Allen and Earland																	(R)																
Discorbis nakamurai Asano																		(R)															

Species \ Horizons	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Discorbis opercularis (d'Orbigny)																	C																
Discorbis sp.																	R	R															
Discopulvinulina bradyi Cushman														(R)			R					R											
Discopulvinulina hofkeri Asano																R	R							R									
Discopulvinulina isabelleana (d'Orbigny)																														(R)			
Discopulvinulina sp.																								R									
Valvulineria nipponica Ishizaki										(R)												R											
Valvulineria sadonica Asano										R		R	R				R	R				R		R									
Gyroidina orbicularis d'Orbigny																	R	R		R		C	R	R			R	R	R		C	R	
Gyroidina soldanii d'Orbigny																	R					R	R										
Eponides frigidus (Cushman)				R		R														R				R									
Eponides frigidus calidus Cushman and Cole			R			R	R	R	R	F					R			R		R		R											
Eponides nipponicus (Husezima and Maruhasi)						R				R			R				(R)	(R)															
Eponides praecinctus (Karrer)																			R				R							R	R		
Eponides subpraecinctus Asano																			R						R		R	R		R			
Eponides umbonatus (Reuss)																				R	R	R	F						R		R	R	
Eponides sp.										R												R	R										
Rotalia beccarii (Linnaeus)					(R)	(C)		(F)	(C)	(C)	(R)		(R)			(R)															(R)		
Rotalia beccarii hatatatensis Takayanagi												A	R																	R	R	F		
Rotalia inflata (Seguenza)																																(R)		
Rotalia takanabensis (Ishizaki)															R				R			A	F	R	C		A		C	R	F	C	R
Rotalia tochigiensis Uchio																			F	F	R			R									
Rotalia sp.						R																											
Baggina notoensis Asano																	C	R									R						
Baggina sp.						R												R															
Amphistegina lessonii d'Orbigny																	F	R															
Epistominella japonica (Asano)																	R			C		A	F	F	R		A	F	A	C	F	A	
Epistominella sp.																		R															
Cassidulina globosa Hantken																											R						
Cassidulina laevigata carinata Cushman																				A	R	F	F	R	R		R	R	R	R	R	R	
Cassidulina margareta Karrer																	R				R		R	R								R	
Cassidulina orientale Cushman																								(R)									
Cassidulina subglobosa Brady																	F	R		R	R	R	R	R				R	R	R	R	R	
Ehrenbergina notoensis Asano																						F	R		(R)		C					(R)	
Ehrenbergina serrata Reuss																							R										
Ehrenbergina sp.																							R										
Pullenia bulloides (d'Orbigny)																						R	R	R									

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Pullenia salisburyi R. E. and K. C. Stewart												C		A	C	F		R				R	R		R
Sphaeroidina austriaca d'Orbigny						R								F	F		R		R	R	R		R		R
Sphaeroidina compacta Cushman and Todd												R		A	R	R		C				(R)			
Sphaeroidina japonica Asano												R		F	R			R							
Anomalina grabrata Cushman				F						(R)		R	R			R									
Anomalina sp.										R															
Planulina nipponica Asano												A	C		R		F	R	R	R	R			R	
Planulina wuellerstorfi (Schwager)													(R)		R	R					(R)				
Planulina n. sp.																	R				R		R		
Hanzawaia nipponica Asano		R		R							R	F	R		R		R	R							
Hanzawaia tagaensis Asano					R			R		R		F													
Cibicides aknerianus (d'Orbigny)												R		F	F						R		R		
Cibicides lobatulus (Walker and Jacob)					R			R				A	A		A	R	A	R	C	R	C	R	A	C	
Cibicides pseudoungerianus (Cushman)	R			R								(C)	(C)		(A)	(F)	(R)	(R)	(C)		(F)	(R)	(R)	(C)	(R)
Cibicides refulgens (Montfort)														(R)	R		R	R			R			(R)	
Cibicides n. sp.																		R							
Cibicides sp.				R								R			R		R								
Dyocibicides biserialis Cushman and Valentine												F					R								
Dyocibicides perforata Cushman and Valentine												C							R						
Dyocibicides sp.															R			R							
Miogypsina kotoi Hanzawa												C													
Globigerina spp.						R		R	R	R		C	R	R		R	R	A		F	R	A	R	A	A	R
Globorotalia spp.					R							R			R		A			R	F	A	F	A	A	R

R ; Rare F ; Few C ; Common A ; Abundant ( ); Identity similar

Sampling horizons:

1- Stratigraphically about 5.0 m. above the base of the Tsukiyoshi sandstone, exposed at the road cliff of the Tsukiyoshi-Togari section, about 2.0 km. northwest of the Mizunami Railway Station, Mizunami City, Gifu Prefecture (Lat. 35°22′31″ N., long. 137°14′4.4″E.).

2- Stratigraphically about 1.0m. above horizon 1.

3- Stratigraphically about 3.0m. above horizon 1.

4- Stratigraphically about 9.5m. above horizon 1.

5- Stratigraphically about 14.0m. above horizon 1.

6- Stratigraphically about 21.0m. above horizon 1.

7- Stratigraphically about 23.0m. above horizon 1.

8- Stratigraphically about 27.0m. above horizon 1.

9- Stratigraphically about 29.5m. above horizon 1.

10- Stratigraphically about 31.5m. above horizon 1.

11- Stratigraphically about 33.5m. above horizon 1.

12- Stratigraphically about 35.5m. above horizon 1.

13- Stratigraphically about 37.5m. above horizon 1.

14- Stratigraphically about 38.5m. above horizon 1.

15- Stratigraphically about 40.0m. above horizon 1.

16- Stratigraphically about 42.0m. above horizon 1.

17- Stratigraphically about 5.2m. above the base of the Shukunohora sandstone, exposed at the cliff of Shuku, about 4.5 km. north of the Mizunami Railway Station, Mizunami City, Gifu Prefecture (Lat. 35°24′21″ N., long. 137°15′29.4″.E).

18- Stratigraphically about 0.8m. above horizon 17.

19- Stratigraphically about 2.8m. above horizon 17.
20- Stratigraphically about 3.6m. above horizon 17.
21- Stratigraphically about 4.4m. above horizon 17.
22- Stratigraphically about 6.8m. above horizon 17.
23- Stratigraphically about 8.8m. above horizon 17.
24- Stratigraphically about 12.8m. above horizon 17.
25- Stratigraphically about 13.8m. above horizon 17.
26- Stratigraphically about 14.8m. above horizon 17.
27- Stratigraphically about 16.3m. above horizon 17.
28- Stratigraphically about 18.3m, above horizon 17.
29- Stratigraphically about 22.3m. above horizon 17.
30- Stratigraphically about 25.3m. above horizon 17.
31- Stratigraphically about 30.3m, above horizon 17.
32- Stratigraphically about 33.3m. above horizon 17.
33- Stratigraphically about 36.3m. above horizon 17.

CHAPTER III

REMARKS ON THE NEWLY OBTAINED SMALLER FORAMINIFERA AND THEIR SIGNIFICANCE

A. A Boring Well at Nishitakasaki, near Okayama City, Okayama Prefecture

No the marine Miocene sediments are known to be exposed throughout the surface area around Kojima Bay, which is situated in the south of Okayama City. In 1957, a boring was undertaken in Kojima Bay by the Department of Commerce and Industry, Okayama Prefecture, for the purpose of natural gas exploration. This boring well was lowered to 131 meters in depth and the locality is at Nishitakasaki, Nadazaki-machi, Kojima-gun, Okayama Prefecture (Lat. 34°32′45″ N., long. 133°53′32.4″ E.).

The Miocene sediments distinguished in the boring cores are a hard black shale facies which yielded upon washing fragments of molluscan shells and the thickness of the shale was measured to be 68 meters. The shale facies lithologically corresponds to the Upper Shale of the Bihoku group.

The smaller Foraminifera to be discussed were taken from fifteen horizons of above-mentioned shale facies which is considered to belong to the upper Bihoku group. The Foraminifera consist of 56 species and subspecies (Table XVII) belonging to 31 genera and 13 families, excluding the pelagic forms. The genera *Gaudryina*, *Plectina*, *Robulus*, *Dentalina*, *Elphidium*, *Bulimina*, *Eponides*, *Cassidulina*, *Pullenia*, *Hanzawaia*, and *Cibicides* contain the majority of the species and individuals of the present microfauna. From the distribution of the Foraminifera shown in Table XVII, the Okayama microfauna may be divided into four foraminiferal assemblages in ascending order, namely, *Bulimina-Robulus-Cassidulina-Elphidium-*, *Bulimina-Eponides-*, *Bulimina-Cyclammina-Plectina-Robulus-Eponides-*, and *Plectina-Cyclammina* faunules.

Microbiostratigraphically, the lower part of the upper Bihoku group which contains the former three faunules above mentioned, corresponds to the *Lagenonodosaria scalaris-Uvigerina crassicostata* zone, and the upper part which contains the latter one faunule to the lower part of the *Cyclammina orbicularis-Martinottiella communis* zone (Plate 38).

TABLE XVII
Distribution of Okayama Foraminifera

Zones	*Ls — Uc* Z												*Co-Mc* Z		
	Lower										Up.		Lower		
Faun.	*B—R—* F						*B—E—* F				*B-C-* F		*P-C-* F		
Depth in meters.	130.4	126.2	121.3	118.2	115.0	110.8	105.3	100.0	95.0	90.0	85.0	80.0	75.2	70.0	66.3
Hors.															
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Cyclammina ezoensis Asano		2									15				
C. incisa (Stache)			2								8	3	1		

Species \ Horizons	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C. sp. indet.	1		2										1		2
Gaudryina ishikiensis Asano	29	15	5	4		15	1	12	1	3	1	3			
G. yabei Asano		1		2		2									
Plectina nipponica Asano											55	36	5	1	
P. sp. indet.			2												
Goesella schenzki Asano											1				
Robulus lucidus (Cushman)	28	11	22	9		22		3			1	1			
R. nikobarensis (Schwager)	21	8	12	4		2	1	2	1		2				
R. cf. *nikobarensis* (Schwager)		24				4									
R. sp. indet.		1	8	4	2	1	8		43		5	18			
Lenticulina sp.		1													
Dentalina emaciata Reuss		1													
D. insecta (Schwager)	2														
D. tauricornis (Schwager)											2	2			
D. sp. indet.			2		1		1		3		1	6			
Nodosaria longiscata d'Orbigny						2									
Pseudoglandulina laevigata (d'Orbigny)		1													
Saracenaria akitaensis Iwasa and Kikuchi						4									
Guttulina irregularis (d'Orbigny)								2			1				
Nonion cf. *nicobarense* Cushman							5	1							
N. scaphum (Fichtel and Moll)		1				1	1								
N. sp. indet.						1									
Nonionella miocenica Cushman		2	3	3		1	10	4	2		1				
Elphidium cf. *clavatum* Cushman								1							
E. etigoense Huzezima and Maruhasi						1									
E. tsudai Chiji and Nakaseko	12	8	13	5	5	7	3								
Elphidiella momiyamaensis Uchio	5	10	16		1	3									
Robertina hanzawai (Asano)							3								
Bulimina imamurai Tai, n. sp.	73	28	45	61	132	14	95	84	88	121	50	55			
B. okayamaensis Tai, n. sp.	5	8	19	10	21	2	20	19	27	29	20	25			
B. pupoides d'Orbigny	11	9	10	21	35	16	13	21	23	35	20	13			
Globobulimina perversa (Cushman)						1							1	1	
Virgulina ishikiensis Asano			1	1											
Bolivina marginata masudai Asano			1			1	1					1			
B. robusta Brady						2				1					
Gyroidinoides planulata (Cushman and Renz)		1													
Gyroidina soldanii d'Orbigny		2													
Eponides frigidus (Cushman)	1		25	65			38	6	11		13	17			
E. frigidus calidus Cushman and Cole		16				2				9					
E. nipponicus (Huzezima and Maruhasi)	1														
E. cf. *praecinctus* (Karrer)						1									
Cassidulina imamurai Tai, n. sp.		30	1	2		10						5			
C. margareta Karrer	3	18	1	8	1	41						3			
C. subglobosa Brady		1				1						1			
Pullenia apertula Cushman						4									
P. salisburyi R. E. and K.C. Stewart	3	1	1	1		6				1					
Anomalina glabrata Cushman			4			4									
A. kojimaensis Tai, n. sp.								1							
Planulina nipponica Asano	3		1			18					1	1			
P. wuellerstorfi (Schwager)	1														
Hanzawaia tagaensis Asano			1		1			43	1			4			
Cibicides lobatulus (Walker and Jacob)			1			5									
C. pseudoungerianus (Cushman)	1		2		1	5		1		1	3	6			
C. refulgens (Montfort)						1									
Total number of benthonic Foraminifera	200	200	200	200	200	200	200	200	200	200	200	200	8	2	2

Species \ Horizons	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Globigerina spp.		R													
Globorotalia spp.										R					

Ls-Uc Z; *Lagenonodosaria scalaris-Uvigerina crassicostata* Zone, *Co-Mc* Z; *Cyclammina orbicularis-Martinottiella communis* Zone, *B-R*-F; *Bulimina-Robulus-Cassidulina-Elphidium* Faunule, *B-E*-F; *Bulimina-Eponides* Faunule, *B-C*-F; *Bulimina-Cyclammina-Plectina-Robulus-Eponides* Faunule, *P-C*-F; *Plectina-Cyclammina* Faunule, R; Rare.

B. Uetsukinaka and Miuchi in the Tsuyama Basin, Okayama Prefecture

In 1954 and 1957, the writer had already dealt with the Miocene Foraminifera from the Bihoku group exposed at Yoshino and Yasuda in the Tsuyama basin (Tables II and XI). Some Foraminifera from the following two localities are added to these Miocene Tsuyama microfaunas. The smaller Foraminifera to be discussed were collected by D. TANI, T. UNNO and others (1957) from Uetsukinaka, Katsuta-gun, (Lat. 35°3′41″ N., long. 134°7′22.4″ E.) and Miuchi, Tsuyama City, (Lat. 35°4′50″ N., long. 133°58′40.4″ E.) Okayama Prefecture. The sediment which yielded the Uetsukinaka microfauna is a fine-grained facies yielding a number of *Vicarya callosa* and corresponds to the lower Bihoku group outlined in Chapter I. The sediment yielding the Miuchi microfauna also belongs to the lower part of the same group.

Microbiostratigraphically, two parts of the lower Bihoku group which yielded the Uetsukinaka and Miuchi microfaunas respectively correspond to the lower and upper parts of the *Miogypsina kotoi-Operculina complanata japonica* zone as shown in Plate 38.

The Uetsukinaka and Miuchi Foraminifera are listed in Table XVIII.

TABLE XVIII

Uetsukinaka and Miuchi Foraminifera

Species \ Zone	*Mk-Oc* Z	
	Low	Upp
Faun.	*R*-F	*R-E*-F
Loc.	Uet	Miu
Robulus nikobarensis (Schwager)		R
R. cf. *orbicularis* (d'Orbigny)		R
R. sp.		R
Elphidium cf. *etigoense* Husezima and Maruhasi	R	
Elphidiella momiyamaensis Uchio		R
Eponides praecinctus (Karrer)		R
E. subpraecinctus Asano		R
Rotalia beccarii (Linnaeus)	R	
R. beccarii hatatatensis Takayanagi	A	
R. takanabensis (Ishizaki)		R
R. tochigiensis Uchio	R	R
Ehrenbergina notoensis Asano		R

Mk-Oc Z; *Miogypsina kotoi-Operculina complanata japonica* Zone, *R*-F; *Rotalia* Faunule, *R-E*-F; *Robulus-Eponides* Faunule, Uet; Uetsukinaka, Miu; Miuchi, A; Abundant, R; Rare.

C. Minomi, Kisa-machi, Futami-gun, Hiroshima Prefecture

The foraminiferal sample was collected by S. IMAMURA (1958) from a fine-grained sandstone facies of the lower Bihoku group exposed at Minomi, Kisa-machi, Futami-gun, Hiroshima Prefecture. (Lat. 34°41′44″ N., long. 133°1′32.4″ E.).

The smaller Foraminifera picked up from the sample are shown in Table XIX. The Minomi microfauna from its characteristics may be named the *Nonion-Nonionella-Eponides-Rotalia-Robulus* faunule.

Microbiostratigraphically, a sandstone facies of the lower Bihoku group which yielded the faunule seems to correspond to the lower part of the *Lagenonodosaria scalaris-Uvigerina crassicostata* zone (Plate 38).

TABLE XIX
Minomi Foraminifera

Species \ Zone	*Ls-Uc* Z
Faunule	Lower
	N-N-F
Quinqueloculina sp.	6
Robulus lucidus (Cushman)	6
R. nikobarensis (Schwager)	7
R. sp.	1
Lagenonodosaria scalaris (Batsch)	1
Lagena sp.	1
Nonion japonicum Asano	43
N. nakosoense Asano	18
N. cf. *scaphum* (Fichtel and Moll)	3
Nonionella miocenica Cushman	80
Fissurina sp. indet.	1
Uvigerina crassicostata Schwager	1
U. nitidula Schwager	1
Gyroidina orbicularis d'Orbigny	2
Eponides frigidus calidus Cushman and Cole	2
E. haidingerii (d'Orbigny)	9
E. praecinctus (Karrer)	6
E. subpraecinctus Asano	3
E. sp.	1
Rotalia cf. *beccarii* (Linnaeus)	7
R. takanabensis (Ishizaki)	19
Baggina notoensis Asano	1
Ceratobulimina sp. indet.	1
Epistominella japonica (Asano)	1
Cassidulina laevigata carinata Cushman	2
C. sp.	1
Hanzawaia tagaensis Asano	19
Cibicides pseudoungerianus (Cushman)	7
Total number of benthonic Foraminifera	250
Globorotalia sp. indet.	R

Ls-Uc Z; *Lagenonodosaria scalaris-Uvigerina crassicostata* Zone, *N-N*-F; *Nonion-Nonionella-Eponides-Rotalia-Robulus* Faunule, R; Rare

D. Oshihara, Kawai-machi, Ota City, Shimane Prefecture

The Kuri formation distributed in the vicinity of Kawai-machi, Ota City, Shimane Prefecture is a black shale facies measuring about 300 meters in thickness and conformably overlies the type Kawai formation which consists of coarse-grained sediments with molluscan fossils. The writer already outlined the geology of the Kuri and Kawai formations in the section of Inner Subprovince in Chapter I.

The smaller Foraminifera discussed were collected by the writer and O. SHÔJI from six horizons of the Kuri formation at Oshihara and consist of 84 species and subspecies belonging to 40 genera and 16 families (Table XX), excluding the pelagic forms. The genera *Cyclammina*, *Robulus*, *Lagenonodosaria*, *Lagena*, *Nonion*, *Nonionella*, *Uvigerina*, *Angulogerina*, *Eponides*, *Rotalia*, and *Cassidulina* contain the majority of the species and individuals of the present microfauna. The occurrence of pelagic Foraminifera is remarkable in all of the sampling horizons.

From the characteristics of the Foraminifera, the Oshihara microfauna may be divided into two foraminiferal assemblages, namely, *Lagenonodosaria-Nonion-Angulogerina-Eponides-Rotalia* faunule below, and *Cyclammina-Plectina-Uvigerina* faunule above. A black shale facies of the Kuri formation which contains these faunules microbiostratigraphically corresponds to the *Lagenonodosaria scalaris-Uvigerina crassicostata* zone (Plate 38).

TABLE XX

Distribution of Oshihara Foraminifera

Species \ Zone / Faunules / Hors.	*Ls-Uc* Z					
	Lower					Up.
	L-N-F					*C-P*-F
	1	2	3	4	5	6
Reophax? sp.						R
Ammodiscoides sp.					R	
Ammobaculites sp.						R
Cyclammina ezoensis Asano						R
C. incisa (Stache)						R
C. cf. *japonica* Asano						R
Spiroplectammina cf. *niigataensis* Asano and Inomata						R
Gaudryina ishikiensis Asano	F				R	
G. sp.					R	
Plectina nipponica Asano						F
Sigmoilina imamurai Tai	R					R
S. schlumbergeri Silvestri						R
Pyrgo murrhina (Schwager)						R
Trochammina sp.				R		R
Robulus lucidus (Cushman)				R		R
R. cf. *nikobarensis* (Schwager)	R	R	R			
R. sp.		R	R			
Planularia sp.				R		
Dentalina sp.		R				
Nodosaria longiscata d'Orbigny						R
Pseudoglandulina laevigata (d'Orbigny)			R			
Lagenonodosaria fukushimaensis Asano	R	F		C		R

Species \ Hors.	1	2	3	4	5	6
L. scalaris (Batsch)		R				
L. scalaris sagamiensis Asano					F	
L. sp.	R		R	R	R	
Saracenaria sp.			R	R		
Lagena cf. *hispidula* Cushman					R	
L. cf. *laevis* (Montagu)		R				
L. perlucida (Montagu)	R		R	R		
L. cf. *perlucida* (Montagu)		R				
L. sulcata spicata Cushman and McCulloch			R			
L. sp.	R		R	R		
Nonion japonicum Asano	C			F	R	
N. cf. *japonicum* Asano		R				
N. nakosoense Asano	R			R		
N. pompilioides (Fichtel and Moll)					R	
N. scaphum (Fichtel and Moll)	R		C		R	
N. cf. *scaphum* (Fichtel and Moll)		C				
N. cf. *umbilicatulum* (Montagu)	R					
Pseudononion japonicum Asano			R			
P. sp.				R		
Nonionella miocenica Cushman		A	R	C	R	F
Elphidium etigoense Husczima and Maruhasi				R		
E. cf. *etigoense* Husczima and Maruhasi		R				
E. sp.	R					
Cribroelphidium yabei (Asano)						F
Globobulimina sp.		R	R			
Virgulina ishikiensis Asano					R	
Bolivina sp.					R	
Uvigerina cf. *crassicostata* Schwager		C		C	R	
U. cf. *hootsi* Rankin					R	F
U. nitidula Schwager		R				
U. cf. *nitidula* Schwager				C		
U. cf. *yabei* Asano		F				
U. sp.	R			R		
Angulogerina cf. *hughesi* (Galloway and Wissler)	R		F			
A. kokozuraensis Asano				A		
A. cf. *kokozuraensis* Asano		A				
A. sp.				R	R	
Ellipsonodosaria lepidula (Schwager)						R
Discopulvinulina sp.				R		
Valvulineria sadonica Asano						R
Eponides frigidus (Cushman)			R	A		
E. cf. *frigidus* (Cushman)	C	R			F	
E. cf. *nipponicus* (Husczima and Maruhasi)					R	
E. subpraecinctus Asano			R			
E. umbonatus (Reuss)			R			
Rotalia beccarii (Linnaeus)	R		R			
R. cf. *beccarii* (Linnaeus)				R		F
R. takanabensis (Ishizaki)			C	C	R	R
R. cf. *takanabensis* (Ishizaki)		A				
Baggina notoensis Asano		F	R	R	R	
Epistominella japonica (Asano)		R				
Cassidulina laevigata carinata Cushman		A	R	C		
C. margareta Karrer		R	R			
C. sp.		R				
Sphaeroidina cf. *japonica* Asano					R	
Planulina wuellerstorfi (Schwager)				R		
P. cf. *wuellerstorfi* (Schwager)	C					
Hanzawaia tagaensis Asano				R	R	
H. cf. *tagaensis* Asano		R				

Species \ Hors.	1	2	3	4	5	6
Cibicides lobatulus (Walker and Jacob)			R			
C. pseudoungerianus (Cushman)			R			
C. sp.				R		
Globigerina spp.	A	A	A	VA	A	R
Globorotalia spp.			A	VA	VA	

Ls-Uc Z; *Lagenonodosaria scalaris-Uvigerina crassicostata* Zone, *L-N*-F; *Lagenonodosaria-Nonion-Angulogerina-Eponides-Rotalia* Faunule, *C-P*-F; *Cyclammina-Plectina-Uvigerina* Faunule, VA; Very abundant, A; Abundant, C; Common, F; Few, R; Rare.

Sampling horizons:

1-A hard black shale of the Kuri formation exposed at the cliff (Lat. 35°7′2″ N., long. 132°30′41.4″ E.) of Oshihara River in Oshihara, Kawai-machi, Ota City, Shimane Prefecture.
2- Stratigraphically about 15m. above horizon 1.
3- Stratigraphically about 31m. above horizon 1.
4- Stratigraphically about 58m. above horizon 1.
5- Stratigraphically about 66m. above horizon 1.
6- Stratigraphically about 77m. above horizon 1.

E. Takuno, Nima-machi, Nima-gun, Shimane Prefecture

The stratigraphy of the Miocene formations which yielded the Foraminifera in the vicinity of Takuno, Nima-machi, Nima-gun, Shimane Prefecture, is now being studied by S. IMAMURA and K. OKAMOTO, and the writer briefly gave an outline of it in Chapter I. The Kawai formation exposed at the cliffs along the road of Nima-Takuno section is an arkose sandstone facies, which has a thickness of about 60 meters, intercalating some mudstone beds which contain megafossils as *Dosinia*, *Volsella*, and *Turritella* etc. The smaller Foraminifera were collected by the writer from six horizons of the mudstone facies above mentioned.

The Takuno microfauna consists of 93 species and subspecies (Table XXI) belonging to 42 genera and 14 families, excluding the pelagic forms. The genera *Ammobaculites*, *Gaudryina*, *Robulus*, *Lagenonodosaria*, *Nonion*, *Nonionella*, *Globobulimina*, *Uvigerina*, *Ellipsonodosaria*, *Eponides*, and *Hanzawaia* contain the majority of the species and individuals of the present microfauna. The depth analysis of these common genera indicates that the mudstone facies in the Kawai formation was deposited in the littoral to the neritic zones. From the characteristics of the Foraminifera in Table XXI, the Takuno microfauna may be divided into two foraminiferal assemblages, namely, *Ammobaculites-Gaudryina-Nonion-Nonionella* faunule below and *Uvigerina-Nonion-Ellipsonodosaria-Nonionella-Robulus* faunule above.

Microbiostratigraphically, the two parts of the Kawai formation which contain these faunules respectively correspond to the *Miogypsina kotoi-Operculina complanata japonica* zone and the lower part of the *Lagenonodosaria scalaris-Uvigerina crassicostata* zone (Plate 38).

TABLE XXI

Distribution of Takuno Foraminifera

Species \ Zones / Faunules / Hors.	*Mk-Ocj* Z			*Ls-Uc* Z		
	Upper			Lower		
	A-G-F			*U-N-F*		
	1	2	3	4	5	6
Rhabdammina sp.		2		1		2
Ammodiscus sp.				1		
Haplophragmoides trullissatum (Brady)				1		
H. sp.		4	3			
Cribrostomoides kyushuense Asano				1		
Ammobaculites sp.	85	74	77		1	1
Cyclammina incisa (Stache)	8	16	4	5		1
Textularia cf. *lythostrota* (Schwager)				1		
T. sp.				7		5
Gaudryina imamurai Tai, n. sp.				1		1
G. ishikiensis Asano	49	39	34	15	18	7
G. cf. *karihaensis* Asano				2		
G. takunoensis Tai, n. sp.				7	6	
G. yabei Asano	20	30	11	4	12	
G. cf. *yabei* Asano						6
Gaudryinella sp.					1	
Triloculina okamotoi Tai, n. sp.				2		
Pyrgo cf. *vespertilio* (Schwager)				4		4
Trochammina cf. *nobensis* Asano	5					
T. sp.		2				1
Robulus lucidus (Cushman)				3	2	4
R. nikobarensis (Schwager)						1
R. notoensis Asano						1
R. orbicularis (d'Orbigny)				2	1	1
R. pseudorotulatus Asano				3		
R. sp.					2	
Marginulina aculeata Neugeboren				1		3
M. cf. *aculeata* Neugeboren					3	
M. glabra d'Orbigny						1
M. masudai Asano					1	
M. sp.						2
Dentalina sp.	14	1	6	1	3	
Nodosaria longiscata d'Orbigny				2		
N. sp.	1	11	2		1	2
Pseudoglandulina laevigata (d'Orbigny)	2	2		1	2	2
Lagenonodosaria fukushimaensis Asano				5	9	
L. scalaris sagamiensis Asano					2	3
L. sp.	9	15				
Saracenaria sp.					1	1
Lagena acuticosta Reuss				1		
L. hispidula Cushman					1	
L. laevis (Montagu)						1
L. sp.	4					
Nonion japonicum Asano			5	7	8	10
N. kidoharaense Fukuda			1	1	14	1
N. nakosoense Asano			2	3	12	7
N. nikobarense Cushman						2
N. scaphum (Fichtel and Moll)			4	7	2	
Astrononion sp.						1
Nonionella miocenica Cushman			14	8	14	12

Species \ Hors.	1	2	3	4	5	6
Elphidium advenum (Cushman)			5		1	
E. etigoense Husezima and Maruhasi						1
E. cf. *tsudai* Chiji and Nakaseko					1	
E. sp.					1	
Globobulimina perversa (Cushman)	1	4	2	9	21	17
Virgulina ishikiensis Asano					1	
V. cf. *nodosa* R. E. and K. C. Stewart				3		
Bolivina marginata masudai Asano				1		
Reussella spinulosa (Reuss)				1		
Uvigerina cf. *akitaensis* Asano				3	13	
U. crassicostata Schwager				1		1
U. nitidula Schwager				7	3	20
U. segundoensis Cushman and Galliher				3		
U. yabei Asano				2		29
U. cf. *yabei* Asano					6	
U. sp.			1	19		2
Angulogerina kokozuraensis Asano			1	2	3	1
A. cf. *occidentalis* (Cushman)				1		
Ellipsonodosaria japonica Ishizaki				15	5	12
E. lepidula (Schwager)				2	2	2
Discopulvinulina cf. *bertheloti* (d'Orbigny)					1	7
D. hofkeri Asano			5	1		
D. sp.			4		1	3
Eponides frigidus (Cushman)			2	1	4	4
E. frigidus calidus Cushman and Cole	1			2		
E. umbonatus (Reuss)			1			
Rotalia beccarii (Linnaeus)			5			1
R. cf. *beccarii* (Linnaeus)				2		
R. takanabensis (Ishizaki)						
Poroeponides sp.				1		
Baggina notoensis Asano					1	
B. sp.					1	
Epistominella japonica (Asano)			1			
E. sp.				1		
Ehrenbergina notoensis Asano					1	
Planulina nipponica Asano				1	1	1
P. wuellerstorfi (Schwager)			1	2		
P. sp.				1		1
Hanzawaia tagaensis Asano			3	15	5	12
Cibicides lobatulus (Walker and Jacob)	1		2	5		1
C. pseudoungerianus (Cushman)				2	5	1
C. sp.			2			
Dyocibicides sp.						1
Total number of benthonic Foraminifera	200	200	200	200	200	200
Globigerina spp.				A	A	A
Globorotalia spp.				C	A	A

Mk-Ocj Z; *Miogypsina kotoi-Operculina complanata japonica* Zone, *Ls-Uc* Z; *Lagenonodosaria scalaris-Uvigerina crassicostata* Zone, *A-G*-F; *Ammobaculites-Gaudryina-Nonion-Nonionella* Faunule, *U-N*-F; *Uvigerina-Nonion-Ellipsonodosaria-Nonionella-Robulus* Faunule, A; Abundant, C; Common.

Sampling horizons:

1- A fossiliferous mudstone facies of the Kawai formation exposed at the road cliff (Lat. 35°9′35″ N., long. 132°24′35.4″ E.) in Takuno, Nima-machi, Nima-gun, Shimane Prefecture.

2- Stratigraphically about 1.0m. above horizon 1.

3- Stratigraphically about 3.0m. above horizon 1.

4- Stratigraphically about 44.0m. above horizon 1.

5- Stratigraphically about 47.0m. above horizon 1.
6- Stratigraphically about 47.5m. above horizon 1.

F. Masuda City, Shimane Prefecture

The Miocene Masuda group distributed in the vicinity of Masuda City comprises cyclic sediments ranging from a coarse-grained facies, which contains megafossils, such as *Ostrea*, *Natica*, *Solen*, *Anadara*, and *Trapezium* etc., to a black shale facies which is barren of or with very few megafossils, and structurally is almost horizontal.

The smaller Foraminifera were collected by the writer from seven horizons of a transitional zone, ranging from coarse- to shale- facies of the Masuda group, exposed in the cliffs at Yoshida, Masuda City, Shimane Prefecture. The foraminiferal fauna of the Masuda group consists of 88 species and subspecies (Table XXII) belonging to 41 genera and 17 families, excluding the pelagic forms. The family Lagenidae is represented by the largest number of genera, species, and individuals. In other families, the genera *Gaudryina*, *Martinottiella*, *Guttulina*, *Bolivina*, *Ellipsonodosaria*, *Eponides*, *Cassidulina*, *Hanzawaia*, and *Cibicides* contain the majority of the species and individuals. The depth analysis of these common genera indicates that a part of the Masuda group was deposited in the littoral to the neritic zones.

From the results of recent field surveys of the Miocene sediments distributed in the vicinity of Masuda City, it has become evident that the stratigraphical sequence of the sediments and their lithological characters, geological structure, and megafossils contained, are, on the whole, similar to those of the Miyoshi-, Shôbara-, and Tsuyama Miocene in the western Setouchi Province.

Further, recent studies of the Foraminifera of the Miyoshi and other Miocene deposits already mentioned reveal that they are correlative with the foraminiferal fauna of the present area.

From the characteristics of the Foraminifera shown in Table XXII, the Masuda microfauna may be divided into two foraminiferal assemblages, namely, *Dentalina-Nodosaria-Vaginulina-Martinottiella* faunule below and *Bolivina-Hanzawaia-Gaudryina* faunule above. Microbiostratigraphically, the Masuda group with its two faunules corresponds to the *Lagenonodosaria scalaris-Uvigerina crassicostata* zone (Plate 38).

TABLE XXII
Distribution of Masuda Foraminifera

Zone / Faunules / Hors. / Species	*Ls-Uc* Z						
	Lower				Upper		
	D-N-V-F				*B-H*-F		
	1	2	3	4	5	6	7
Bathysiphon sp.	2	1	1		1		
Ammodiscus sp.						2	
Haplophragmoides sp.				2			

Species \ Hors.	1	2	3	4	5	6	7
Cribrostomoides kyushuense Asano				1		2	
Cyclammina ezoensis Asano					3		
C. incisa (Stache)					2	1	
C. cf. *japonica* Asano						1	
C. pusilla Brady			1	2			
Gaudryina ishikiensis Asano	1		1	2	13	30	16
G. yabei Asano						3	
Plectina sp.	1						
Martinottiella communis (d'Orbigny)	20	4	21	53	1		
Quinqueloculina cf. *vulgaris* d'Orbigny							1
Q. sp.	1	1				2	1
Spiroloculina communis incisa Cushman	1						
Sigmoilina imamurai Tai	10	4	5	5		1	
S. schlumbergeri Silvestri	2						
Trochammina sp.			2	6	1	1	1
Robulus calcar (Linnaeus)			1				
R. iotus (Cushman)	3	6			1		
R. lucidus (Cushman)	17	13	9	5	11	16	22
R. nikobarensis (Schwager)		3			4	8	4
R. notoensis Asano	1	3			3		
R. orbicularis (d'Orbigny)	3	1	3	1			1
R. pseudorotulatus Asano	8	14		2		1	3
R. sp. indet.		10	18	23	16		
Marginulina aculeata Neugeboren	6	7	8	4	6	5	6
M. glabra d'Orbigny		1	1				
M. masudai Asano	7	1	1	4	2		
Dentalina emaciata Reuss	4	6	3				
D. insecta (Schwager)	2	5	1	8	7	11	4
D. subsoluta (Cushman)	13		7		1		
D. tauricornis (Schwager)	1	2	3	2	1		
Nodosaria longiscata d'Orbigny	1	5	3			1	1
N. notoensis Asano	6	20	13	24	1		
N. pyrula d'Orbigny	2	4	5	5	1		
N. vertebralis (Batsch)	5	3	1			1	
N. cf. *vertebralis* (Batsch)	1						
Lagenonodosaria scalaris (Batsch)	17	18	23	14	45	18	27
L. scalaris sagamiensis Asano	11	5		2			2
Saracenaria akitaensis Iwasa and Kikuchi					1	1	1
S. sp.					1		
Vaginulina bradyi Cushman	6	15	5	2			
Lagena laevis (Montagu)	2	2	1				
L. striata (d'Orbigny)		1					
L. sulcata spicata Cushman and McCulloch		2	4				1
Guttulina irregularis (d'Orbigny)	2	4	6	1	2	3	
G. cf. *kishinouyi* Cushman and Ozawa		1					
G. lactea (Walker and Jacob)	2		2	3			
G. sp.		1	1				
Nonion grateloupi (d'Orbigny)						1	
N. japonicum Asano					2		
N. kidoharaense Fukuda						1	2
Nonionella miocenica Cushman			1				
Elphidium etigoense Husezima and Maruhasi	6	3	7	9			
Plectofrondicularia japonica Asano	1	3	1			2	
Bulimina pupoides d'Orbigny	1						
B. striata d'Orbigny			1	1			
B. striata notoensis Asano			1	4			
Bolivina marginata Cushman					10	3	5
B. marginata masudai Asano		2	1		5	4	2

Species \ Hors.	1	2	3	4	5	6	7
B. robusta Brady						1	2
B. cf. *robusta* Brady		1				1	
Reussella aculeata Cushman	1		3				
Uvigerina cf. *crassicostata* Schwager					1		
U. nitidula Schwager						1	1
Angulogerina kokozuraensis Asano				1		1	1
Ellipsonodosaria japonica Ishizaki		1			1	2	2
E. lepidula (Schwager)	6	1	4	4	3	4	4
Discopulvinulina cf. *nitida* (Williamson)		1					
Gyroidina soldanii d'Orbigny					1		
Eponides frigidus (Cushman)	3	6	2	1		2	
E. praecinctus (Karrer)	5	3	2		21	34	43
E. subpraecinctus Asano	2	2	3	2	5	5	4
E. tanai Uchio			1			1	
E. umbonatus (Reuss)		2	4				3
E. cf. *umbonatus* (Reuss)		2					
Rotalia inflata (Seguenza)					2	2	4
Baggina notoensis Asano	1				1		
Amphistegina sp.						1	
Cassidulina laevigata carinata Cushman	4		6		1		3
C. margareta Karrer				1			
C. pacifica Cushman	3	2				3	
Planulina nipponica Asano		4	9	1		1	
P. wuellerstorfi (Schwager)	1				1	1	1
Hanzawaia tagaensis Asano		2			19	16	23
Cibicides lobatulus (Walker and Jacob)	5		1	1			2
C. pseudoungerianus (Cushman)	3	2	3	4	3	5	7
Total number of benthonic Foraminifera	200	200	200	200	200	200	200
Globigerina spp.	A	A	A	A	R	A	A
Globorotalia spp.			R				

Ls-Uc Z; *Lagenonodosaria scalaris-Uvigerina crassicostata* Zone, *D-N-V*-F; *Dentalina-Nodosaria-Vaginulina-Martinottiella* Faunule, *B-H*-F; *Bolivina-Hanzawaia-Gaudryina* Faunule, A; Abundant, R; Rare.

Sampling horizons:

1- A black shale of the Masuda group exposed at the cliff (Lat. 34°40'9" N., long. 131°50'53.4" E.) of Yoshida, Masuda City, Shimane Prefecture.
2- Stratigraphically about 1.0m. above horizon 1.
3- Stratigraphically about 2.5m. above horizon 1.
4- Stratigraphically about 4.5m. above horizon 1.
5- Stratigraphically about 24.0m. above horizon 1.
6- Stratigraphically about 29.0m. above horizon 1.
7- Stratigraphically about 32.0m. above horizon 1.

G. Kuri-machi, Ota City, Shimane Prefecture

The type Kuri formation is a hard black shale facies, about 250 meters in thickness, and intercalates a remarkable rhyolitic tuff and tuff breccia in its middle part. The formation conformably overlies the Kawai formation of coarse-grained sediments and unconformably underlies the Omori formation which is a volcanic complex of andesite and basalt etc. In the previous Chapter I, the writer outlined the geology of these form-

ations.

The smaller Foraminifera were collected by the writer from fifteen horizons of the type section of the Kuri formation distributed in Kuri-machi, Ota City, Shimane Prefecture.

The foraminiferal fauna from the section consists of 24 species (Table XXIII) belonging to 14 genera and 10 families. A remarkable character of this microfauna is that there are very few calcareous Foraminifera. The arenaceous genera *Martinottiella*, *Cyclammina*, *Sigmoilina*, and *Goësella* contain the majority of the species and individuals of the microfauna.

From the characteristics of the Foraminifera, the Kuri microfauna may be divided into two foraminiferal assemblages, namely, *Martinottiella-Cyclammina* faunule below and *Martinottiella-Sigmoilina-Goësella* faunule above. The type Kuri formation which yielded these faunules corresponds with lower and middle parts of the *Cyclammina orbicularis-Martinottiella communis* zone (Plate 38).

TABLE XXIII
Distribution of Kuri Foraminifera

Zone / Faunules / Hors. / Species	*Co-Mc* Z														
	Lower				Middle										
	M-C-F				*M-S-G*-F										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bathysiphon sp. indet.					R			R	F	R		R		R	R
Haplophragmoides trullissatum (Brady)										R					
H. cf. *trullissatum* (Brady)	R			R					R						
H. sp.		R					R		R		R		R		
Cribrostomoides kyushuense Asano									R						
C. cf. *kyushuense* Asano														R	
Ammobaculites sp.							R								
Cyclammina cf. *ezoensis* Asano										R					
C. incisa (Stache)	R	R		R	R				R						R
C. orbicularis Brady				R						R	R				
C. pusilla Brady					R				R						
Spiroplectammina niigataensis Asano and Inomata			R												
Gaudryina ishikiensis Asano														R	.
Goësella schencki Asano		R	R		R	R	R	R	R	R			R	R	
Martinottiella communis (d'Orbigny)	R	R	R	R	F	R	F	R	F	C	A	C	C	R	C
M. sp.									R						
Sigmoilina imamurai Tai	R	R			R				R		R	R	R		R
S. schlumbergeri Silvestri								R			R		R	R	R
Trochammina nobensis Asano				R							F				
T. sp. indet.	R		R					R					R	R	R
Robulus sp. indet.														R	
Globobulimina perversa (Cushman)							R								R
G. sp.						R									
Rotalia sp. indet.														R	

Co-Mc Z; *Cyclammina orbicularis-Martinottiella communis* Zone, *M-C*-F; *Martinottiella-Cyclammina* Faunule, *M-S-G*-F; *Martinottiella-Sigmoilina-Goësella* Faunule, A; Abundant, C; Common, F; Few, R; Rare.

Sampling horizons:

1- A hard black shale of the type Kuri formation, which is stratigraphically below the rhyolitic tuff and tuff breccia occupying the middle part of the formation, exposed at the cliff (Lat. 35°8′51″ N., long. 132°28′50.4″ E.) of Kuri, Kuri-machi, Ota City, Shimane Prefecture.
2- Stratigraphically about 0.3m. above horizon 1.
3- Stratigraphically about 0.6m. above horizon 1.
4- Stratigraphically about 0.9m. above horizon 1.
5- A hard black shale of the type Kuri formation, which is stratigraphically above the same rhyolitics before-mentioned, exposed at the road cliff (Lat. 35°8′59″ N., long. 132°28′22.4″ E.) of Ichi, Kuri-machi, Ota City, Shimane Prefecture.
6- Stratigraphically about 1.0m. above horizon 5.
7- Stratigraphically about 2.0m. above horizon 5.
8- Stratigraphically about 8.7m. above horizon 5.
9- Stratigraphically about 9.2m. above horizon 5.
10- Stratigraphically about 10.2m. above horizon 5.
11- Stratigraphically about 31.7m. above horizon 5.
12- Stratigraphically about 32.7m. above horizon 5.
13- Stratigraphically about 33.7m. above horizon 5.
14- Stratigraphically about 34.7m. above horizon 5.
15- Stratigraphically about 35.7m. above horizon 5.

H. Tamatsukuri, near Matsue City, Shimane Prefecture

As to the Tamatsukuri formation, the writer already outlined its geology in the section on the Outer Subprovince in Chapter I.

Of the total five samples from a black shale, which is the upper division of the type Tamatsukuri formation, unfortunately four of them were quite barren of Foraminifera. A few Foraminifera however were collected by the writer from a cliff (Lat. 35°24′47″ N., long. 133°0′31.4″ E.) of the upper Tamatsukuri formation exposed at Tamatsukuri, Tamayu-machi, Yatsuka-gun, Shimane Prefecture.

The foraminiferal assemblege shown in Table XXIV may be named the *Cyclammina-Trochammina* faunule. A black shale facies of the Tamatsukuri formation which yielded the faunule microbiostratigraphically corresponds to the lower part of the *Cyclammina orbicularis-Martinottiella communis* zone (Plate 38).

TABLE XXIV
Tamatsukuri Foraminifera

Species \ Zone / Faunule	*Co-Mc* Z
	Lower
	C-T-F
Bathysiphon? sp.	Rare
Haplophragmoides sp.	Rare
Cyclammina ezoensis Asano	Rare
Cyclammina cf. *japonica* Asano	Rare
Cyclammina pusilla Brady	Rare
Trochammina sp.	Common

Co-Mc Z; *Cyclammina orbicularis-Martinottiella communis* Zone, *C-T*-F; *Cyclammina-Trochammina* Faunule.

I. Muro and Aoki, Yakumo-mura, Yatsuka-gun, Shimane Prefecture

The smaller Foraminifera collected by the writer from two horizons of the Miocene Tamatsukuri formation distributed at Muro (Lat. 35°24′12″ N., long. 133°4′22.4″ E.) and Aoki (Lat. 35°24′31″ N., long. 133°5′34.4″ E.), Yakumo-mura, Yatsuka-gun, Shimane Prefecture, are discussed here.

The geology of the Tamatsukuri formation was outlined by the writer in the section on the Outer Subprovince in Chapter I. The upper Tamatsukuri formation here is a hard black shale facies interbedding a rhyolite flow in its middle part. Of the two horizons which yielded Foraminifera, the one at Muro is in a shale facies below the rhyolite flow and the other at Aoki occurs above the same flow. The Foraminifera from the two localities are very few as shown in Table XXV.

Microbiostratigraphically, the two parts of the Tamatsukuri formation which yielded the Muro and Aoki microfaunas (or *Cyclammina*-, and *Cyclammina-Haplophragmoides* faunules), respectively correspond to the lower and middle parts of the *Cyclammina orbicularis-Martinottiella communis* zone (Plate 38).

TABLE XXV
Muro and Aoki Foraminifera

Species \ Zone / Faunules / Locs.	*Co-Mc* Z	
	Lower	Middle
	C-F	*C-H*-F
	Muro	Aoki
Haplophragmoides sp.		R
Cyclammina incisa (Stache)	R	
Cyclammina japonica Asano	R	R
Cyclammina sp.		R
Goësella sp.		R
Dentalina sp.		R

Co-Mc Z; *Cyclammina orbicularis-Martinottiella communis* Zone, *C*-F; *Cyclammina* Faunule, *C-H*-F; *Cyclammina-Haplophragmoides* Faunule, R; Rare.

J. Matsue City, Shimane Prefecture

As to the geology of the Matsue formation, the writer already summarized it in the section on Shimane Peninsula Subprovince in Chapter I.

The two foraminiferal faunas were collected from both the Kuroda- and Terazu-sandstone members, the upper- and lower-most divisions of the Matsue formation.

The Foraminifera from the Kuroda member was derived from six cores of a boring well of the City Water-Works Department, Matsue City, for the purpose of ground water exploration in 1950. The locality of the boring well is Kitada-machi (Lat. 35° 28′26″ N., long. 133°3′41.4″ E.), Matsue City, and the Foraminifera yielded therefrom are shown in Table XXVI. The Kuroda microfauna in Table XXVI may be named

the *Rotalia-Bulimina* faunule from its characteristics. Microbiostratigraphically, the Kuroda sandstone member which yielded the faunule represents the upper part of the *Rotalia* cf. *beccarii* zone (Plate 38).

TABLE XXVI
Distribution of Kuroda Foraminifera

Species \ Zone / Faun. / Dep. in M. / Hors.	*Rb* Z					
	Upper					
	R-B-F					
	10.5	9.3	7.6	7.0	6.5	5.8
	1	2	3	4	5	6
Haplophragmoides cf. *canariensis* (d'Orbigny)			R			
Trochammina sp. indet.			R			
Nonion cf. *akitaense* Asano	F					
N. sp. indet.	R					
Bulimina imamurai Tai, n. sp.		R		R	R	R
B. cf. *pupoides* d'Orbigny				R		R
Rotalia cf. *beccarii* (Linnaeus)	F			R	R	

Rb Z; *Rotalia* cf. *beccarii* Zone, *R-B*-F; *Rotalia-Bulimina* Faunule, F; Few, R; Rare.

On the other hand, a foraminiferal sample of the Terazu sandstone member was obtained by the writer from a fine-grained sandstone facies exposed at the road cliff at Yada, south of Matsue City (Lat. 35°26′0″ N., long. 133°6′19.4″ E.). The sandstone facies there yields important megafossils, as *Turritella saishuensis*, *Cultellus izumoensis*, *Mya japonica*, and *Trophonopsis* n. sp. etc. The occurrence of these megafossils suggests that the lower Matsue formation may be lower Pliocene in age.

The Yada microfauna in Table XXVII may be named the *Nonion-Elphidium-Rotalia* faunule. Microbiostratigraphically, the Terazu member at Yada which contains the faunule represents the lower part of the *Rotalia* cf. *beccarii* zone (Plate 38).

TABLE XXVII
Yada Foraminifera

Species \ Zone / Faunule	*Rb* Z
	Lower
	N-E-R-F
Eggerella cf. *bradyi* (Cushman)	Rare
Gaudryina cf. *yabei* Asano	Abundant
Quinqueloculina akneriana d'Orbigny	Few
Q. vulgaris d'Orbigny	Few
Lagena hispidula Cushman	Rare
L. sp. indet.	Rare
Guttulina sp.	Rare
Nonion japonicum Asano	Few
N. nicobarense Cushman	Abundant
N. pacificum (Cushman)	Rare

Species \ Faunule	*N-E-R*-F
Elphidium clavatum Cushman	Rare
E. etigoense Husezima and Maruhasi	Abundant
Cribroelphidium tomitai Tai	Few
C. yabei (Asano)	Few
Eolivina substriatula Asano	Rare
Eponides frigidus (Cushman)	Rare
E. frigidus calidus Cushman and Cole	Rare
Rotalia cf. *beccarii* (Linnaeus)	Common
R. cf. *papillosa* Brady	Rare
R. cf. *takanabensis* (Ishizaki)	Rare
Globigerina bulloides d'Orbigny	Common

Rb Z; *Rotalia* cf. *beccarii* Zone, *N-E-R*-F; *Nonion-Elphidium-Rotalia* Faunule.

K. Tochimoto, near Tottori City, Tottori Prefecture

The Miocene smaller Foraminifera were collected by M. NISHIWAKI from seven localities of the Tochimoto shale, the upper division of the Taisei group, distributed in Tochimoto, Kokufu-machi, Iwami-gun, Tottori Prefecture.

The stratigraphy of the Miocene formations in the environs of Tochimoto (NISHIWAKI and IMAMURA, 1956) is summarized in descending order as follows:

TAISEI GROUP

Tochimoto shale member; black shale yielding megafossils as *Chlamys miyatokoensis, Propeamussium* cf. *tateiwai*, and *Lima* sp. etc. and with thin sandstone layers in the lower part; 200m.
Nawashiro sandstone and conglomerate member; sandstone and conglomerate with megafossils as *Patinopecten* cf. *kimurai* and *Shichiheia japonica* etc.; 130m.

~~~~~~~~~~ unconformity ~~~~~~~~~~

YAMASAKI GROUP

Fuganji shale member; stratified hard shale with plant fossils as *Myrica Naumanni* and *Glyptostrobus* etc.; 80m.
Arafune tuff member; 230m.
Genmonji andesite; 120m.
Funayama conglomerate member; 60m.

~~~~~~~~~~ unconformity ~~~~~~~~~~

BASEMENT ROCKS

The smaller Foraminifera from the Tochimoto shale consist of 29 species and subspecies (Table XXVIII) belonging to 20 genera and 10 families, excluding the pelagic forms.

From the characteristics of the Foraminifera, the Tottori microfauna may be divided into two faunules, namely, *Martinottiella-Sigmoilina-Lagenonodosaria* faunule below and *Cyclammina* faunule above. Microbiostratigraphically, a part of the upper Taisei group which yielded the former faunule seems to correspond to the upper part of the *Lagenonodosaria scalaris-Uvigerina crassicostata* zone and the latter faunule to the lower part of the *Cyclammina orbicularis-Martinottiella communis* zone (Plate 38).

TABLE XXVIII
Distribution of Tottori Foraminifera

Species \ Zones / Fauns. / Locs.	*Ls-Uc* Z						*Co-Mc* Z
	Upper						Lower
	M-S-F						*C*-F
	1	2	3	4	5	6	7
Bathysiphon sp.		F					
Haplophragmoides cf. *trullissatum* (Brady)			R				
H. sp.	R						
Cribrostomoides cf. *kyushuense* Asano			R				
C. sp. indet.			R				
Cyclammina cf. *incisa* (Stache)	R	R					R
C. pusilla Brady	R						
C. sp. indet.							R
Plectina nipponica Asano			R				
Martinottiella communis (d'Orbigny)		A	C	C	C	R	
Sigmoilina imamurai Tai		A	R				
S. cf. *schlumbergeri* Silvestri			R				
S. sp.						R	
Miliolinella cf. *circularis* (Bornemann)	R						
Pyrgo sp.	R						
Trochammina cf. *nobensis* Asano	R						
T. sp.	F		R	R			
Robulus sp. indet.	R						
Dentalina sp. indet.	R		R				
Lagenonodosaria scalaris sagamiensis Asano		R				R	
L. sp.		R				R	
Lagena sulcata spicata Cushman and McCulloch		R					
Oolina cf. *hexagona* (Williamson)						R	
Uvigerina crassicostata Schwager	R						
Gyroidina orbicularis d'Orbigny	R						
Rotalia takanabensis (Ishizaki)	R						
Cassidulina laevigata carinata Cushman	R						
C. cf. *margareta* Karrer	R						
Cibicides lobatulus (Walker and Jacob)	R						
Globigerina bulloides d'Orbigny	R			R			

Ls-Uc Z; *Lagenonodosaria scalaris-Uvigerina crassicostata* Zone, *Co-Mc* Z; *Cyclammina orbicularis-Martinottiella communis* Zone, *M-S*-F; *Martinottiella-Sigmoilina-Lagenonodosaria* Faunule, *C*-F; *Cyclammina* Faunule, A; Abundant, C; Common, F; Few, R; Rare.

Sampling localities:

1- A hard black shale of the Tochimoto shale, the upper division of the Taisei group, exposed at Amedaki, Kokufu-machi, Iwami-gun, Tottori Prefecture (Lat. 35°28′37″ N., long. 134°24′5.4″ E.).

2- A hard black shale of the Tochimoto shale, exposed at the road cliff (Lat. 35°28′8″ N., long. 134°22′2.4″ E.) at Tochimoto, Kokufu-machi, Iwami-gun, Tottori Prefecture.

3- Stratigraphically about 19.0m. above locality 2.

4- A hard black shale of the Tochimoto shale, exposed at Waji, Kokufu-machi, Iwami-gun, Tottori Prefecture (Lat. 35°26′45″ N., long. 134°22′40.4″ E.).

5- Stratigraphically about 20.0m. above locality 4.

6- Stratigraphically about 40.0m. above locality 4.

7- A hard black shale of the Tochimoto shale, which is stratigraphically probably above locality 6, exposed at Waji, Kokufu-machi, Iwami-gun. Tottori Prefecture (Lat. 35°26′40″ N., long. 134°23′19.4″ E.).

L. Okuyamada, near Kyôto City, Kyôto Prefecture

According to the study of S. ISHIDA and others (1954), the stratigraphy of the Miocene Tsuzuki group distributed in Ujitawara-machi, Tsuzuki-gun, Kyôto Prefecture is summarized as follows in descending order;

TSUZUKI GROUP
- Yuantani formation
  - Tawara arkose sandstone and conglomerate; 50m.
  - Shiodani sandstone; containing megafossils as *Anadara* sp., *Dosinia* sp., *Felaniella "usta"*, *Katelysia nakamurai*, *Protorotella yuantaniensis*, and *Turritella s-hataii*; 65m.
- Okuyamada formation
  - Kaya tuffaceous mudstone; containing megafossils as *Anadara* sp., *Chlamys* sp., *Dosinia* sp., *Glycymeris ayugawaensis*, *Ostrea gigas*, and *Myrica Naumanni*; 95m.
  - Miyamura sandstone; containing megafossils as *Dosinia* sp., *Katelysia nakamurai*, *Turritella s-hataii*, and *Vicaryella* sp., 20m.
  - Kawakami conglomerate; 35m.

~~~~~~~~~~ unconformity ~~~~~~~~~~

BASEMENT ROCKS

Unfortunately 41 samples of the total 44 were barren of Foraminifera. Therefore, the Foraminifera discussed herein are from only three horizons of the Shiodani sandstone, the lower division of the Yuantani formation mentioned above. The Okuyamada microfauna consisting of 18 species as shown in Table XXIX may be named the *Rotalia-Eponides-Nonion* faunule. The upper part of the Tsuzuki group which yielded the faunule microbiostratigraphically seems to correspond to the upper part of the *Nonion mizunamiense* zone which type section is in the lower Mizunami group, Gifu Prefecture (Plate 38).

TABLE XXIX
Distribution of Okuyamada Foraminifera

Species \ Zone / Faun. / Samp. Locs.	*N*-Z		
	Upper		
	R-E-F		
	1	2	3
Dentalina sp.			R
Lagenonodosaria sp.			R
Lagena sp.			R
Nonion japonicum Asano	C	A	
N. nakosoense Asano		F	
N. sp.		R	F
Pseudononion cf. *japonicum* Asano	F	R	R
P. cf. *tredecum* Asano			R
Nonionella miocenica Cushman		R	
Elphidium cf. *etigoense* Husezima and Maruhasi			R
Cribroelphidium yabei (Asano)			F
Elphidiella cf. *momiyamaensis* Uchio			R
Eponides frigidus (Cushman)	R	R	C
~~~~~~~~~~

Species \ Samp. Locs.	1	2	3
Rotalia beccarii (Linnaeus)	VA	VA	C
R. takanabensis (Ishizaki)	R	C	C
R. tochigiensis Uchio	R	R	C
Anomalina glabrata Cushman		R	
Hanzawaia tagaensis Asano		R	

N-Z; *Nonion mizunamiense* Zone, *R-E*-F; *Rotalia-Eponides-Nonion* Faunule, VA; Very abundant, A; Abundant, C; Common, F; Few, R; Rare.

Sampling localities:

1- A fossiliferous fine-grained sandstone of the Shiodani sandstone, the lower division of the Yuantani formation, exposed at the cliff (Lat. 34°51'3" N., long. 135°55'44.4" E.) of the stream in Kaya, Ujitawara-machi, Tsuzuki-gun, Kyôto Prefecture.

2- Stratigraphically about 4.0m. above locality 1.

3- A fossiliferous medium-grained sandstone of the Shiodani sandstone, which is stratigraphically probably above locality 2, exposed at the floor (Lat. 34°50'44" N., long. 135°54'11.4" E.) of the stream in Shiodani, Ujitawara-machi, Tsuzuki-gun, Kyôto Prefecture.

M. Tokiwa, North of Awaji Island, Hyôgo Prefecture

The smaller Foraminifera discussed herein was collected by the writer from the sediments exposed at Tokiwa, Hokutan-machi, Tsuna-gun, Hyôgo Prefecture.

The sediments correspond to the Miocene Iwaya formation (SHIKAMA, 1936) distributed in the area north of the Awaji Island. The Iwaya formation in the vicinity of the sampling locality has a thickness of about 100m. and consists of two parts of coarse-grained facies below and fine-grained facies with some molluscan fossils above. As shown in Table XXX, the Foraminifera from the two samples of the latter facies above mentioned consist of 31 species belonging to 21 genera and 10 families. The microfauna shown in Table XXX may be named the *Elphidium-Elphidiella-Cibicides* faunule.

Microbiostratigraphically, the upper part of the Iwaya formation which yielded the faunule seems to correspond to the *Miogypsina kotoi-Operculina complanata japonica* zone (Plate 38).

TABLE XXX

Distribution of Awaji Foraminifera

Species \ Zone / Faun. / Sam. Locs.	*Mk-Oc* Z	
	E-E-F	
	1	2
Haplophragmoides sp.	R	R
Cyclammina incisa (Stache)	R	R
Gaudryina ishikiensis Asano		R
G. yabei Asano	R	R
Quinqueloculina sp.	R	R
Triloculina sp.	R	
Trochammina sp.	R	F
Marginulina sp.		R
Pseudoglandulina laevigata (d'Orbigny)	R	R

Species \ SamP. Locs.	1	2
Guttulina irregularis (d'Orbigny)		R
Globulina sp.	R	
Nonion grateloupi (d'Orbigny)	R	R
N. scaphum (Fichtel and Moll)		R
N. umbilicatulum (Montagu)		R
N. sp.	R	
Elphidium etigoense Husezima and Maruhasi	C	F
Elphidiellu momiyamaensis Uchio	A	A
Eulimina ovata d'Orbigny	R	
B. sp		R
Bolivina marginata Cushman	R	R
B. robusta Brady		R
Eponides frigidus (Cushman)		R
E. sp.	R	
Anomalina glabrata Cushman		R
A. sp.	R	
Planulina nipponica Asano	R	R
P. wuellerstorfi (Schwager)		R
Hanzawaia tagaensis Asano	R	
Cibicides lobatulus (Walker and Jacob)	R	R
C. pseudoungerianus (Cushman)	F	A
Dyocibicides perforata Cushman and Valentine	R	C

Mk-Oc Z; *Miogypsina kotoi-Operculina complanata japonica* Zone, *E-E*-F; *Elphidium-Elphidiella-Cibicides* Faunule, A; Abundant, C; Common, F; Few, R; Rare.

Sampling localities:

1- A fossiliferous fine-grained sandstone of the Iwaya formation exposed at the road cliff (Lat. 34°33′30″ N., long. 134°58′24.4″ E.) of Tokiwa, Hokutan-machi, Tsuna-gun, Hyôgo Prefecture.

2- Stratigraphically about 1.0m. above locality 1.

N. Tanabe City, Wakayama Prefecture

According to the study of T. TAKEYAMA (1930), the stratigraphy of the Miocene formations in the vicinity of Tanabe City, Wakayama Prefecture is summarized as follows in descending order;

KANAYAMA GROUP 1000m.
Upper conglomerate
Lower sandstone; medium-grained sandstone with *Serpula-*, *Turritella-*, and *Paphia* fossil zones in downward sequence.

~~~~~~~~ partial unconformity ~~~~~~~~

TANABE GROUP 2000-1500m.
Asso formation; hard black shale with sandstone beds.
Maro formation and its equivalents; alternation of sandstone, conglomerate, and shale.
Inari formation and its equivalents; sandstone and conglomerate intercalating sandy shale.
Tagawa formation; conglomerate and sandstone with some plant fossils.

~~~~~~~~ unconformity ~~~~~~~~

BASEMENT ROCKS (MURU GROUP)

The smaller Foraminifera discussed herein was collected by the writer from nine horizons of the Asso formation, the uppermost division of the Tanabe group above

mentioned, and one from the Lower sandstone, the lower division of the Kanayama group.

As shown in Table XXXI, the foraminiferal fauna of the Tanabe Tertiary formations consists of 57 species and subspecies belonging to 32 genera and 14 families, excluding the pelagic forms.

Generally speaking, the family Lagenidae is represented by the largest number of genera, species, and individuals. In other families, the genera *Cyclammina*, *Plectina*, *Martinottiella*, and *Nonion* include a large number of the species and individuals. The occurrence of pelagic forms is remarkable throughout the majority of the horizons.

From the characteristics of the Foraminifera shown in Table XXXI, the Tanabe microfauna may be divided into two faunules, namely, *Cyclammina-Martinottiella-Marginulina-Robulus* faunule below and *Cyclammina* faunule above.

Microbiostratigraphically, the upper Tanabe group which yielded the former faunule seems to correspond to the *Lagenonodosaria scalaris-Uvigerina crassicostata* zone and the transitional zone from the Tanabe group to the Kanayama group, which contains the latter faunule, to the *Cyclammina orbicularis-Martinottiella communis* zone (Plate 38).

TABLE XXXI
Distribution of Tanabe Foraminifera

Formations	Tan G								KG	
	Asso F								SF	
Zones	*Ls-Uc* Z								*Co-Mc* Z	
Fauns.	*C-M*-F								*C*-F	
Species / Hors.	1	2	3	4	5	6	7	8	9	10
Bathysiphon sp.		R	R	R	R			R		
Ammodiscus sp.				R				R		
Ammodiscoides? sp.					R					
Cyclammina ezoensis Asano				R	R					R
C. cf. *ezoensis* Asano							R			
C. incisa (Stache)		R		F	R	R	R	A		C
C. cf. *japonica* Asano						R				
C. orbicularis Brady									R	
C. cf. *pusilla* Brady								A		
C. sp.				F	R					
Textularia cf. *conica* d'Orbigny					R					
Gaudryina ishikiensis Asano	R	R	R					R		
G. yabei Asano									R	
Plectina cf. *nipponica* Asano								R		
P. sp.	R									
Goësella schencki Asano								R	R	
Karreriella tanabensis Tai, n. sp.		F	R	R						
Martinottiella communis (d'Orbigny)	R	R	R	R	R	R	R	F		R
Schenckiella victoriensis (Cushman)									R	
Sigmoilina imamurai Tai	R	F	R	R						
S. schlumbergeri Silvestri				R						
Pyrgo sp.								R		
Trochammina sp.				R				R		

Species \ Hors.	1	2	3	4	5	6	7	8	9	10
Robulus calcar (Linnaeus)			R							
R. etigoensis Asano								R		
R. cf. *iotus* (Cushman)								R		
R. lucidus (Cushman)			R			R		F		
R. nikobarensis (Schwager)								R		
R. cf. *orbicularis* (d'Orbigny)			R							
R. pseudorotulatus Asano				R						
R. cf. *sagamiensis* Asano								R		
R. sp.								R		
Marginulina aculeata Neugeboren	R	R	R	R		R	R	R		
M. glabra d'Orbigny								R		
M. masudai Asano			R	R						
M. sp.								R		
Dentalina communis d'Orbigny		R								
D. cf. *subsoluta* (Cushman)								R		
D. sp.				R						
Nodosaria pyrula d'Orbigny								R		
Pseudoglandulina sp.								R		
Lagenonodosaria scalaris sagamiensis Asano								R		
Lagena sp.								R		
Guttulina irregularis (d'Orbigny)								R		
Nonion kidoharaense Fukuda								R		
N. nakosoense Asano								R		
N. pompilioides (Fichtel and Moll)						R		F		
Nonionella miocenica Cushman				R				R		
Bulimina sp.	R	R	R							
Fissurina sp.						R				
Eponides praecinctus (Karrer)								R		
Rotalia cf. *inflata* (Seguenza)								R		
R. takanabensis (Ishizaki)								R		
Baggina notoensis Asano				R			R			
Planulina nipponica Asano			R					R		
Hanzawaia tagaensis Asano								R		
Cibicides pseudoungerianus (Cushman)								R		
Globigerinidae:	A	A	A	C			R	A	R	

Tan G; Tanabe Group, KG; Kanayama Group, Asso F; Asso Formation, SF; Lower Sandstone, *Ls-Uc* Z; *Lagenonodosaria scalaris-Uvigerina crassicostata* Zone, *Co-Mc* Z; *Cyclammina orbicularis-Martinottiella communis* Zone, *C-M*-F; *Cyclammina-Martinottiella-Marginulina-Robulus* Faunule, *C*-F; *Cyclammina* Faunule, A; Abundant, C; Common, F; Few, R; Rare.

Sampling horizons:

1- A hard black shale of the Asso formation, exposed at the northern cliff (Lat. 33°43′15″ N., long. 135° 24′2.4″ E.) of Mori Harbour, Tanabe City, Wakayama Prefecture.
2- Stratigraphically about 5m. above horizon 1.
3- Stratigraphically about 10m. above horizon 1.
4- Stratigraphically about 15m. above horizon 1.
5- Stratigraphically about 20m. above horizon 1.
6- Stratigraphically about 25m. above horizon 1.
7- Stratigraphically about 78m. above horizon 1.
8- Stratigraphically about 83m. above horizon 1.
9- Stratigraphically about 136m. above horizon 1.
10- Stratigraphically about 189m. above horizon 1.

O. Imaichi-machi, Izumo City, Shimane Prefecture

The stratigraphy of the Miocene Fujina formation in the vicinity of Imaichi-machi, Izumo City, Shimane Prefecture, has been studied by K. OKAMOTO (1959) and the writer briefly gave an outline of it in Chapter I.

The marine sediments which yielded the Miocene Foraminifera discussed herein correspond to the Fujina mudstone member, the upper division of the Fujina formation. The foraminiferal samples were collected by K. OKAMOTO from six horizons of the Fujina member distributed in Imaichi-machi, Izumo City, Shimane Prefecture.

The Imaichi microfauna consists of 13 species and subspecies (Table XXXII) belonging to 8 genera and 6 families.

From the characteristics of the Foraminifera shown in Table XXXII, the Imaichi microfauna may be divided into two faunules, namely, *Haplophragmoides-Trochammina* faunule below and *Nonion-Eponides* faunule above. Microbiostratigraphically, a part of the upper Fujina formation which yielded the former faunule seems to correspond to the lower part of the *Uvigerina subperegrina-Epistominella pulchella* zone and the latter faunule to the middle part of the same zone (Plate 38).

TABLE XXXII
Distribution of Imaichi Foraminifera

Species \ Zone / Fauns. / Samp. hors.	*Us-Ep* Z					
	Lower			Middle		
	H-T-F			*N-E*-F		
	1	2	3	4	5	6
Haplophragmoides sp.	C					
Cyclammina pusilla Brady	R					
C. sp. indet.		R				
Plectina cf. *nipponica* Asano	F					
Trochammina cf. *nobensis* Asano	R					
T. sp.	A					
T.? sp.		R	R			
Nonion japonicum Asano					R	
N. scaphum (Fichtel and Moll)					R	
Eponides frigidus calidus Cushman and Cole					R	
E. praecinctus (Karrer)				R		
Rotalia cf. *beccarii hatatatensis* Takayanagi						R
Epistominella pulchella Huseзima and Maruhasi					R	

Us-Ep Z; *Uvigerina subperegrina-Epistominella pulchella* Zone, *H-T*-F; *Haplophragmoides-Trochammina* Faunule, *N-E*-F; *Nonion-Eponides* Faunule, A; Abundant, C; Common, F; Few, R; Rare.

Sampling horizons:

1- A very fine-grained sandstone facies of the Fujina mudstone member, the upper division of the Fujina formation, distributed at Kurihara, Imaichi-machi, Izumo City, Shimane Prefecture (Lat. 35°21′9″ N., long. 132°47′20.4″ E.).

2- Stratigraphically about 79m. above horizon 1.

3- Stratigraphically about 97m. above horizon 1.

4- Stratigraphically about 99m. above horizon 1.
5- Stratigraphically about 370m. above horizon 1.
6- Stratigraphically about 480m. above horizon 1.

P. Kute- and Asayama-machi, Ota City, Shimane Prefecture

The smaller Foraminifera obtained from many horizons of the Miocene Kuri and Omori formations distributed in Kute- and Asayama-machi, Ota City, Shimane Prefecture are discussed here.

The geology of the Kuri and Omori formations was outlined by the writer in the section on the Inner Subprovince in Chapter I.

The Kuri formation here is a hard black shale facies interbedding a dacitic tuff breccia in its upper part and from its shale facies 33 foraminiferal samples were collected by the writer and M. OKUHARA. On the other hand, the Omori formation, which consists mainly of andesite flow and its pyroclastics, intercalates some black shale facies in the upper part and from its shale facies 8 foraminiferal samples were collected by M. OKUHARA.

The smaller Foraminifera picked up from these samples consist of 101 species and subspecies (Table XXXIII) belonging to 44 genera and 16 families, excluding the pelagic forms. The genera *Haplophragmoides*, *Cyclammina*, *Martinottiella*, *Sigmoilina*, *Robulus*, *Nodosaria*, *Lagenonodosaria*, *Nonionella*, *Uvigerina*, *Eponides*, and *Rotalia* contain the majority of the species and individuals of the present microfauna. From the characteristics of the Foraminifera shown in Table XXXIII, the Kute and Asayama microfaunas may be divided into five foraminiferal assemblages in ascending order, namely, *Cyclammina-*, *Epistominella-*, *Cyclammina-Robulus-Lagenonodosaria-Uvigerina-*, *Haplophragmoides-Cyclammina-Martinottiella-Sigmoilina-*, and *Cyclammina-Martinottiella* faunules. Of these faunules, the last two faunules, *Haplophragmoides-* and *Cyclammina*-ones, are very similar each other, though the latter faunule slightly differs from the former one by having a fewer individual number of Foraminifera.

Microbiostratigraphically, the middle part of the Kuri formation which contains the former three faunules above mentioned, corresponds to the upper part of the *Lagenonodosaria scalaris-Uvigerina crassicostata* zone, and the upper part of the same formation which contains the next faunule to the lower and middle parts of the *Cyclammina orbicularis-Martinottiella communis* zone, and the Omori formation which contains the last faunule to the upper part of the same zone just mentioned above (Plate 38).

TABLE XXXIII

Distribution of Kute and Asayama Foraminifera

Species \ Formations / Zones / Faunules / Hors.	KURI																							OMORI							
	Ls-Uc																					*Co-Mc*									
	Upper																					Lower					Midd.	Upper			
	Cyc						*Ep*				*C-R-L-U*											*H-C-M-S*								*C-M*		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Bathysiphon sp. A																	R			R		A					F							R						
B. sp. B																	A			C		C					C					R							R	R
B. ? sp.	R			R				F		A		F	F	C	F	F	C		C	A			R	F	R	R			R		R	C							
Ammodiscus sp.										R														R			R												
Haplophragmoides spp.								R		F	F	F	A	C		C	A	C	C	C	R	A	A	A	A	R	R	A	R	R	A		C	R		F	R	A		R
H. ? sp.	A																					C																	
Cribrostomoides sp.	C										C	F	C	F	F									R	R		C		R	C	F			R					
Ammobaculites sp.		R							R								R	R	R						R						R								
Cyclammina ezoensis Asano	C		R	C			R	R		R	C	R	F	F	R	A	A	F	C	R			C		F	F	R	F	R		R	C	F					R	
C. cf. *ezoensis* Asano					R																																		
C. ezoensis okuharai Tai, n. subsp.																																						R	
C. incisa (Stache)	C	R		A		R	A	F			R	F		R	R	R	C	C	C				F		R		R	R		R	F	C		R	R				
C. cf. *incisa* (Stache)										F																													
C. japonica Asano			R	F			C		F					R		R	C	F	F		R			F		R			C	A		R	R					
C. cf. *japonica* Asano	C										R	R											C			R		F			F								
C. orbicularis Brady																							F	F	F		C			F	A	C		R					
C. pusilla Brady	C							C				R				R	C	F	A	F	R	R	C	A			A			R		A		R					
C. cf. *pusilla* Brady																																					R		
C. sp.	C		R	A			R		R		C	R		R	R	C	A		F											R	F	F		R					
Gaudryina ishikiensis Asano																R	R																						
Dorothia ? sp.							R																																
Plectina nipponica Asano	A			F					R	R						R	R			A	F	R										F							
P. sp.	C	R		R	R	R		R			R	R						R	R		R	F	R				F			R									
P. ? sp.							R	R																																
Goësella schencki Asano	R			R																	R									R									
G. sp.																													R										
G. ? sp.								R																															
Martinottiella communis (d'Orbigny)										R			R				R	R	C	C	C	R	C	C	A			A	R	A	F	R	A		C	R	R		A	
Sigmoilina imamurai Tai										R			C	R	F	R	R	R					R		C			R			R		A			R	F		A	

S. schlumbergeri Silvestri											R	C	R	C						R	A			C	R	R	R		C		R			R	
Trochammina spp.	A				R	R		R			F	F	F		C				F	F	C									F	R				R
Robulus lucidus (Cushman)									R		R	F	R	R	F			R	R																
R. miyagiensis Asano									R																										
R. nikobarensis (Schwager)												R		R				R	R																
R. orbicularis (d'Orbigny)																		R																	
R. cf. *orbicularis* (d'Orbigny)													R																						
R. pseudorotulatus Asano													R																						
R. sp.					R					R	F	R	R	R	R																				
Marginulina aculeata Neugeboren									R										R																
M. glabra d'Orbigny												R						R																	
M. masudai Asano									R																										
M. mukaei Tai and Okamoto, n. sp.									R			C	R	F	R			F																	
M. sp.											R																								
Dentalina subsoluta (Cushman)									R																										
D. sp.	F									R	R		F	R	R			R																	
Nodosaria longiscata d'Orbigny									A		F	R	R		R																				
N. pyrula d'Orbigny										C	A	C	C	F	F			R																	
Pseudoglandulina laevigata (d'Orbigny)						R	R			R		R																							
Lagenonodosaria fukushimaensis Asano	R								R	F					R			A	R																
L. scalaris (Batsch)	R								F	R	R	R			R			R																	
L. scalaris sagamiensis Asano									R	R	F	F			C			C																	
L. sp.	R			R					R						R			R																	
Lagena laevis (Montagu)														R				R																	
L. substriata Williamson									R									R																	
L. sulcata spicata Cushman & McCulloch									R	R	R							F																	
L. sp.									R	R	R	R						R																	
Pyrulina cylindroides (Roemer)											R							R																	
Nonion japonicum Asano												F																							
N. kidoharaense Fukuda	R											R	R		F																				
N. nakosoense Asano									R			R																							
N. scaphum (Fichtel and Moll)						R				F	F		R	F				R																	
Pseudononion japonicum Asano									R																										
Nonionella miocenica Cushman					F	R	R	R	C	F	R	F		A	A																				
Elphidium tsudai Chiji and Nakaseko												R																							
Plectofrondicularia longistriata LeRoy									F																										
Bulimina sp.											R																								
Globobulimina perversa (Cushman)														R				F	F																
G. sp.								R																											
Fissurina marginata (Montagu)									R																										
Virgulina sp.									R																										
Bolivina marginata Cushman												F																							

Species \ Hors.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
B. marginata masudai Asano									R					F	C	C																									
B. robusta Brady														F	C																										
B. cf. *robusta* Brady																F																									
Uvigerina cf. *hootsi* Rankin											A	A	C																												
U. nitidula Schwager											A	A	A	R	C	F	F																								
U. proboscidea Schwager											A	C	A	F																											
U. segundoensis Cushman and Galliher											A	A	A	R	F	F	F																								
U. yabei Asano											C	R	R																												
U. sp.	R										C																													
Angulogerina kokozuraensis Asano								R							R					R																				
Ellipsonodosaria japonica Ishizaki											C		C	R		R																								
E. lepidula (Schwager)											C			R		R					R																			
E. sp.															F																									
Discopulvinulina sp.							R		R								R			F	R																			
Gyroidina orbicularis d'Orbigny																					R																			
G. soldanii d'Orbigny							R	R																																
G. sp.																				R																			
Eponides frigidus (Cushman)													R																											
E. frigidus calidus Cushman and Cole							F	F	R		C	C	C	C		R	R			C																				
E. nipponicus (Husezima and Maruhasi)												C		R						R																			
E. umbonatus (Reuss)													R		R		R																							
E. sp.								R				R			R	R																								
Rotalia takanabensis (Ishizaki)	F						F	R	R		A	A	F	A	A	A				A	R																			
R. sp.																					R																			
Baggina notoensis Asano											R			F	F																									
Epistominella japonica (Asano)							A	C	R																															
Cassidulina margareta Karrer								R																																
Planulina nipponica Asano																				F	R																			
Hanzawaia tagaensis Asano														R		R																								
Cibicides pseudoungerianus (Cushman)									R											A	F																			
Pelagic forms											R	R	R	R	R	F	C			C	R																			

Ls-Uc; *Lagenonodosaria scalaris-Uvigerina crassicostata* Zone, *Co-Mc*; *Cyclammina orbicularis-Martinottiella communis* Zone, *Cyc*; *Cyclammina* Faunule, *Ep*; *Epistominella* Faunule, *C-R-L-U*; *Cyclammina-Robulus-Lagenonodosaria-Uvigerina* Faunule, *H-C-M-S*; *Haplophragmoides-Cyclammina-Martinottiella-Sigmoilina* Faunule, *C-M*; *Cyclammina-Martinottiella* Faunule, A; Abundant, C; Common, F; Few, R; Rare.

Sampling horizons:

1- A black shale of the Kuri formation, exposed at the cliff along the road of Hata-Kanbara section of Asayama-machi, NE of Ota City, Shimane Prefecture (Lat. 35°13′33″ N., long. 132°34′30.4″ E.).
2- Stratigraphically about 40.0m. above horizon 1.
3- Stratigraphically about 41.0m. above horizon 1.
4- Stratigraphically about 45.0m. above horizon 1.
5- Stratigraphically about 51.5m. above horizon 1.
6- Stratigraphically about 52.5m. above horizon 1.
7- Stratigraphically about 61.5m. above horizon 1.
8- Stratigraphically about 64.0m. above horizon 1.
9- Stratigraphically about 65.5m. above horizon 1.
10- Stratigraphically about 69.5m. above horizon 1.
11- Stratigraphically about 72.5m. above horizon 1.
12- Stratigraphically about 74.0m. above horizon 1.
13- Stratigraphically about 75.0m. above horizon 1.
14- Stratigraphically about 76.5m. above horizon 1.
15- Stratigraphically about 78.0m. above horizon 1.
16- Stratigraphically about 80.0m. above horizon 1.
17- Stratigraphically about 82.5m. above horizon 1.
18- Stratigraphically about 84.0m. above horizon 1.
19- Stratigraphically about 85.0m. above horizon 1.
20- Stratigraphically about 105.0m. above horizon 1.
21- Stratigraphically about 106.5m. above horizon 1.
22- Stratigraphically about 108.5m. above horizon 1.
23- Stratigraphically about 116.5m. above horizon 1.
24- Stratigraphically about 134.5m. above horizon 1.
25- Stratigraphically about 138.5m. above horizon 1.
26- Stratigraphically about 139.5m. above horizon 1.
27- Stratigraphically about 140.5m. above horizon 1.
28- Stratigraphically about 141.5m. above horizon 1.
29- Stratigraphically about 142.5m. above horizon 1.
30- A hard black shale of the Kuri formation, exposed at the cliff of the Tagi Primary School, which is situated in Kuchitagi, Taki-mura, Hinokawa-gun, Shimane Prefecture (Lat. 35°15′26″ N., long. 132°35′9.4″ E.).
31- Stratigraphically about 8.5m. above horizon 30.
32- Stratigraphically about 13.5m. above horizon 30.
33- A hard black shale of the Kuri formation, exposed at Tsukao-dani, Taki-mura, Hinokawa-gun, Shimane Prefecture (Lat. 35°15′29″ N., long. 132°35′25.4″ E.).
34- A hard black shale of the Omori formation, exposed at Suzumi, SE of Kute-machi, Ota City, Shimane Prefecture (Lat. 35°13′13″ N., long. 132°31′14.4″ E.).
35- Stratigraphically about 5.0m. above horizon 34.
36- Stratigraphically about 10.0m. above horizon 34.
37- A tuffaceous hard shale of the Omori formation, exposed at the road side cutting of Suzumi, Kute-machi, Ota City, Shimane, Prefecture (Lat. 35°13′16″ N., long. 132°31′23.4″ E.).
38- A hard black shale of the Omori formation, exposed at Asakura, Asayama-machi, Ota City, Shimane Prefecture (Lat. 35°14′42″ N., long. 132°33′56.4″ E.).
39- A hard black shale of the Omori formation, exposed at Kuchitagi, Taki-mura, Hinokawa-gun, Shimane Prefecture (Lat. 35°15′27″ N., long. 132°34′59.4″ E.).
40- A hard black shale of the Omori formation, exposed at the road side cutting of Tsuto, Asayama-machi, Ota City, Shimane Prefecture (Lat. 35°15′30″ N., long. 132°34′38.4″ E.).
41- A hard black shale of the Omori formation, exposed at the floor of the stream in Senzan, Asayama-machi, Ota City, Shimane Prefecture (Lat. 35°15′16″ N., long. 132°34′18.4″ E.).

CHAPTER IV

CORRELATION

A. Definition of Terms

As R. M. KLEINPELL has stated in his *Miocene Stratigraphy of California* (1938, p. 96), the terms zones and stages should be used in "an attempt to arrive at a chronological classification of rocks independent of both lithologic and faunal facies".

KLEINPELL (1938) emphasized that "the particular type of assemblage or association upon which depends the recognition of a zone could better be described as the joint occurrence in the same strata of two or more species having different geologic ranges", and should be distinguished from the usage of ecologists who use the terms assemblage or association in classifying environmental phenomena. For those fossil assemblages characteristics of which are due more to environmental than chronological factors KLEINPELL employed FENTON's terms faunule* as redefined by FENTON and FENTON (1928). As FENTON and FENTON pointed out in the same paper, what geologists have for study as an assemblage is "a representation of the plant or animal population of a given area during a given time, minus unknown subtraction, plus undetermined (or undeterminable) additions, and representing, probably, more than one habitat".

It was with such assemblage that FENTON and FENTON discussed the terms faunule and zonule.

In the previous pages, the various faunules or assemblages noted in the Historical Summary (Chapter II) and in the section on the Remarks on the Newly Obtained Foraminifera (Chapter III) have been recognized under such consideration, and have been graphically correlated in Plate 38. They are also tied into the standard chronologic-biostratigraphic section which is reviewed in the following pages, together with the type sections of a number of the formations more commonly referred to in the literature on West Honshû Miocene stratigraphy.

B. Stages and Zones

1. Togarian Stage: The name "Togarian" was first proposed to designate a time-stratigraphic unit of stage magnitude in the Japanese Miocene by J. MAKIYAMA (1939). A more strict redefinition based upon the smaller Foraminifera of the stage will be given here.

The type of this stage is the lower division of the Mizunami group, which yielded a skull of *Desmostylus japonicus*, distributed in Togari, near Mizunami City northeast of Nagoya. The Mizunami group here corresponds lithostratigraphically to MAKIYAMA's Togari formation, the type of his Togarian stage. Thus the Togarian redefined by the writer falls into the lower division of MAKIYAMA's stage excluding the *Mio-*

* Faunule or florule: an assemblage of fossil animals or plants, associated in one or a few contiguous strata, and dominated by the representatives of one community, commonly either an association or a layer society.

gypsina-bearing part from his stage. On the other hand, the upper division of MAKIYAMA's Togarian stage, as described in the following pages, corresponds to the lower part of the superjacent Miyoshian stage established by the writer (1958) from the Miyoshi Miocene in the Chûgoku District. The *Miogypsina*-bearing part above mentioned is the Shukunohora sandstone member of the upper Mizunami group and microbiostratigraphically corresponds to the lower division of the Miyoshian stage or the *Miogypsina kotoi-Operculina complanata japonica* zone in the following pages.

In 1939, MAKIYAMA, from the evidence afforded by the molluscan-and mammalian fossils, concluded that his Togarian is middle Miocene and equivalent of the European Vindobonian.

The lower Mizunami group is the type of the stage, which consists of the Tsukiyoshi sandstone-, Togari sandstone-, and Yamanouchi mudstone members combined, and overlies unconformably granitic rocks, though in some localities its equivalents occur unconformably above the Nakamura formation, which is a lacustrine deposit with coal seams. The top of the lower Mizunami group underlies unconformably a pumiceous coarse-grained facies (or the Hazama member of K. FUJITA and S. OGOSE, 1951) considered by the writer (1958), as a horizon equivalent to the *Miogypsina*-bearing Shukunohora sandstone member, which is a base facies of the upper Mizunami group. The columnar section of about 52m. in thickness at the type locality of the stage is outlined in Plate 37. The sediments of the type section are remarkably tuffaceous, fossiliferous, and noduliferous, and vary generally from coarse-grained sandstone through tuff and fine-grained sandstone to mudstone in upward sequence.

As to the other occurrences of the Togarian stage, it became evident that the Miocene sediments in Okuyamada near Kyôto City is referred to this stage from an examination of its foraminiferal fauna. But in West Honshû the distribution of this stage seems to be restricted within the Kinki and Nôbi Miocene districts.

The Togarian Foraminifera are generally not so rich in species and individuals. Among the Foraminifera, genera such as *Nonion*, *Nonionella*, *Elphidium*, *Elphidiella*, *Eponides*, and *Rotalia* are common and characteristic, suggesting a shallow water habitat. On the whole, the Togarian fauna is somewhat related to that of the overlying Miyoshian, since many species characteristic of the Togarian fauna extend up into the lower part of the Miyoshian stage.

Nonion mizunamiense Zone: The Togarian stage is represented by the *Nonion mizunamiense* zone. This zone corresponds with the microbiostratigraphical unit proposed as the "*Nonion-Elphidium*" zone by the writer in the previous report (Table XVI).

The type section of this zone is the same as chosen for the type locality of the Togarian stage. Perhaps two zones may be distinguished as subdivisions of the stage, but a discussion of these is withheld for the time being. As described by the writer in Table XVI, an assemblage of foraminiferal species in the lower part of the type zone comprises two faunules, namely, *Elphidium*-, and *Nonion-Elphidium-Eponides* faunules. These two faunules occur only from the Tsukiyoshi and Togari members and the

lower part of the Yamanouchi member combined, all of which are included in the lower part of the lower Mizunami group. The occurrences equivalent to this assemblage are unknown from the other Miocene areas in West Honshû so far as the writer examined. Some of the species that make their first or abundant appearance in the lower zone are: *Nonion* cf. *grateloupi*, *N. japonicum*, *N. mizunamiense*, *N. nakosoense*, *N. nikobarense*, *N. scaphum*, *Nonionella miocenica*, *Elphidium etigoense*, *E. ozawai*, *E.* cf. *sendaiense*, *E. tsudai*, *Elphidiella momiyamaensis*, *Eponides frigidus*, *E. frigidus calidus*, *Rotalia* cf. *beccarii*, *Hanzawaia tagaensis*, *Cibicides lobatulus*, and *C. pseudoungerianus*.

In the upper part of the lower zone, a few pelagic Foraminifera also occur.

The type of the upper part of the zone is the upper half of the Yamanouchi mudstone member which has yielded an assemblage of the *Lagena-Rotalia-Nonion-Elphidium* faunule (Table XVI). Though this assemblage also is very similar with the subjacent lower assemblage above mentioned, it is distinguished from the subjacent one in having a few species of the genera such as, *Robulus*, *Dentalina*, *Nodosaria*, *Lagenonodosaria*, *Lagena*, *Bolivina*, and *Angulogerina*, characteristic of neritic depths. Other similar occurrence of this upper assemblage was found from the Shiodani sandstone member, the lower division of the Yuantani formation in the Okuyamada Miocene near Kyôto (Table XXIX). Of the 18 species consisting of the Okuyamada fauna, 12 occur in the upper assemblage. Thus a part of the Tsuzuki group which contains the Okuyamada microfauna corresponds with the upper part of the zone and therefore falls into the microbiostratigraphic position as shown graphically in Plate 38.

2. Miyoshian Stage: The Miyoshian stage represents the age of maximum transgression in the Miocene stages in West Honshû, and therefore is marked by the widest distribution.

The Miyoshi basin in Hiroshima Prefecture is the type area for the Miyoshian stage of the writer (1958). The type section measures about 48 meters in thickness and the same facies is exposed in about the lower half of the type Bihoku group distributed along the road side of Obara in the basin. The sediments of the type section consist of two parts, namely, a sandstone facies which yielded abundant larger Foraminifera and molluscan fossils below, and a shale facies with smaller Foraminifera in profusion above. Though the top of the stage underlies the superjacent Iwami-Otan stage with conformable relation in a continuous black shale sequence of the upper Bihoku group, unfortunately, the base of the stage covers a mass of Cretaceous granite-porphyry. Despite the fact that the Miyoshian assemblages are widespread and characteristic in West Honshû, the choice of a type locality for the stage was difficult, since a stage is best defined in a continuous fossiliferous marine sequence and it is important that both the subjacent and superjacent stages be developed. For example, though the base of the Miyoshian stage in Togari, Mizunami City, unconformably covers the top of the subjacent Togarian stage, the upper part of the Miyoshian stage is missing, but it is developed in the type Miyoshi area.

The lithology of this stage nearly everywhere indicates generally a transitional zone

ranging conformably from the rich molluscs-bearing sandstone facies to fossiliferous shale or mudstone facies in upward sequence, and is not commonly tuffaceous. The thickness of the stage is somewhat variable in the lower part according to places.

The Miyoshian in the Setouchi Province overlaps the pre-Tertiary rocks at many localities, though in some places it unconformably overlies the Miocene Shiomachi formation and its equivalents, which consist of lacustrine deposits. The stage in the Inner Subprovince of the San'in Province everywhere occurs with unconformable relation above the Miocene Hata group and its equivalents, which comprises a volcanic complex. On the other hand, areas in which the stage is missing are the Outer-, Shimane Peninsula-, and Oki Islands Subprovinces, of the same Province, in which the horizons equivalent to the stage consist of variable lithofacies composed of pyroclastic materials and lacustrine sediments (Chapter I). These sediments, from the evidence afforded by the plant fossils and volcanostratigraphy, are shown graphically in Plate 38, together with the sediments which yielded the Foraminifera.

The Miyoshian microfauna is geographically most extensive in distribution among the Miocene stages and is remarkable in that its fauna shows very little if any ecologic diversity, though some local differences can be recognized in the lower faunules throughout the West Honshû. Of the sedimentary facies forming the stage, the lower Miyoshian faunule nearly everywhere occurs in a sandstone facies, and the middle and upper Miyoshian commonly in a shale facies. The associated distribution of both the sedimentary facies and Foraminifera and their gradual change from one to the other is in good agreement with the transitional change observed in their environmental conditions.

Miogypsina kotoi-Operculina complanata japonica Zone: This zone characterizes the lower Miyoshian stage and its microfauna comprises typically tropical or subtropical elements represented by larger Foraminifera, such as *Miogypsina* and *Operculina* and their associated smaller ones. Another characteristic feature of this particular horizon is the restricted occurrence of; *Quinqueloculina* cf. *elongata*, *Q.* cf. *sawanensis*, *Q.* cf. *yezoensis*, *Triloculina tricarinata*, *Planularia yabei*, *Bulimina ovata*, *Discorbis* cf. *australensis*, *D.* cf. *nakamurai*, and *Amphistegina lessonii*. These species however comprise a small population. The families Rotaliidae and Nonionidae contain the majority of the species and individuals of the zone, though the actual number of species is not great.

The foraminiferal assemblages corresponding to the zone are faunules derived from: the upper Mizunami group in Mizunami (Table XVI); the lower Toyoda formation in Nara (Table XIV); the Iwaya formation in North Awaji Island (Table XXX); the lower Bihoku group in the Tsuyama basin (Table X, XII, XVIII), in the vicinity of Niimi City (Table IX), in the Shôbara basin (Table VII), and in the type Miyoshi basin (Table VI); the Kawai formation in Hiebara (Table XV) and in Takuno (Table XXI).

Lagenonodosaria scalaris-Uvigerina crassicostata Zone: This zone occupies the middle and upper parts of the Miyoshian stage. In the zone, the family Lagenidae are repre-

sented by the largest number of genera, species, and individuals. Of the other families, the genera *Uvigerina*, *Ellipsonodosaria*, *Nonion*, *Angulogerina*, *Eponides*, *Gaudryina*, *Bolivina*, *Bulimina*, *Hanzawaia*, *Cibicides*, *Cassidulina*, and *Epistominella* contain the majority of species and individuals. Another outstanding feature of this zone is the large number of specimens of the pelagic, open-sea genera *Globigerina* and *Globorotalia*, which are widespread and occur in considerable numbers.

Of the species distinguished by the writer from the West Honshû Miocene formations, about one third are restricted species of the zone. These Foraminifera comprise the upper and lower faunules and show close affinity each other, but the former is distinguished from the latter by showing a remarkable increase of arenaceous forms, such as *Cyclammina*, *Sigmoilina*, *Martinottiella*, *Plectina*, *Gaudryina*, and *Haplophragmoides* etc.

As shown in Plate 38, a complete sequence of the zone with the two faunules seems to be at present, restricted to the Miocene areas within the Chûgoku District. These were distinguished in areas of: the Bihoku group in Tsuyama (Table X, XII), in the vicinity of Okayama (Table XVII), in Shôbara (Table VII), in the type Miyoshi (Table VI); the Masuda group in Masuda (Table XXII); the Tochimoto shale member near Tottori (Table XXVIII); the Kawai formation in Hiebara (Table XV), and in Oshihara (Table XX). The faunule equivalent to the lower zone also occur in the Oidawara mudstone member of the upper Mizunami group in Mizunami (Table XVI); in the Toyoda formation in Nara (Table XIV); in the Bihoku group in Niimi (Table IX), in Minomi (Table XIX); and in the Kawai formation in Takuno (Table XXI). A faunule equivalent to the upper zone also occurs in the Kuri formation in Asayama (Table XXXIII).

Thus, the nature and distribution of the Foraminifera of the zone seem to suggest conditions of comparatively low relief during the greater part of the Miyoshian age in West Honshû.

Although some of the arenaceous Foraminifera appearing in this Miyoshian stage extend their range up into the superjacent Iwami-Otan stage, the faunal change observable between the Miyoshian and Iwami-Otan is the most pronounced one recognized within the West Honshû Miocene. In other words, the warm-water elements characteristic of the Miyoshian stage have largely disappeared by the Iwami-Otan time and there is a change marked by existence of only arenaceous Foraminifera, such as *Cyclammina*, *Martinottiella*, *Plectina*, *Gaudryina*, *Sigmoilina*, and *Goësella*.

3. Iwami-Otan Stage: The Iwami-Otan stage where it occurs always conformably overlies the Miyoshian stage. The lithology of the Iwami-Otan stage is represented by a hard black shale facies associated with remarkable rhyolite flow and its pyroclastic materials, and particularly in its upper part there was evidenced an unstable depositional condition due to violent volcanic activities. Despite the fact that the stage is thicker than those of the subjacent ones, its Foraminifera nearly everywhere comprise only a few arenaceous forms or those associated with one or two species of calcareous forms. In some equivalent rocks of the stage Foraminifera are sometimes lacking. The

contrasting occurrences of arenaceous and calcareous forms, the associated and/or single occurrences of particular elements, the intervention of Foraminifera barren lithologic units, and other physical phenomena are considerable important in the distinction and recognition of superjacent and subjacent time-rock units.

The type of the lower and middle parts of the Iwami-Otan stage coincides with the type Kuri formation, distributed in the vicinity of Kuri-machi, Ota City, Shimane Prefecture. The two parts are a continuous shale facies having a rhyolitic, green tuff and tuff breccia at the uppermost horizon of the lower part of both and together are estimated to have a thickness of about 250 meters. On the other hand, the type of the upper part of the stage is the Omori formation distributed in the southeast of Kute-machi, Ota City, Shimane Prefecture. The Omori formation is a volcanic complex, which consists mainly of andesite and its pyroclastic materials which are considered to have been produced by violent submarine eruptions. This volcanism is so remarkable throughout the San'in Province that almost everywhere the Omori formation fails to intercalate sedimentary facies containing microfossils. Therefore, difficulty as to selection of the most favorable standard for the Iwami-Otan stage which should be distinguished from a continuous, fossiliferous, sedimentary facies. The boundary between the upper and middle Iwami-Otan stages is that between the Omori and Kuri formations where the sequence is apparently unconformable. On the other hand, the boundary between the lower and middle Iwami-Otan stages everywhere is conformable and is placed at the top of the rhyolitic, tuff and tuff breccia bed intercalated in the middle part of the Kuri formation. This rhyolitic bed is widespread and therefore it may be taken as an important key bed for correlation purposes among the areas of the marine shale facies within the San'in Miocene.

Cyclammina orbicularis-Martinottiella communis Zone: This zone represents the Iwami-Otan stage. The Foraminifera which occur in the zone comprise almost arenaceous forms and diversity in their assemblage is not recognized. The genera *Bathysiphon*, *Haplophragmoides*, *Cyclammina*, *Gaudryina*, *Plectina*, *Goësella*, *Martinottiella*, *Sigmoilina*, and *Trochammina* contain the majority of the species and individuals. An environmental analysis of these arenaceous genera suggest that the hard black shale of the zone was deposited under a special condition. Conclusive remarks with regard to this particular sedimentary environment will be expressed at another opportunity because the work is still in progress.

The upper, middle, and lower parts of the zone respectively coincide with those of the Iwami-Otan stage mentioned above. The assemblages from these parts closely resemble each other, notwithstanding the conspicuous differences in their respective individual numbers. The middle part of the zone is characteristic in yielding some specimens of undetermined species of the calcareous genera, such as *Robulus*, *Dentalina*, *Globobulimina*, and *Rotalia*.

The faunules corresponding to the lower Iwami-Otan stage occur: in the upper Bi hoku group at Yasuda in the Tsuyama basin (Table XII), in the same group of a bor-

ing well near Okayama City (Table XVII), and in the type section of the Miyoshian stage (Table VI); in the Tochimoto shale member near Tottori City (Table XXVIII); in the Kuri formation in the Hiebara basin (Table XV), in the type Kuri (Table XX III), and in Asayama-machi (Table XXXIII); in the Tamatsukuri formation in Tamatsukuri (Table XXIV), and in Muro south of Matsue City (Table XXV). The type faunule and its equivalents which all correspond to the middle Iwami-Otan stage occur: in the type Kuri (Table XXIII) and in the Kuri formation of Asayama-machi (Table XXXIII); in the Tamatsukuri formation at Aoki south of Matsue City (Table XXV); and in the Jôsoji shale member, northwest of Matsue City, Shimane Prefecture (p. 286). The upper Iwami-Otan stage is represented by the faunules from the Omori formation of Kute-machi (Table XXXIII) in Ota City and from the Ushikiri alternation member (p. 286) in Matsue City, Shimane Peninsula.

4. Fujinan Stage: The type of the Fujinan stage is the Fujina formation distributed along the southern side of Shinji Lake, Shimane Prefecture.

This stage is characterized by the considerable diversity in the sedimentary environments and in the faunal assemblages. The lithology of the type section which is more than 700 meters in thickness is almost uniform, being of fossiliferous mudstone or shaly sandstone facies which becomes coarse-grained in its lower part and seems to represent an intervolcanic age, since it is not tuffaceous.

The subjacent Iwami-Otan stage below the type Fujinan stage is the Omori formation, which is a volcanic complex and thus has yielded no Foraminifera. The relation between both stages is apparently unconformable. On the other hand, in the northern side of Shinji Lake, the relation between the two stages is evidently conformable. The boundary is between the Ushikiri alternation- and Furue mudstone members, the middle and upper divisions of the type Furue formation (Chapter I).

The superjacent stage of the Fujinan is represented by the Matsue formation, which is distributed in the central part of the Shimane Peninsula. This is newly treated as "Lower Pliocene" in the present report. The relation between it and the subjacent stage is evidently conformable in both the southern and northern sides of Shinji Lake. The distribution of the Fujinan stage is restricted mainly to within the Shimane Peninsula- and Outer Subprovinces, though its equivalents also occur in Oki Islands Subprovince. The Fujinan stage is noteworthy in that it is relatively thick compared with its narrow and restricted distribution in West Honshû. Namely, the stage on the northern side of Shinji Lake amounts to about 1000 meters in thickness. The type Fujinan section of the southern of the same Lake is nearly equal in thickness. The Fujinan stage of the northern side is defined by the Furue mudstone member. The microfauna from it is dissimilar from that of the type Fujinan. This difference, as already pointed out by the writer (1955), was determined from the ecological conditions inferred from the microfaunas and is due to the characteristic paleo-configuration which suggests a "graben-trough". Thus, from the stratigraphical and structural point of views, the sedimentary basin entombing these microfaunas varied with places.

From the forgoing remarks, it became evident that the localization based upon the orogenic movement, as indicated by the unconformable relation of the units on the southern side and the conformable one on the northern side, occurred between the Fujinan and the subjacent Iwami-Otan. This movement continued during the Fujinan age. It seems possible that the commencement of such orogenic movement had begun already from about the middle Iwami-Otan age, as indicated by the unconformable relation between the Kuri and Omori formations in the Inner- and Outer Subprovinces.

The Foraminifera of the Fujinan stage is represented by the families Buliminidae, Lituolidae, Cassidulinidae, Nonionidae, and Anomalinidae. A remarkable feature of the Fujinan Foraminifera is the disappearance of the Miyoshian microfauna, which is characterized by dominant warm-water forms belonging to the family Lagenidae and is similar to the so-called late Tertiary faunas distinguished in the Indo-Pacific regions, such as Kar Nicobar, Java, Sumatra, and Fiji Islands. Radiolarian- and diatom fossils also occur abundantly in association with the Fujinan Foraminifera. Pelagic Foraminifera are relatively rare in the stage.

Uvigerina subperegrina-Epistominella pulchella Zone: This zone represents the Fujinan stage. The genera *Uvigerina*,*Epistominella*, *Cassidulina*, *Cibicides*, *Nonion*, *Cribroelphidium*, *Pullenia*, *Cyclammina*, *Gaudryina*, *Haplophragmoides*, and *Plectina* contain the majority of the species and individuals of the Foraminifera of the zone. This zone is characterized by the restricted occurrences of *Epistominella pulchella*, *Haplophragmoides compressum*, *H. emaciatum*, *Quinqueloculina sakaii*, and *Bulimina* cf. *auriculata*. The species that make their first appearance in the zone are *Cribroelphidium tomitai* and *Quinqueloculina akneriana*, and those that terminate in the zone are: *Bathysiphon* sp., *Ammodiscus* sp., *Haplophragmoides trullissatum*, *Cribrostomoides* cf. *kyushuense*, *Cyclammina* cf. *cancellata*, *C.* cf. *ezoensis*, *C. incisa*, *C. japonica*, *C.* sp., *Spiroplectammina niigataensis*, *Textularia lythostrota*, *Plectina nipponica*, *Goëselia schencki*, *Martinottiella communis*, *Lagenonodosaria fukushimaensis*, *Lagena laevis*, *L. striata*, *L. sulcata spicata*, *Guttulina* (*Sigmoidina*) *pacifica*, *Nonion pompilioides*, *N. scaphum*, *N. umbilicatulum*, *Nonionella miocenica*, *Entosolenia marginata*, *Bolivina* cf. *robusta*, *Uvigerina* cf. *hootsi*, *U. nitidula*, *U. segundoensis*, *U. subperegrina*, *U. yabei*, *U.* sp., *Angulogerina* cf. *hughesi*, *A. kokozuraensis*, *Discopulvinulina bertheloti*, *Eponides praecinctus*, *Rotalia* cf. *beccarii hatatatensis*, *Cassidulina laevigata carinata*, *C. margareta*, *C.* cf. *subglobosa*, *Pullenia salisburyi*, *Anomalina glabrata*, *Cibicides aknerianus*, *C. lobatulus*, and *C. pseudoungerianus*.

The uppermost part of the type zone is defined by the about 200 meters thick Furue mudstone member, which occurs directly below the lower Matsue formation distributed at Terazu of Matsue City. To be repeated is that the larger part of the type zone is defined by the type Fujina formation distributed in the vicinity of Fujina in the southern side of Shinji Lake.

The faunules corresponding to the lower and middle Fujinan stage occur: in the type Fujina formation (Table III), and in the Fujina formation distributed in the vicinity of Imaichi-machi in the western side of Shinji Lake (Table XXXII); in the type Furue mudstone member (Table III). The faunules corresponding to the middle Fu-

jinan stage occur in the Tsuma sandstone- and Igo mudstone members distributed in Dôgo, Oki Islands, Shimane Prefecture (Table IV). The faunule of the upper Fujinan stage is only from the uppermost part of the type Furue mudstone member (Table III). Each of these faunules is shown respectively on the left side of Plate 38.

5. Unnamed "Lower Pliocene" Stage: No angular discordance is known between the "Lower Pliocene" and Fujinan stages. The unnamed "Lower Pliocene" stage is represented by the type Matsue formation, the uppermost division of the Shinji group (Chapter I). The type Matsue formation is a coarse-grained sandstone facies, with some coal seams in the upper and lower parts and basaltic flows in its middle part, although intercalating of fossiliferous shale rarely. The formation distributed in the vicinity of Matsue City forms a synclinorium with the axis direction of about E-W. The formation is variable in thickness and in lithofacies, and a volcanic member occupies its middle part. The thickness is estimated to about 400-1100 meters. The lower and middle parts of the formation have yielded abundant so-called Pliocene characteristic megafossils as *Turritella saishuensis*, *T. nipponica*, *Chlamys cosibensis*, and other mollusca (Chapter I).

The unnamed "Lower Pliocene" stage although lithologically rather well developed has yielded very few and frequently no Foraminifera so far as examined. But the unnamed "Lower Pliocene" stage seems to be characterized by a zone named "*Rotalia* cf. *beccarii*".

Rotalia cf. *beccarii Zone*: The faunule of this zone, on the whole, are characterized by the littoral or shallow-water genera such as *Rotalia*, *Quinqueloculina*, *Nonion*, and *Elphidium*. The lower faunule of the zone was obtained from the Terazu sandstone member exposed at Yada, south of Matsue City (Table XXVII). On the other hand, the upper faunule of the same zone was derived from the Kuroda sandstone member distributed in a boring well, north of Matsue City (Table XXVI).

The "Lower Pliocene" microfauna is evidently distinguished from the subjacent Fujinan microfauna in lacking specimens of the genera, such *Cyclammina*, *Uvigerina*, *Epistominella*, *Cassidulina*, *Cibicides*, *Pullenia*, and *Plectina* which dominate the Fujinan.

C. Summary of Foraminiferal Sequence

The stratigraphic occurrences of the species of the Foraminifera recorded by the writer from the West Honshû Neogene deposits are given in the Range Chart of the Foraminifera (Table XXXIV). Thus the nature of the faunules and prominent faunal changes which characterized the stages and zones described in this paper may be understood.

It may be added that faunal differences due to ecological factors or to sedimentary control have been analyzed in detail in order that the established time-rock units may not conflict with the faunal differentiation due to physical agencies and not to time. Further to test the validity and value of the established time-rock units, broad areas, continuous or isolated have been surveyed stratigraphically and paleontologically, compared and correlated. From available data concerning the Neogene sediments of West Honshû it may be said with considerable confidence that the opinions expressed in the early pages as well as in those to follow serve as a good working basis.

TABLE XXXIV

Range Chart of Foraminifera in Neogene of West Honshû, Japan

Legend: A=Abundant, C=Common, F=Few, R=Rare, ( )=Identity similar, ?=Identity doubtful, N=*Nonion mizunamiense* Zone, MO=*Miogypsina kotoi-Operculina complanata japonica* Zone, LU=*Lagenonodosaria scalaris-Uvigerina crassicostata* Zone, CM=*Cyclammina orbicularis-Martinottiella communis* Zone, UE=*Uvigerina subperegrina-Epistominella pulchella* Zone, R=*Rotalia* cf. *beccarii* Zone

Species \ Stages	Toga-rian		Miyoshian			Iwami-Otan			Fujinan			Unna-med	
Species \ Zones	N		MO	LU		CM			UE			R	
	L	U	L	M	U	L	M	U	L	M	U	L	U
Rhabdammina sp.	—	—	R	R	—	—	—	—	—	—	—	—	—
Bathysiphon sp.	—	—	—	R	F	C	F	R	R	R	—	—	—
Reophax? sp.	—	—	—	—	R	—	—	—	—	—	—	—	—
Ammodiscus sp.	—	—	—	R	R	R	—	—	R	R	—	—	—
Ammodiscoides sp.	—	—	—	R	—	R	—	—	—	—	—	—	—
Haplophragmoides canariensis (d'Orbigny)	—	—	—	—	—	—	—	—	—	—	—	—	(R)
Haplophragmoides compressum LeRoy	—	—	—	—	—	—	—	—	R	R	—	—	—
Haplophragmoides emaciatum (Brady)	—	—	—	—	—	—	—	—	(R)	(R)	—	—	—
Haplophragmoides renzi Asano	—	—	—	—	—	R	—	—	—	—	—	—	—
Haplophragmoides trullissatum (Brady)	—	—	(R)	R	(R)	(R)	R	—	C	C	—	—	—
Haplophragmoides sp.	—	—	R	R	C	A	R	F	F	C	—	—	—
Cribrostomoides kyushuense Asano	—	—	—	(R)	(R)	(R)	R	—	—	(R)	—	—	—
Cribrostomoides sp.	—	—	—	R?	R	A	C	R	R?	R?	—	—	—
Ammobaculites catenulatus Cushman and McCulloch	—	—	—	(R)	—	—	—	—	—	—	—	—	—
Ammobaculites sp.	—	—	R	R	R	R	R	—	—	—	—	—	—
Cyclammina cf. *cancellata* Brady	—	—	—	—	—	—	R	C	C	—	—	—	—
Cyclammina ezoensis Asano	—	—	—	R	C	A	C	—	(F)	(F)	—	—	—
Cyclammina ezoensis okuharai Tai, n. subsp.	—	—	—	—	—	—	—	R	—	A	—	—	—
Cyclammina incisa (Stache)	—	—	R	F	C	C	R	R	A	—	—	—	—
Cyclammina japonica Asano	—	—	(R)	(R)	C	C	A	R	A	A	—	—	—
Cyclammina orbicularis Brady	—	—	—	—	—	F	A	R	—	—	—	—	—
Cyclammina pusilla Brady	—	—	—	R	R	C	R	R	C	F	—	—	—
Cyclammina sp.	—	—	R	R	R	F	R	R	R	R	—	—	—
Spiroplectammina niigataensis Asano and Inomata	—	—	—	—	(R)	R	—	—	F	R	—	—	—
Textularia cf. *conica* d'Orbigny	—	—	—	R	—	—	—	—	—	—	—	—	—
Textularia lythostrota (Schwager)	—	—	—	R	—	—	—	—	—	R	—	—	—
Textularia sp.	—	—	—	R	—	—	—	—	—	R	—	—	—
Gaudryina imamurai Tai, n. sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Gaudryina ishikiensis Asano	—	—	C	A	A	R	R	—	—	—	—	—	—
Gaudryina cf. *karihaensis* Asano	—	—	—	—	R	—	—	—	—	—	—	—	—
Gaudryina cf. *oga* Asano	—	—	—	—	R	R	—	—	—	—	—	—	—
Gaudryina takunoensis Tai, n. sp.	—	—	—	F	—	—	—	—	—	—	—	—	—
Gaudryina yabei Asano	—	—	R	R	(R)	R	—	—	—	(R)	—	(C)	—
Gaudryina sp.	—	—	R	R	—	—	—	—	—	—	—	—	—
Gaudryinella tsuchidai Uchio	—	—	—	R	—	—	—	—	—	—	—	—	—
Gaudryinella sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Eggerella cf. *bradyi* (Cushman)	—	—	—	—	—	—	—	—	—	—	—	—	R
Dorothia sp.	—	—	—	—	R	—	—	—	—	—	—	—	—
Plectina nipponica Asano	—	—	R	R	C	C	F	—	A	A	—	—	—
Plectina sp.	—	—	—	R	R	A	F	—	C	F	—	—	—
Goësella schencki Asano	—	—	R	R	R	A	R	—	C	A	—	—	—
Goësella sp.	—	—	—	—	R	F	R	—	—	—	—	—	—
Karreriella tanabensis Tai, n. sp.	—	—	—	R	F	—	—	—	—	—	—	—	—
Martinottiella communis (d'Orbigny)	—	—	—	R	A	A	A	C	F	C	—	—	—
Martinottiella sp.	—	—	—	—	R	R	R	—	R	F	—	—	—

Species	L	U	L	M	U	L	M	U	L	M	U	L	U
Schenckiella victoriensis (Cushman)	—	—	—	R	—	R?	—	—	—	—	—	—	—
Quinqueloculina akneriana d'Orbigny	—	—	—	—	—	—	—	—	—	R	—	F	—
Quinqueloculina elongata Natland	—	—	(R)	—	—	—	—	—	—	—	—	—	—
Quinqueloculina sakaii Tai	—	—	—	—	—	—	—	—	—	R	—	—	—
Quinqueloculina sawanensis Asano	—	—	(R)	—	—	—	—	—	—	—	—	—	—
Quinqueloculina vulgaris d'Orbigny	—	—	R	—	(R)	—	—	—	—	F	—	F	—
Quinqueloculina yezoensis Asano	—	—	(R)	—	—	—	—	—	—	—	—	—	—
Quinqueloculina sp.	R	—	R	R	R	—	—	—	—	—	—	—	—
Miliolinella circularis (Bornemann)	—	—	—	—	(R)	—	—	—	—	—	—	—	—
Spiroloculina communis Cushman and Todd	—	—	—	R	—	—	—	—	—	—	—	—	—
Spiroloculina communis incisa Cushman	—	—	—	R	R	—	—	—	—	—	—	—	—
Spiroloculina sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Sigmoilina imamurai Tai	—	—	—	F	C	R	R	C	—	—	—	—	—
Sigmoilina schlumbergeri Silvestri	—	—	—	R	F	R	C	C	—	—	—	—	—
Sigmoilina tenuis (Czizek)	—	—	—	R	—	—	—	—	—	—	—	—	—
Sigmoilina sp.	—	—	—	R	A	C	—	—	—	—	—	—	—
Triloculina okamotoi Tai, n. sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Triloculina tricarinata d'Orbigny	—	—	R	—	—	—	—	—	—	—	—	—	—
Triloculina sp.	R	R	R	—	—	—	—	—	—	—	—	—	—
Pyrgo murrhina (Schwager)	—	—	—	—	R	—	—	—	—	—	—	—	—
Pyrgo cf. *vespertilio* (Schlumberger)	—	—	—	R	—	—	—	—	—	—	—	—	—
Pyrgo sp.	—	—	—	R	R	—	—	—	—	—	—	—	—
Trochammina nobensis Asano	—	—	(R)	—	(R)	R	F	—	(R)	—	—	—	—
Trochammina sp.	—	—	R	R	C	A	F	C	C	C	—	—	R
Robulus asanoi Takayanagi	—	—	(R)	R	R	—	—	—	—	—	—	—	—
Robulus bicostatus Asano	—	—	—	R	—	—	—	—	—	—	—	—	—
Robulus calcar (Linnaeus)	—	—	—	R	(R)	—	—	—	—	—	—	—	—
Robulus etigoensis Asano	—	—	—	R	—	—	—	—	—	—	—	—	—
Robulus iotus (Cushman)	—	—	—	F	R	—	—	—	—	—	—	—	—
Robulus izumoensis Tai and Okamoto, n. sp.	—	—	—	R	R	—	—	—	—	—	—	—	—
Robulus javana (Koch) var.	—	—	—	R	R	—	—	—	—	—	—	—	—
Robulus javana simplex (Koch)	—	—	—	R	R	—	—	—	—	—	—	—	—
Robulus lucidus (Cushman)	—	R	R	A	C	—	—	—	—	—	—	—	—
Robulus miyagiensis Asano	—	—	—	—	R	—	—	—	—	—	—	—	—
Robulus nikobarensis (Schwager)	—	—	R	C	R	—	—	—	—	—	—	—	—
Robulus notoensis Asano	—	—	—	R	R	—	—	—	—	—	—	—	—
Robulus orbicularis (d'Orbigny)	—	—	(R)	C	R	—	—	—	—	—	—	—	—
Robulus pseudorotulatus Asano	—	—	—	C	R	—	—	—	—	—	—	—	—
Robulus cf. *sagamiensis* Asano	—	—	—	R	—	—	—	—	—	—	—	—	—
Robulus cf. *surugaensis* Asano	—	—	—	R	—	—	—	—	—	—	—	—	—
Robulus cf. *tangens* LeRoy	—	—	—	—	R	—	—	—	—	—	—	—	—
Robulus yoshitakiensis Chiji and Nakaseko	—	—	(R)	R	(R)	—	—	—	—	—	—	—	—
Robulus sp.	—	R	C	A	A	—	R	—	—	R	—	—	—
Lenticulina asanoi Tai	—	—	—	R	—	—	—	—	—	—	—	—	—
Lenticulina sp.	—	—	R?	R	R?	—	—	—	—	—	—	—	—
Planularia yabei Asano	—	—	R	—	—	—	—	—	—	—	—	—	—
Planularia yokoii Tai, n. sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Planularia sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Marginulina aculeata Neugeboren	—	—	R	C	R	—	—	—	—	—	—	—	—
Marginulina glabra d'Orbigny	—	(R)	R	F	R	—	—	—	—	—	—	—	—
Marginulina masudai Asano	—	—	—	F	R	—	—	—	—	—	—	—	—
Marginulina mukaei Tai and Okamoto, n. sp.	—	—	—	C	C	—	—	—	—	—	—	—	—
Marginulina cf. *nakamurai* (Asano)	—	—	—	—	R	—	—	—	—	—	—	—	—
Marginulina sendaiensis Asano	—	—	—	—	R	—	—	—	—	—	—	—	—
Marginulina sp.	—	—	R	F	R	—	—	—	—	—	—	—	—
Dentalina communis d'Orbigny	—	—	—	R	R	—	—	—	—	—	—	—	—
Dentalina emaciata Reuss	—	—	—	F	R	—	—	—	—	—	—	—	—
Dentalina insecta (Schwager)	—	—	—	F	C	—	—	—	—	—	—	—	—
Dentalina soluta Asano	—	—	R	(R)	—	—	—	—	—	—	—	—	—

Species	L	U	L	M	U	L	M	U	L	M	U	L	U
Dentalina spinosa d'Orbigny	—	—	—	R	—	—	—	—	—	—	—	—	—
Dentalina subsoluta (Cushman)	—	—	—	F	R	—	—	—	—	—	—	—	—
Dentalina tauricornis (Schwager)	—	—	—	R	R	—	—	—	—	—	—	—	—
Dentalina sp.	—	R	R	C	F	—	R	—	—	R	—	—	—
Nodosaria longiscata d'Orbigny	—	—	R	C	A	—	—	—	—	—	—	—	—
Nodosaria notoensis Asano	—	—	R	C	C	—	—	—	—	—	—	—	—
Nodosaria pyrula d'Orbigny	—	—	R	A	C	—	—	—	—	—	—	—	—
Nodosaria radicula (Linne')	—	R	—	—	—	—	—	—	—	—	—	—	—
Nodosaria tosta Schwager	—	—	—	C	—	—	—	—	—	—	—	—	—
Nodosaria vertebralis (Batsch)	—	—	—	R	R	—	—	—	—	—	—	—	—
Nodosaria sp.	—	—	F	R	R	—	—	—	—	—	—	—	—
Pseudoglandulina laevigata (d'Orbigny)	—	—	R	R	R	—	—	—	—	—	—	—	—
Pseudoglandulina sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Lagenonodosaria fukushimaensis Asano	—	(R)	—	F	C	—	—	—	R	R	—	—	—
Lagenonodosaria scalaris (Batsch)	—	—	—	A	A	—	—	—	—	—	—	—	—
Lagenonodosaria scalaris sagamiensis Asano	—	—	—	A	R	—	—	—	—	—	—	—	—
Lagenonodosaria sp.	—	R	R	A	C	—	—	—	—	—	—	—	—
Saracenaria akitaensis Iwasa and Kikuchi	—	—	—	R	R	—	—	—	—	—	—	—	—
Saracenaria cf. *latifrons* (Brady)	—	—	—	R	—	—	—	—	—	—	—	—	—
Saracenaria sp.	—	—	—	C	R	—	—	—	—	—	—	—	—
Vaginulina cf. *awaensis* Asano	—	—	—	R	—	—	—	—	—	—	—	—	—
Vaginulina bradyi Cushman	—	—	R	C	C	—	—	—	—	—	—	—	—
Vaginulina yoshihamaensis Inoue & Nakaseko	—	—	—	R	R	—	—	—	—	—	—	—	—
Vaginulina sp.	—	—	—	R	R	—	—	—	—	—	—	—	—
Frondicularia foliacea (Schwager)	—	—	—	F	—	—	—	—	—	—	—	—	—
Frondicularia sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Lagena acuticosta Reuss	—	—	—	R	R	—	—	—	—	—	—	—	—
Lagena cf. *globosa* (Montagu)	—	—	—	R	—	—	—	—	—	—	—	—	—
Lagena hispidula Cushman	—	R	—	R	—	—	—	—	—	—	—	R	—
Lagena laevis (Montagu)	—	R	(R)	R	R	—	—	—	—	R	—	—	—
Lagena perlucida (Montagu)	—	—	R	R	R	—	—	—	—	—	—	—	—
Lagena striata (d'Orbigny)	—	—	—	R	R	—	—	—	—	R	—	—	—
Lagena substriata Williamson	—	(R)	—	(R)	R	—	—	—	—	—	—	—	—
Lagena sulcata (Walker and Jacob)	—	—	—	R	—	—	—	—	—	—	—	—	—
Lagena sulcata laevicostata Cushman & Gray	—	—	—	R	—	—	—	—	—	—	—	—	—
Lagena sulcata spicata Cushman & McCulloch	—	—	—	C	F	—	—	—	—	C	—	—	—
Lagena sp.	—	R	R	C	C	—	—	—	—	—	—	R	—
Guttulina irregularis (d'Orbigny)	—	—	F	C	C	—	—	—	—	—	—	—	—
Guttulina kishinouyi Cushman and Ozawa	—	R	—	(R)	—	—	—	—	—	—	—	—	—
Guttulina lactea (Walker and Jacob)	—	—	—	R	—	—	—	—	—	—	—	—	—
Guttulina cf. *problema* d'Orbigny	—	—	—	R	—	—	—	—	—	—	—	—	—
Guttulina cf. *sadoensis* (Cushman and Ozawa)	—	—	—	R	—	—	—	—	—	—	—	—	—
Guttulina (*Sigmoidina*) *pacifica* (Cushman and Ozawa)	—	—	—	R	—	—	—	—	—	R	—	—	—
Guttulina sp.	—	—	R	F	R	—	—	—	—	C	—	R	—
Globulina sp.	—	—	R	R?	R?	—	—	—	—	—	—	—	—
Pyrulina cylindroides (Roemer)	—	—	—	—	R	—	—	—	—	—	—	—	—
Nonion cf. *akitaense* Asano	—	—	—	—	—	—	—	—	—	—	—	—	F
Nonion grateloupi (d'Orbigny)	(A)	(R)	R	R	R	—	—	—	—	—	—	—	—
Nonion japonicum Asano	A	A	A	A	R	—	—	—	—	C	—	F	—
Nonion kidoharaense Fukuda	(R)	(A)	R	R	R	—	—	—	—	—	—	—	—
Nonion mizunamiense Tai, n. sp.	R	F	—	—	—	—	—	—	—	—	—	—	—
Nonion nakosoense Asano	C	F	C	A	R	—	—	—	—	—	—	—	—
Nonion nicobarense Cushman	C	—	R	C	—	—	—	—	—	—	—	A	—
Nonion pacificum (Cushman)	—	—	—	—	—	—	—	—	—	—	—	R	—
Nonion pompilioides (Fichtel and Moll)	—	R	—	R	R	—	—	—	—	A	—	—	—
Nonion scaphum (Fichtel and Moll)	C	R	C	C	R	—	—	—	—	R	—	—	—
Nonion shukuense Tai, n. sp.	—	—	—	F	—	—	—	—	—	—	—	—	—

Species	L	U	L	M	U	L	M	U	L	M	U	L	U
Nonion umbilicatulum (Montagu)	—	—	R	R	R	—	—	—	—	A	—	—	—
Nonion sp.	A	F	C	C	C	—	—	—	—	—	—	—	R
Astrononion sp.	R	—	—	R	—	—	—	—	—	—	—	—	—
Pseudononion hashimotoi Tai, n. sp.	R	—	—	—	—	—	—	—	—	—	—	—	—
Pseudononion japonicum Asano	R	(R)	R	R	R	—	—	—	—	—	—	—	—
Pseudononion tredecum Asano	—	(R)	—	—	—	—	—	—	—	—	—	—	—
Pseudononion sp.	F	R	—	R	—	—	—	—	—	—	—	—	—
Nonionella miocenica Cushman	A	C	C	A	F	—	—	—	—	—	R	—	—
Nonionella sp.	R	—	R	R	R	—	—	—	—	F	—	—	—
Elphidium advenum (Cushman)	—	—	R	F	R	—	—	—	—	—	—	—	—
Elphidium clavatum Cushman	—	—	—	(R)	(R)	—	—	—	—	—	—	R	—
Elphidium craticulatum (Fichtel and Moll)	R	—	—	—	—	—	—	—	—	—	—	—	—
Elphidium etigoense Husezima and Maruhasi	R	(R)	F	C	—	—	—	—	R	C	—	A	—
Elphidium imanishii Asano	—	C	—	—	—	—	—	—	—	—	—	—	—
Elphidium ozawai Uchio	R	R	—	—	—	—	—	—	—	—	—	—	—
Elphidium sendaiense Takayanagi	(F)	R	—	—	—	—	—	—	—	—	—	—	—
Elphidium tsudai Chiji and Nakaseko	R	—	(R)	R	R	—	—	—	—	—	—	—	—
Elphidium sp.	R	—	R	F	—	—	—	—	—	R	—	—	—
Cribroelphidium tomitai Tai	—	—	—	—	—	—	—	—	—	A	R	F	—
Cribroelphidium yabei (Asano)	—	R	—	—	R	—	—	—	—	C	—	F	—
Cribroelphidium sp.	—	—	—	—	R	—	—	—	—	—	—	—	—
Elphidiella momiyamaensis Uchio	R	R	A	R	—	—	—	—	—	—	—	—	—
Operculina complanata japonica Hanzawa	—	—	A	—	—	—	—	—	—	—	—	—	—
Plectofrondicularia japonica Asano	—	—	R	C	F	—	—	—	—	—	—	—	—
Plectofrondicularia longistriata LeRoy	—	—	—	R	R	—	—	—	—	—	—	—	—
Plectofrondicularia miocenica Cushman	—	—	—	R	—	—	—	—	—	—	—	—	—
Plectofrondicularia sp.	R	—	—	R	R	—	—	—	—	—	—	—	—
Robertina hanzawai (Asano)	—	—	—	R	—	—	—	—	—	—	—	—	—
Bulimina cf. *auriculata* Bailey	—	—	—	—	—	—	—	—	—	F	—	—	—
Bulimina imamurai Tai, n. sp.	—	—	—	F	C	—	—	—	—	—	—	—	R
Bulimina inflata Seguenza	—	—	—	R	—	—	—	—	—	—	—	—	—
Bulimina okayamaensis Tai, n. sp.	—	—	—	C	F	—	—	—	—	—	—	—	—
Bulimina ovata d'Orbigny	—	—	R	—	—	—	—	—	—	—	—	—	—
Bulimina pupoides d'Orbigny	—	—	—	C	R	—	—	—	—	—	—	—	(R)
Bulimina pyrula d'Orbigny	—	—	—	R	—	—	—	—	—	—	—	—	—
Bulimina striata d'Orbigny	—	—	—	A	R	—	—	—	—	—	—	—	—
Bulimina striata notoensis Asano	—	—	—	A	R	—	—	—	—	—	—	—	—
Bulimina sp.	—	—	R	R	R	—	—	—	—	R	—	—	—
Globobulimina perversa (Cushman)	—	—	R	F	F	R	R	—	—	—	—	—	—
Globobulimina sp.	—	—	—	R	R	—	R	—	—	F	—	—	—
Fissurina marginata (Montagu)	—	—	—	C	R	—	—	—	—	F	—	—	—
Fissurina orbignyana Seguenza	—	—	—	R	(R)	—	—	—	—	—	—	—	—
Fissurina sp.	—	—	—	R	R	—	—	—	—	—	—	—	—
Oolina hexagona (Williamson)	—	—	—	R	(R)	—	—	—	—	—	—	—	—
Oolina melo d'Orbigny	—	—	R	F	—	—	—	—	—	—	—	—	—
Virgulina complanata Egger	—	—	R	R	—	—	—	—	—	—	—	—	—
Virgulina ishikiensis Asano	—	—	—	F	—	—	—	—	—	—	—	—	—
Virgulina cf. *nodosa* R. E. and K. C. Stewart	—	—	—	R	—	—	—	—	—	—	—	—	—
Virgulina sp.	—	—	—	—	R	—	—	—	—	—	—	—	—
Bolivina hongoensis Tai, n. sp.	—	—	—	F	—	—	—	—	—	—	—	—	—
Bolivina marginata Cushman	—	—	R	R	C	—	—	—	—	—	—	—	—
Bolivina marginata masudai Asano	—	—	—	A	C	—	—	—	—	—	—	—	—
Bolivina robusta Brady	—	(R)	R	F	R	—	—	—	—	(A)	—	—	—
Bolivina substriatula Asano	—	—	R	F	F	—	—	—	—	—	—	R	—
Bolivina sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Reussella aculeata Cushman	—	—	—	F	R	—	—	—	—	—	—	—	—
Reussella spinulosa (Reuss)	—	—	R	F	—	—	—	—	—	—	—	—	—
Reussella sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Uvigerina cf. *aculeata* d'Orbigny	—	—	—	R	—	—	—	—	—	—	—	—	—

Species	L	U	L	M	U	L	M	U	L	M	U	L	U
Uvigerina cf. *akitaensis* Asano	—	—	—	R	—	—	—	—	—	—	—	—	—
Uvigerina crassicostata Schwager	—	—	—	A	C	—	—	—	—	—	—	—	—
Uvigerina cf. *hootsi* Rankin	—	—	—	A	C	—	—	—	—	A	—	—	—
Uvigerina multicostata LeRoy	—	—	—	R	—	—	—	—	—	—	—	—	—
Uvigerina nitidula Schwager	—	—	—	A	R	—	—	—	—	A	—	—	—
Uvigerina proboscidea Schwager	—	—	—	C	F	—	—	—	—	—	—	—	—
Uvigerina segundoensis Cushman and Galliher	—	—	—	R	R	—	—	—	—	A	—	—	—
Uvigerina subperegrina Cushman & Kleinpell	—	—	—	R	R	—	—	—	R	A	—	—	—
Uvigerina yabei Asano	—	—	—	R	R	—	—	—	—	A	—	—	—
Uvigerina sp.	—	—	R	C	R	—	—	—	—	A	—	—	—
Hopkinsina hispida (Schwager)	—	—	—	R	—	—	—	—	—	—	—	—	—
Hopkinsina sp.	—	—	R	—	—	—	—	—	—	—	—	—	—
Siphogenerina sp.	—	—	R?	—	—	—	—	—	—	—	—	—	—
Angulogerina cf. *hughesi* (Galloway & Wissler)	—	—	—	R	—	—	—	—	—	R	—	—	—
Angulogerina kokozuraensis Asano	—	R	R	A	R	—	—	—	—	R	—	—	—
Angulogerina occidentalis (Cushman)	—	R	—	(R)	—	—	—	—	—	—	—	—	—
Angulogerina sp.	—	—	—	F	R	—	—	—	—	—	—	—	—
Ellipsonodosaria japonica Ishizaki	—	—	—	C	C	—	—	—	—	—	—	—	—
Ellipsonodosaria lepidula (Schwager)	—	—	—	A	A	—	—	—	—	—	—	—	—
Ellipsonodosaria sp.	—	R	R	C	F	—	—	—	—	—	—	—	—
Discorbis australensis Heron-Allen & Earland	—	—	(R)	—	—	—	—	—	—	—	—	—	—
Discorbis nakamurai Asano	—	—	(R)	—	—	—	—	—	—	—	—	—	—
Discorbis opercularis (d'Orbigny)	—	—	R	(R)	—	—	—	—	—	—	—	—	—
Discorbis sp.	—	—	R	—	—	—	—	—	—	—	—	—	—
Discopulvinulina bertheloti (d'Orbigny)	—	—	—	(R)	—	—	—	—	—	R	—	—	—
Discopulvinulina bradyi Cushman	—	(R)	R	R	—	—	—	—	—	—	—	—	—
Discopulvinulina hofkeri Asano	—	R	R	R	—	—	—	—	—	—	—	—	—
Discopulvinulina isabelleana (d'Orbigny)	—	—	—	(R)	(R)	—	—	—	—	—	—	—	—
Discopulvinulina nitida (Williamson)	—	—	—	(R)	—	—	—	—	—	—	—	—	—
Discopulvinulina sp.	—	—	R	F	R	—	—	—	—	—	—	—	—
Valvulineria nipponica Ishizaki	(R)	—	—	R	—	—	—	—	—	—	—	—	—
Valvulineria sadonica Asano	R	R	R	R	R	—	—	—	—	—	—	—	—
Valvulineria sp.	—	—	—	R?	R	—	—	—	—	R	—	—	—
Gyroidinoides planulata (Cushman and Renz)	—	—	—	R	—	—	—	—	—	—	—	—	—
Gyroidina nipponica Ishizaki	—	—	—	R	—	—	—	—	—	—	—	—	—
Gyroidina orbicularis d'Orbigny	—	—	R	C	R	—	—	—	—	—	—	—	—
Gyroidina soldanii d'Orbigny	—	—	F	C	F	—	—	—	—	—	—	—	—
Gyroidina sp.	—	—	R	R	R	—	—	—	—	—	—	—	—
Eponides bengarensis (Schwager)	—	—	—	(R)	(R)	—	—	—	—	—	—	—	—
Eponides frigidus (Cushman)	R	C	F	A	A	—	—	—	—	A	R	R	—
Eponides frigidus calidus Cushman and Cole	F	R	F	C	F	—	—	—	—	R	—	R	—
Eponides haidingerii (d'Orbigny)	—	—	C	C	F	—	—	—	—	—	—	—	—
Eponides naraensis Tai, n. sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Eponides nipponicus (Husezima & Maruhasi)	R	R	(R)	R	R	—	—	—	—	—	—	—	—
Eponides praecinctus (Karrer)	—	—	C	A	C	—	—	—	—	R	—	—	—
Eponides subpraecinctus Asano	—	—	C	C	F	—	—	—	—	—	—	—	—
Eponides tanai Uchio	—	—	(R)	R	F	—	—	—	—	—	—	—	—
Eponides umbonatus (Reuss)	—	—	F	C	F	—	—	—	—	—	—	—	—
Eponides sp.	R	—	F	C	C	—	—	—	—	R	—	—	—
Rotalia beccarii (Linnaeus)	(C)	C	C	F	(R)	—	—	—	—	—	—	(F)	(C)
Rotalia beccarii hatatatensis Takayanagi	—	C	C	F	—	—	—	—	—	(R)	—	—	—
Rotalia inflata (Seguenza)	—	—	C	C	R	—	—	—	—	—	—	—	—
Rotalia papillosa Brady	—	—	—	—	—	—	—	—	—	—	—	(R)	—
Rotalia takanabensis (Ishizaki)	—	C	A	A	C	—	—	—	—	A	—	(R)	—
Rotalia tochigiensis Uchio	—	C	A	F	—	—	—	—	—	—	—	—	—
Rotalia sp.	R	—	C	C	R	—	R	—	—	—	—	—	—
Poroeponides sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Cancris auriculus (Fichtel and Moll)	—	—	—	R	—	—	—	—	—	—	—	—	—
Cancris sp.	—	—	—	R	—	—	—	—	—	—	—	—	—

Species	L	U	L	M	U	L	M	U	L	M	U	L	U
Baggina notoensis Asano	—	—	C	A	C	—	—	—	—	—	—	—	—
Baggina sp.	R	—	R	R	R	—	—	—	—	—	—	—	—
Amphistegina lessonii d'Orbigny	—	—	R	—	—	—	—	—	—	—	—	—	—
Amphistegina sp.	—	—	—	R	R	—	—	—	—	—	—	—	—
Ceratobulimina sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Epistominella japonica (Asano)	—	—	R	C	R	—	—	—	—	—	—	—	—
Epistominella pulchella Husezima & Maruhasi	—	—	—	—	—	—	—	—	—	A	—	—	—
Epistominella sp.	—	—	R	R	R	—	—	—	—	—	—	—	—
Cassidulina globosa Hantken	—	—	—	R	—	—	—	—	—	—	—	—	—
Cassidulina imamurai Tai, n. sp.	—	—	—	A	R	—	—	—	—	—	—	—	—
Cassidulina laevigata carinata Cushman	—	—	—	A	C	—	—	—	—	A	—	—	—
Cassidulina margareta Karrer	—	—	R	A	F	—	—	—	—	R	—	—	—
Cassidulina orientale Cushman	—	—	—	(R)	—	—	—	—	—	—	—	—	—
Cassidulina pacifica Cushman	—	—	—	R	R	—	—	—	—	—	—	—	—
Cassidulina subglobosa Brady	—	—	R	F	R	—	—	—	—	(R)	—	—	—
Cassidulina sp.	—	—	—	F	R	—	—	—	—	F	—	—	—
Cassidulinoides miuraensis Higuchi	—	—	—	R	—	—	—	—	—	—	—	—	—
Ehrenbergina notoensis Asano	—	—	R	F	—	—	—	—	—	—	—	—	—
Ehrenbergina serrata Reuss	—	—	—	R	—	—	—	—	—	—	—	—	—
Ehrenbergina sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Pullenia apertula Cushman	—	—	—	R	—	—	—	—	—	—	—	—	—
Pullenia bulloides (d'Orbigny)	—	—	—	R	—	—	—	—	—	—	—	—	—
Pullenia quinqueloba (Reuss)	—	—	—	R	—	—	—	—	—	—	—	—	—
Pullenia salisburyi R. E. and K. C. Stewart	—	—	—	C	—	—	—	—	—	A	—	—	—
Pullenia sp.	—	—	—	R?	—	—	—	—	—	R	—	—	—
Sphaeroidina austriaca d'Orbigny	R	—	—	F	—	—	—	—	—	—	—	—	—
Sphaeroidina compacta Cushman and Todd	—	—	—	F	—	—	—	—	—	—	—	—	—
Sphaeroidina japonica Asano	—	—	—	C	R	—	—	—	—	—	—	—	—
Sphaeroidina sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Anomalina glabrata Cushman	F	R	F	F	—	—	—	—	—	C	—	—	—
Anomalina kojimaensis Tai, n. sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Anomalina sp.	—	R	R	R?	—	—	—	—	—	R	—	—	—
Planulina asanoi Tai, n. sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Planulina nipponica Asano	—	—	C	A	R	—	—	—	—	—	—	—	—
Planulina subdepressa Asano	—	—	—	(R)	—	—	—	—	—	—	—	—	—
Planulina wuellerstorfi (Schwager)	—	—	C	A	F	—	—	—	—	—	—	—	—
Planulina sp.	—	—	R	F	F	—	—	—	—	—	—	—	—
Hanzawaia nipponica Asano	R	R	R	C	R	—	—	—	—	—	—	—	—
Hanzawaia tagaensis Asano	R	F	A	A	A	—	—	—	—	—	—	—	—
Hanzawaia sp.	—	—	—	F	—	—	—	—	—	—	—	—	—
Cibicides aknerianus (d'Orbigny)	—	—	R	F	R	—	—	—	—	F	—	—	—
Cibicides dogoensis Tai, n. sp.	—	—	—	—	—	—	—	—	—	F	—	—	—
Cibicides floridanus (Cushman)	—	—	—	(F)	—	—	—	—	—	—	—	—	—
Cibicides lobatulus (Walker and Jacob)	R	—	A	A	C	—	—	—	—	A	—	—	—
Cibicides (?) *omurai* Asano and Inomata	—	—	—	—	R	—	—	—	—	—	—	—	—
Cibicides pseudoungerianus (Cushman)	R	—	A	A	A	—	—	—	—	A	—	—	—
Cibicides refulgens (Montfort)	—	—	—	F	—	—	—	—	—	—	—	—	—
Cibicides shukuensis Tai, n. sp.	—	—	—	R	—	—	—	—	—	—	—	—	—
Cibicides sp.	R	—	C	C	C	—	—	—	—	—	—	—	—
Dyocibicides biserialis Cushman & Valentine	—	—	R	F	—	—	—	—	—	R	—	—	—
Dyocibicides perforata Cushman & Valentine	—	—	C	F	—	—	—	—	—	—	—	—	—
Dyocibicides sp.	—	—	—	C	—	—	—	—	—	—	—	—	—
Miogypsina kotoi Hanzawa	—	—	C	—	—	—	—	—	—	—	—	—	—
Globigerinidae :	R	—	R	A	A	R	—	—	—	C	—	R	—
Globorotaliidae:	R	—	R	A	—	—	—	—	—	R	—	—	—

D. Geohistorical Summary of the West Honshû Miocene

Based upon Figure 2 and Plates 37, 38, showing the micropaleontological features of the respective lithological units and time-rock units and their inter-relation by means of correlation, the general geohistory of the San'in and Setouchi Provinces may be summarized as given in the lines to follow.

As may be noticed from the correlation chart the foundation rocks of the Neogene sedimentaries distributed within the San'in and Setouchi Provinces are everywhere in unconformable. Upon this eroded surface there are developed either eruptives and their pyroclastics as seen throughout the San'in Province and brackish to lagoonal deposits as observed in the western part of the Setouchi Province. Elsewhere as in the central and eastern parts of the Setouchi Province and in the Nankai Province there are found shallow water marine deposits covering the basement rocks unconformably.

From the relationship between the basement and covering Neogene sedimentaries it is quite evident that the first marine transgression in the areas of West Honshû which is represented by the Togarian stage commenced either by very shallow tranquil warm thermal seas which was in part contemporaneous with the rather violent volcanism on the land and also with already formed lagoons and brackish water embayments then fringing the land surface. These latter terrestrial to brackish water deposits were soon drowned by the transgressing sea. This sea brought into the central part of the setouchi Province shallow water lithofacies characterized with thickshelled molluscs of large size and variety was succeeded only in the Okuyamada area of the central part of this Province with shallow neritic smaller Foraminifera, which mark the upper part of the Togarian.

The upper part of the Togarian represented by the *Nonion mizunamiense* zone represented the shallower part of the transgressing sea prior to deeping of the Provinces and extension of the invading seas.

The next Miyoshian stage represents the period of most widespread distribution of the transgressing seas which brought in to the present Provinces warm-thermal waters carrying a microfauna consisting of elements typical of subtropical to warm temperate regions. Unlike the coarse clastic sediments characterizing the Togarian, the Miyoshian becomes more argillaceous although coarse clastics still continue in local areas of the San'in and Setouchi Provinces. The shallow nature of the Miyoshian seas is readily distinguished by such genera as *Miogypsina*, *Operculina*, *Elphidium*, and from the characteristic occurrence of *Rotalia* in some areas such as the western and central parts of the Setouchi Province it seems evident that even though transgression was widespread and seems to have reached the climax at this time, there also existed some embayments. These embayments were soon destroyed by the continued sinking of the land being covered by the maximum transgression which lead to a rather abrupt change in the faunal elements, by which the younger Miyoshian is distinguished into two parts, the lower of which is characterized by the still existence of embayment facies and the upper by the drowning of those embayments to produce an open sea facies

which typifies the upper part of the Miyoshian.

The younger part of the Miyoshian is typified by the abundant occurrence of members of the Lagenidae and planktonic Foraminifera and at the same time it appears as if nearly all of the pre-existing embayments have become flooded and the conditions changed to that of an open sea. Lithologically it can be stated that from about this time argillaceous sediments increase in amount and become of common occurrence, whereas coarse clastic become scarce in good agreement with the microfauna. However, the warm thermal seas continue to prevail in the present Province although their effect on the fauna seems to have become more influencial as may be noticed from the occurrence of species flourishing in the Kar Nicobar Miocene dominating the present area. The conditions changing to that of an open sea resulted in the stabilization of the fauna living there and the production of uniform sediments which either occur in the form of an alternation of fine-grained siltstone and sandstone or be massive, homogenus black shales, except in areas as the Shimane Peninsula and Oki Islands where terrestrial conditions still prevailed.

During the middle part of the Miyoshian there was rather intense volcanicity throughout the Setouchi Province and this influenced the larger part of the San'in Province as is recognized from a plagiorhyolitic tuff bed extending nearly throughout both of the said Provinces. This physical phenomena defines the top of the middle part of the Miyoshian and also marks the faunal change by which the younger Miyoshian is divided into two faunules, and these two comprise the upper zone of the two of the Miyoshian. Prior to gradual uplift of the whole West Honshû Miocene there occurred a gradual deeping of the seas in which was deposited the Iwami-Otan stage. The Iwami-Otan based upon fauna, lithology and paleooceanographical conditions can be subdivided into three parts, of which the lower two comprise two distinct faunules of wide distribution in the Provinces dealt with and the upper generally of volcanic sediments but of argillaceous ones where they occur. The middle subdivision is separated from the lower by a rhyolitic tuff and the upper from the next younger Fujinan stage by two pyroxene andesite flows.

Thus during the Iwami-Otan conditions seems to have been rather uniform through the time of deposition of the two lower subdivisions of the stage except for the spreading of volcanic sediments in its middle part. From their microfauna, it is evident that the seas continued to be temperate and their depth rather great. However, during the later part of the Iwami-Otan there seems to have been a gradual uplift associated with volcanism and the introduction of newly formed coarse clastic sediments, which released the argillaceous ones characterizing the lower and middle divisions of the Iwami-Otan. This gradual uplift lead to the production of sediments of a regressive phase characterized the Fujinan stage. The Fujinan stage is developed only in the San'in Province in West Honshû so far as studied by the writer. Its typical development is in central Shimane Peninsula where its relation with subjacent and superjacent stages can be observed, elsewhere only its lower and middle parts are found and un-

fortunately in those places they are unconformably overlain by younger deposits, therefore, the exact amount of sediment that has been eroded away remain unknown. However, since typical development can be observed in the Shimane Peninsula, rough judgement of the amount of lost sediment can be undertaken.

The stage is subdivided into three parts chiefly by the smaller Foraminifera contained in the sediments, by the lithological characteristics and by the sediments commencing from coarse clastic, changing upwards into finer ones and then argillaceous ones. The second cycle which starts with coarse clastic (sandstone) forms the basal part of the next younger unnamed "Lower Pliocene" stage, the stage being left unnamed because its uppermost is difficult to determine owing to being superposed with an unconformity.

The lower division of the Fujinan is characterized with a shallow water fauna in its larger part but locally with some deep water forms according to the bottom configuration of the then existing seas. The middle part in which *Uvigerina* and *Cassidulina* appear as a characteristic forms seems to indicate the maximum depth of the area under which sedimentation was proceeding and the upper division suggests gradual shallowing of the sedimentary basin. The gradual uplift resulted in the production of an unconformity throughout the greater part of the sedimentary basin, but the repeated subsidence in the local basin of Central Shimane Peninsula and South Matsue resulted in the construction of the next younger unnamed "Lower Pliocene" stage. By the end of the Fujinan stage the whole area of West Honshû was raised above sea-level and erosion became very active, particularly throughout all parts except where local subsidence was again repeated as shown by the distribution and development as well as faunal facies of the unnamed Pliocene time-rock unit.

During the early part of the unnamed "Lower Pliocene" stage there occured rather widespread flows of olivine trachybasalts extending from the Oki Islands to South Matsue via the central part of the Shimane Peninsula. Accordingly this widespread volcanism is important as a good guide in the upper part of the lower subdivision of the unnamed "Lower Pliocene" stage.

The youngest unnamed stage in West Honshû is characterized by abundant specimens of *Rotalia* cf. *beccarii*, which shows that the conditions were very shallow, of bay-like character, not long-lived, and together with volcanisms and the deposition of coarse clastics suggests that the conditions were far from stable.

Thus, from the remarks concerning the characteristics of the smaller faunal subdivisions, bottom conditions under which the Foraminifera once lived, development of cyclic sediments, lithological units and their distribution within the present area together with their relationship with volcanisms it becomes evident that:

1-the geographically isolated localities where stratigraphical observations and palcontological investigations have been carried out have intimate relationship,

2-the intimate relationship is shown in the correlation chart in the form of distribution of the respective stages and their subdivisions throughout West Honshû,

3–the gradual change in thermal conditions from subtropical or warm temperate as indicated by the foraminiferal fauna of Indo-Pacific origin in the early time-rock units to subtemperate then to temperate and finally to cool temperate in the latest stage, is a typical feature of the Neogene deposits of Japan, reserving the fact that small differences occur locally,

4–the periods of volcanism having widespread or more or less extensive distribution within the areas surveyed occured at least five times. The significant one which is considered the first took place during Togarian time and is represented by basalt, two pyroxene andesite, dacite, rhyolite, and their pyroclastics. Where marine sedimentaries are developed the lithofacies is tuffaceous. This significant activity is concentrated in the Inner Subprovince of the San'in Province. The second which is more or less extensive is represented by acidic tuff and occurs between the upper and middle subdivisions of the Miyoshian stage. The third consists of rhyolite and is less extensive than the second and occurs at the uppermost part of the lower subdivision of the Iwami-Otan stage. The still less extensive or fourth volcanism is represented by the two pyroxene andesite flows and its pyroclastics which occurs in the upper part of the upper subdivision of the Iwami-Otan stage. The fifth outburst which is confined to a part of the San'in Province consists of olivine trachybasalt and its pyroclastics; this occurs in the upper part of the lower subdivision of the unnamed "Lower Pliocene" stage. It is evident that the distribution of the volcanic ejecta became less intense and less extensive in upward sequence, but showed intimate relation with faunal displacement and introduction as well as with lithological subdivision of the stratigraphic sequence where they occur, (The details of these volcanisms, from the petrological and volcanostratigraphical points of view, have been reported by M. MUKAE. (1954, 1957, 1958)

5–the differentiation in upward sequence of the assemblage of the smaller Foraminifera apparently have relationship with instability of the sea-bottom of the sedimentary basins in which they lived as is clarified by the investigation from the bio-, litho-, paleooceano-, and other facies so far determined,

6–the faunal sequence and their change in elements and reflected paleoecological conditions when compared with the time-rock units introduced by R. M. KLEINPELL for the Tertiary sediments of Northwest America are found to show harmony,

7–geological age determinations although difficult from the view of strict European standard have been tentatively settled according to general usage in the North Pacific area,

8–finally it is to be added that further researches are advisable before conclusive remarks can be stated for the Neogene deposits developed in Japan, but to be repeated is that the present work may be fruitful as a working basis and as the nucleus for future standardization of the varied fauna and sediments which are influenced by highly variable oceanographical conditions.

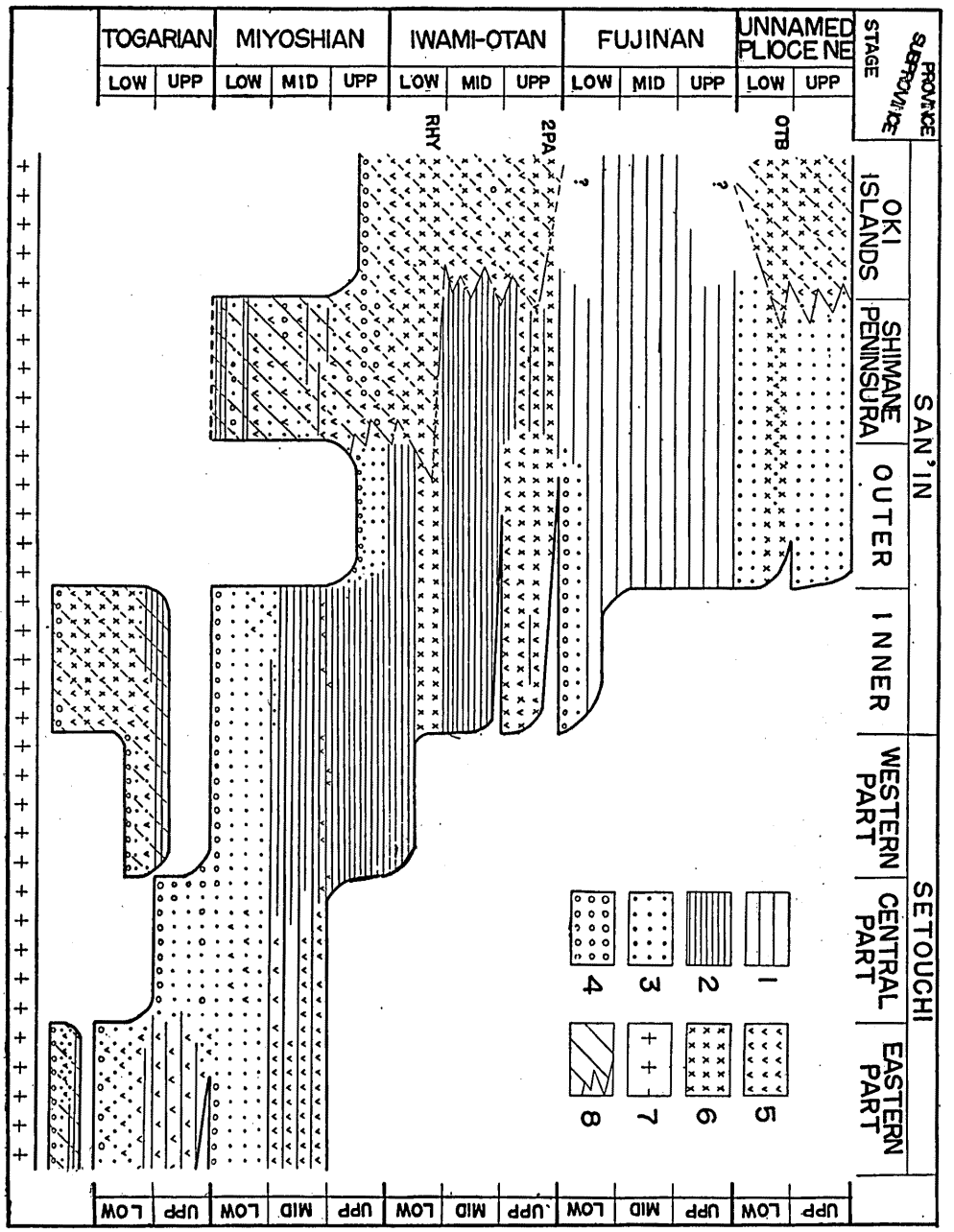


FIG. 2 Schematic sedimentary reconstruction of the Miocene-lower Pliocene lithofacies developed in the San'in and Setouchi Provinces, showing the relation of the litho-stratigraphic units and the time-stratigraphic ones. Explanation of the prevalent lithology: 1. Mudstone, 2. Shale, 3. Sandstone, 4. Conglomerate, 5. Tuff, 6. Lava-flow, 7. Basement rocks, 8. Non marine facies, OTB; Olivene trachybasalt, 2PA; Two pyroxene andesite, RHY; Rhyolite. (Y. TAI, 1959)

E. Correlation of the West Honshû Miocene Biostratigraphical and Time-Rock Units with Other Areas in the Japanese Islands

Based upon the foregoing discussions and presented evidences the lithological units of Neogene age developed within the San'in and Setouchi Provinces, may be correlated with one another as shown in Plate 38, in which particular emphasis is given to the distribution of the established stages and zones. The Togarian stage and the larger part of the Miyoshian stage occur in the marine formations of the eastern Setouchi Province, while the whole Miyoshian stage and the lower part of the Iwami-Otan stage are found in the marine formation distributed in the western Setouchi Province. The types of the other stages occur in three subprovinces of the San'in Province, namely, the type Iwami-Otan stage in the Inner Subprovince, the type Fujinan in the Outer Subprovince, and the unnamed "Lower Pliocene" stage in the Shimane Peninsula Subprovince. Of the stages distinguished in the West Honshû Neogene, it became evident that the San'in includes all except the Togarian stage and that the Setouchi contains about the lower half of them.

The most useful key with regard to the correlation carried out in West Honshû mentioned above was the Miyoshian stage. Particularly, the *Lagenonodosaria scalaris-Uvigerina crassicostata* zone, the upper one of the Miyoshian stage, is most widespread in distribution and yields the most uniform, stable, and abundant faunal assemblage represented by the family Lagenidae. At the same time, this zone is particularly important as it is the horizon which yields the most abundant pelagic Foraminifera. From such reasons the San'in and Setouchi Miocene Provinces could be tied together by this particular zone. Furthermore, it seems very probable to the writer that this zone will become an important key for correlation in the Japanese Miocene should researches be extended more extensively.

From the Pacific side of West Honshû, Foraminifera were distinguished from the Tanabe Miocene, Wakayama Prefecture (Table XXXI), and from the results of the paleontological and biostratigraphical studies of the Foraminifera and its yielding strata, the microfauna from the Asso formation, the uppermost one of the Tanabe group, is equivalent to the *Lagenonodosaria scalaris-Uvigerina crassicostata* zone; it belongs to the upper and middle Miyoshian stage. Further, the foraminiferal assemblage from the lowermost part of the Kanayama group is very similar to that of the lower Iwami-Otan stage. The Tanabe Miocene area belongs to the Nankai Province, about the central part of the West Outside Province, proposed by N. IKEBE (1957). The occurrence of the Miyoshian stage in this Province suggests a possibility for correlation between the Setouchi and West Outside Miocene and serves to show the widespread distribution of the time-rock unit.

In 1953, K. ASANO reported on the Miocene smaller Foraminifera from the upper part of the Higashi-innai and Najimi formations in the Noto Peninsula, Ishikawa Prefecture. As a result of his studies, he concluded that the fauna is similar to that of Kar Nicobar or Fiji Islands, which indicates an age corresponding to the Preangerian

(Vindobonian). At the same time, he stated that in the Noto microfauna the family Lagenidae is represented by the largest number of genera, species, and individuals and in other families, the genera *Bulimina*, *Uvigerina*, *Cassidulina*, *Guttulina*, *Nonion*, *Cibicides*, *Gaudryina*, and *Valvulineria* contain the majority of the species and individuals. Pelagic Foraminifera of the family Globigerinidae also occur in abundance in association with this benthonic fauna.

The majority of this Noto microfauna are common to that of the upper zone of the Miyoshian stage, the *Lagenonodosaria scalaris-Uvigerina crassicostata* zone. According to the stratigraphical study of the Noto Miocene by K. MASUDA (1954), this upper part of the Higashi-innai formation under discussion succeeds conformably the middle part of the same formation, which contains many important fossils, such as *Miogypsina*, *Operculina*, *Vicarya*, and *Patinopecten* etc. Accordingly, it seems possible that this middle part corresponds to the lower zone of the Miyoshian stage, the *Miogypsina kotoi-Operculina complanata japonica* zone, although smaller Foraminifera have not been reported from this part.

K. ASANO (1953) further stated that the middle part of the Higashi-innai formation can be correlated with the lower part of the Nishikurosawa formation in Akita Prefecture, which contains the *Miogypsina-Operculina* fauna. Both the upper parts of the Higashi-innai and the Najimi formations are correlated by him with the upper part of the Nishikurosawa formation, the Onnagawa or the Funakawa formation, which appear in succession along the southern coast of Oga Peninsula in Akita Prefecture.

Recently S. IWASA and Y. KIKUCHI (1954) reported about 150 species of smaller Foraminifera from the middle Miocene Sugota formation distributed in the Dewa Hills between the Yokote and Honjô basins in Akita Prefecture. This Sugota foraminiferal fauna is very similar with those of the middle and upper Miyoshian stage in West Honshû under discussion. They stated that the family Lagenidae is represented by the largest number of genera, species, and individuals, occupying about one-third of the fauna, and of the other families, those of the Nonionidae, Buliminidae, Rotaliidae, and Anomalinidae are next in abundance. The pelagic forms of the family Globigerinidae also occur in abundance. They concluded that the Sugota formation is a correlative of the Nishikurosawa formation above mentioned and may belong to the Vindobonian age. This age determination was previously upheld by S. NOMURA and K. HATAI (1936) from the their study of the molluscs and brachiopods from the Sugota formation.

O. YAMAGATA (1957) recorded about 30 species of Miocene Foraminifera from the upper Oisawa formation and the Mizusawa formation in the area west of Aterazawa-machi, Yamagata Prefecture. According to the stratigraphical study of that author, the upper Oisawa formation which yielded the smaller Foraminifera overlies conformably the lower Oisawa formation which contains abundant *Miogypsina* cf. *kotoi*, *Operculina complanata japonica*, and *Liquidambar formosana*. From the comparisons of the foraminiferal sequence and composition and general lithology, the Oisawa formation seems

to correspond to the Miyoshian stage in the present paper. On the other hand, all Foraminifera from the Mizusawa formation above the Oisawa occur in the microfauna of the Iwami-Otan stage in the present paper as important arenaceous forms of its stage. Accordingly, the Mizusawa formation seems to correspond to the Iwami-Otan represented lithologically by hard black shale facies. It is very interesting that the sharp line recognized between the Miyoshian and Iwami-Otan faunas also occurs evidently in the faunal change between the Oisawa and Mizusawa formations. O. YAMAGATA (1957), in the same report, correlated the upper Oisawa microfauna with the Noto microfauna (K. ASANO, 1953) succeeding the *Miogypsina-Operculina* zone in the Noto Peninsula, Ishikawa Prefecture.

S. IWASA (1955) distinguished a large number of benthonic Foraminifera from the Ishizawagawa group, the principal oil-bearing strata in Honjô City and its environs in Akita Prefecture. He stated that the foraminiferal fauna of the Ishizawagawa group indicates a cool thermal condition contrary to the underlying Sugota formation, which contains a fauna of warm thermal waters. He further stated that from the foraminiferal assemblages and stratigraphic distribution of some of the characteristic forms, this Ishizawagawa fauna can be divided into the following four zonules, namely, *Martinottiella-*, *Miliammina-*, *Uvigerina-Angulogerina-*, and *Cassidulina* zonules. These four zonules, which occupy the middle and upper parts of the Ishizawagawa group, the Tate-, Minaminomata-, and Osawa formations combined, in general, seem to correspond to the *Uvigerina subperegrina-Epistominella pulchella* zone of the Fujinan stage in the present report. But only the uppermost part of the Osawa formation, the upper part of the *Cassidulina* zonule, may possibly correspond to the Matsue formation, the type of the unnamed "Lower Pliocene" stage or *Rotalia* cf. *beccarii* zone, since the following evidences were recognized to be common in both the Matsue formation and the upper Osawa formation above, namely, the regressive facies entombing in abundance *Turritella saishuensis*, the disappearance of *Epistominella pulchella*, the increase of specimens belonging to the families Rotaliidae and Nonionidae, the common occurrence of *Gaudryina yabei*, *Cribroelphidium yabei*, *Eponides frigidus*, *Rotalia takanabensis* etc., and lying conformably above the underlying Fujinan stage and ist equivalent above mentioned. The lowermost part of the Ishizawagawa group is the Toridame formation which has not been classified into zonule divisions in this area. In his same paper, he reported that the Toridame formation yields a characteristic microfauna consisting only of arenaceous forms, such as *Haplophragmoides*, *Cyclammina*, *Goësella*, *Martinottiella*, and *Sigmoilina* etc. This fact is very similar to that of the Iwami-Otan stage. Accordingly, if the Sugota formation can be correlated with the Miyoshian stage as already mentioned, the Toridame formation overlying conformably the Sugota may correspond to the Iwami-Otan stage lying above the Miyoshian stage.

These Nishikurosawa, Sugota, Onnagawa, Funakawa, and the other formations afore-mentioned are considered to be typical Miocene formations of the oil fields along the Japan Sea coast of North Honshû. Therefore, the recognition of the Miyoshian

stage in these formations seems to worthy for detailed correlation between the West and North Honshû Miocene.

N. IKEBE (1949) and K. NAKASEKO (1952) established five microbiostratigraphical units from the Neogene Yokawa group distributed in western Toyama and eastern Ishikawa Prefectures. The five units are arranged by the same authors into the following zones in ascending order: *Miogypsina kotoi*-, *Nodosaria insecta*-, *Martinottiella* cf. *communis*-, *Epistominella pulchella*-, and OST zones. The former two zones combined were named the "Onomian", the next two combined were named the "Kamishôan" and the last one the "Tonamian" by them. Based upon the biochronologic scale proposed by N. IKEBE (1947, 1948, 1954), they concluded the Onomian to be F_3 in age, the Kamishôan to be G, and the Tonamian to be H_1. As a result of the comparison based upon the foraminiferal sequence, it became evident that the most pronounced faunal change recognized between the Miyoshian and Iwami-Otan stages occurs no doubt in the faunal change between the Onomian and Kamishôan in the Hokuriku Province. This faunal change in common between the adjacent stages is the disappearance of the warm water elements of the Indo-Pacific regions. Furthermore, the Miyoshian microfauna is very similar to that of the Onomian, and the Iwami-Otan and Fujinan microfaunas to that of the Kamishôan. Accordingly, the Miyoshian stage is considered to correspond to the Onomian, and the Iwami-Otan and Fujinan stages combined to correspond to the Kamishôan. The unnamed "Lower Pliocene" stage also seems to correspond to the Tonamian, because the Arayama and Mita sandstone members (K. NAKASEKO, 1953, 1954) belonging to the Tonamian yield in common with the Matsue formation of the unnamed "Lower Pliocene" the following mega- and microfossils; *Turritella saishuensis*, *Anadara amicula*, *Macoma tokyoensis*, *Rotalia* cf. *beccarii*, and *Quinqueloculina vulgaris*.

As mentioned above, it is of interest that the San'in and Setouchi foraminiferal sequences, on the whole, are very similar with the Hokuriku foraminiferal one, notwithstanding the conspicuous differences in the depositional conditions, volcanic activities, and crustal movements. Thus, the mutual comparison based upon the microbiostratigraphical units and sequence of the foraminiferal assemblages seems to be of prime importance for detailed correlation of the Neogene marine sediments distributed in isolated geographical regions in West Honshû, Japan.

In the Pacific side of North Honshû, the Miocene Foraminifera from the Date formation in the vicinity of Yanagawa-machi, Fukushima Prefecture, was reported by Y. FUJITA and S. ITÔ (1957). This microfauna seems to be very similar to that of the Miyoshian stage in its elements.

Y. TAKAYANAGI (1952) recorded some Miocene smaller Foraminifera from the Hatatate formation, near Sendai City, Miyagi Prefecture. This microfauna seems to be similar to that of the middle Miyoshian stage.

Another correlative of the lower Miyoshian stage seems to be the smaller Foraminifera reported by T. UCHIO (1950) from the Momiyama sandstone member which has

yielded *Miogypsina kotoi*; this belongs to the upper part of the Kanuma formation, at Momiyama, Kitaoshi-mura, Shimotsuga-gun, Tochigi Prefecture.

O. FUKUTA and R. SHINOKI (1952) reported about 70 species of smaller Foraminifera from the middle part of the Nishikatsura group, which yields *Operculina complanata japonica* and overlies unconformably the so-called Misaka group with *Lepidocyclina* (*Nephrolepidina*) *nipponica*, at Nishikatsura-mura, Minamitsuru-gun,- and Shimada-mura, Kitatsuru-gun, Yamanashi Prefecture and at Nakura-mura, Tsukui-gun, Kanagawa Prefecture. The Foraminifera-bearing middle part of the Nishikatsura group corresponds to a part of the Miyoshian stage. On the other hand, whether the underlying *Lepidocyclina*-bearing Misaka group corresponds to the writer's Togarian stage lying unconformably below the Miyoshian stage is not yet evident from the smaller Foraminifera. J. MAKIYAMA (1939) reported that the Misaka group is equivalent to the *Lepidocyclina*-bearing Ooigawa group in Shizuoka Prefecture, which is the type of his Ooigawan stage. It is thought that a microbiostratigraphical study of the Ooigawa and Misaka groups may reveal the relation between them and the writer's Togarian and MAKIYAMA's Ooigawan stages.

K. ASANO (1953) reported about 28 species of smaller Foraminifera from the Honya shale at Yagawase, Taira City, Fukushima Prefecture. Of those 28 species, 16 occur in the fauna of the Miyoshian stage. This suggests that a part of the foraminiferal sequence distinguished in the West Honshû Miocene also occurs in the Miocene area of the Pacific coast of North Japan. He stated that the Honya shale of the Jôban coal-field may be correlated to the Funakawa formation in the oil-field of Akita, Yamagata, and Niigata Prefectures.

K. ASANO (1949) reported about 68 species of smaller Foraminifera from the Kokozura formation at Kokozura, Nakoso-machi, Ishiki-gun, Fukushima Prefecture. Many of those 68 species also occur in the Miyoshian stage. For correlation purpose with the Miyoshian stage, it seems to be important that there are many planktonic Globigerinidae and Globorotaliidae included among the predominating forms of the Lagenidae.

Further, K. ASANO (1953) reported on the Foraminifera from the Wakkauenbetsu formation and the Shintotsugawa group in the Shintotsugawa area, Kabato-gun, Hokkaidô. He stated that the Wakkauenbetsu Foraminifera excluding the new species are commonly found in the so-called "Black shale" formations such as the Funakawa and Kubiki formations in Akita, Yamagata, and Niigata Prefectures, and that some sampling horizons, from which arenaceous forms, such as *Cyclammina*, *Trochammina*, and *Bathysiphon*, are found to be dominant without calcareous ones occur in association in the Wakkauenbetsu formation. This characteristic of the Wakkauenbetsu microfauna is very similar to that of the microfauna of the Iwami-Otan stage or of a transitional part ranging from the Miyoshian to the overlying Iwami-Otan. On the other hand, it became evident that the fauna of the Shintotsugawa group which is represented by the families Buliminidae, Cassidulinidae, and Globigerinidae has many species in common with the Fujinan fauna. He concluded that there is a sharp line between

the Shintotsugawa and Wakkauenbetsu faunas, and the former represents the upper Miocene foraminiferal fauna of the Japan Sea coast, while the latter can be correlated with the Funakawa and Kubiki formations afore-mentioned and indicates a middle Miocene age.

K. TSUSHIMA, K. MATSUNO, and S. YAMAGUCHI (1954) recorded some smaller Foraminifera from the uppermost horizon of the upper Kotanbetsu formation distributed in the area south of Tomamae-machi, Rumoi-gun, Hokkaidô. This foraminiferal assemblage seems to be very similar to that of the middle Fujinan stage.

F. Faunal Comparisons with the Indo-Pacific Regions

As mentioned in the foregoing pages, it is quite evident that the microfauna of the Miyoshian stage is the most outstanding key for the correlation of the Japanese Miocene. Further, a microfauna similar with the Miyoshian seems to occur in some late Tertiary areas in the Indo-Pacific regions as following.

L. W. LEROY (1944) recorded and illustrated a large number of smaller Foraminifera from the Miocene (Telisa, Lower and Middle Palembang) of central Sumatra, Netherlands East Indies. The species common to both Sumatra and the Miyoshian microfaunas include the following:

Bolivina marginata Cushman
Bulimina pupoides d'Orbigny
Bulimina pyrula d'Orbigny
Bulimina striata d'Orbigny
Cancris auriculus (Fichtel and Moll)
Dentalina communis d'Orbigny
Dentalina tauricornis (Schwager)
Elphidium advenum (Cushman)
Eponides praecinctus (Karrer)
Eponides umbonatus (Reuss)
Globigerina bulloides d'Orbigny
Lagena acuticosta Reuss
Lagena globosa (Montagu)
Lagena sulcata (Walker and Jacob)
Lagenonodosaria scalaris (Batsch)
Nodosaria tosta Schwager
Nodosaria vertebralis (Batsch)
Pseudoglandulina laevigata (d'Orbigny)
Plectofrondicularia longistriata LeRoy
Pullenia salisburyi R. E. and K. C. Stewart
Robulus orbicularis (d'Orbigny)
Robulus tangens LeRoy
Uvigerina multicostata LeRoy
Vaginulina bradyi Cushman

In the same paper, L. W. LEROY (1944) reported on the Miocene smaller Foraminifera from the Tjijarian Bridge of West Java, Netherlands East Indies. Some of the recorded Java species which also appear in the Miyoshian microfauna are as follows:

Anomalina glabrata Cushman
Bulimina inflata Seguenza
Bulimina pupoides d'Orbigny
Cassidulina pacifica Cushman
Cibicides aknerianus (d'Orbigny)
Dentalina insecta (Schwager)
Ehrenbergina serrata Reuss
Eponides bengalensis (Schwager)
Eponides praecinctus (Karrer)
Guttulina problema d'Orbigny
Lagena acuticosta Reuss
Lagena globosa (Montagu)
Lagenonodosaria scalaris (Batsch)
Nodosaria longiscata d'Orbigny
Nodosaria tosta Schwager
Nodosaria vertebralis (Batsch)
Planulina wuellerstorfi (Schwager)
Pseudoglandulina laevigata (d'Orbigny)
Pullenia quinqueloba (Reuss)
Reussella spinulosa (Reuss)
Robulus calcar (Linne')
Saracenaria latifrons (Brady)
Uvigerina crassicostata Schwager
Uvigerina proboscidea Schwager

L. W. LEROY (1941) also distinguished many smaller Foraminifera from the late Tertiary of East Borneo, Netherlands East Indies. He stated that the Borneo fauna shows a close affinity with the Tjijarian fauna (Miocene) of West Java afore-mentioned, in which *Lepidocyclina*, *Miogypsina*, and *Cycloclypeus* were found associated. Species common to both the Borneo and Miyoshian microfaunas include the following:

Amphistegina lessonii d'Orbigny
Anomalina glabrata Cushman
Eolivina robusta Brady
Bulimina inflata Seguenza
Bulimina ovata d'Orbigny
Bulimina pupoides d'Orbigny
Cancris auriculus (Fichtel and Moll)
Cassidulina pacifica Cushman
Cibicides lobatulus (Walker and Jacob)
Dentalina insecta (Schwager)
Dentalina subsoluta (Cushman)
Ehrenbergina serrata Reuss
Ellipsonodosaria lepidula (Schwager)
Eponides praecinctus (Karrer)
Eponides umbonatus (Reuss)
Gyroidina soldanii (d'Orbigny)
Lagena globosa (Montagu)
Lagena striata d'Orbigny
Lagenonodosaria scalaris (Batsch)
Nodosaria longiscata d'Orbigny
Nodosaria tosta Schwager
Nodosaria vertebralis (Batsch)
Planulina wuellerstorfi (Schwager)
Pseudoglandulina laevigata (d'Orbigny)
Reussella spinulosa (Reuss)
Robulus calcar (Linne')
Robulus javana simplex (Koch)
Robulus lucidus (Cushman)
Robulus orbicularis (d'Orbigny)

In the same report, LEROY (1941) recorded and illustrated some smaller Foraminifera from the late Tertiary of Siberoet Island, off the west coast of Sumatra, Netherlands East Indies. He stated that the Foraminifera show affinity with the Borneo microfauna above mentioned. Some species in common with the Miyoshian microfauna are listed below:

Anomalina glabrata Cushman
Eolivina robusta Brady
Bulimina inflata Seguenza
Bulimina ovata d'Orbigny
Cassidulina subglobosa Brady
Cibicides cf. *floridanus* (Cushman)
Cibicides pseudoungerianus (Cushman)
Dentalina communis d'Orbigny
Dentalina insecta (Schwager)
Ehrenbergina serrata Reuss
Ellipsonodosaria lepidula (Schwager)
Eponides praecinctus (Karrer)
Eponides umbonatus (Reuss)
Fissurina marginata (Montagu)
Gyroidina soldanii d'Orbigny
Lagenonodosaria scalaris (Batsch)
Nodosaria longiscata d'Orbigny
Nodosaria tosta Schwager
Nonion pompilioides (Fichtel and Moll)
Planulina wuellerstorfi (Schwager)
Reussella spinulosa (Reuss)
Robulus iotus (Cushman)
Sigmoilina schlumbergeri Silvestri
Vaginulina bradyi Cushman

Of the determined species of the Miyoshian, the following occur from the Miocene of Kar Nicobar Islands (C. SCHWAGER, 1866):

Bulimina inflata Seguenza
Dentalina insecta (Schwager)
Dentalina tauricornis (Schwager)
Ellipsonodosaria lepidula (Schwager)
Eponides bengalensis (Schwager)
Frondicularia foliacea Schwager
Hopkinsina hispida (Schwager)
Nodosaria pyrula d'Orbigny
Nodosaria tosta Schwager
Planulina wuellerstorfi (Schwager)

Pyrgo murrhina (Schwager)
Robulus nikobarensis (Schwager)
Sphaeroidina austriaca d'Orbigny
Textularia lythostrota (Schwager)
Uvigerina crassicostata Schwager
Uvigerina nitidula Schwager
Uvigerina proboscidea Schwager

Of the Miyoshian determined species, the following 13 occur from the late Tertiary of Fiji Islands (J. A. CUSHMAN, 1934). According to a later study of the Indo-Pacific Tertiary (M. F. GLAESSNER, 1943), the so-called late Tertiary deposits of Fiji were correlated with the Rembangian (Burdigarian) and Preangerian (Vindobonian).

Bulimina inflata Seguenza
Cassidulina subglobosa Brady
Dentalina insecta (Schwager)
Eponides umbonatus (Reuss)
Planulina wuellerstorfi (Schwager)
Pullenia quinqueloba (Reuss)
Pyrgo murrhina (Schwager)
Robulus calcar (Linnaeus)
Robulus nikobarensis (Schwager)
Textularia lythostrota (Schwager)
Uvigerina crassicostata Schwager
Uvigerina nitidula Schwager
Uvigerina proboscidea Schwager

R. TODD (1957) also distinguished a large number of smaller Foraminifera from the Miocene Tagpochau limestone of Saipan, Mariana Islands. Some of the recorded Saipan species which also appear in the Miyoshian microfauna are as follows:

Amphistegina lessonii d'Orbigny
Cassidulina pacifica Cushman
Cassidulina subglobosa Brady
Cibicides lobatulus (Walker and Jacob)
Cibicides pseudoungerianus (Cushman)
Ehrenbergina serrata Reuss
Elphidium advenum (Cushman)
Fissurina orbignyana Seguenza
Globigerina bulloides d'Orbigny
Nonion grateloupi (d'Orbigny)
Planulina wuellerstorfi (Schwager)
Pullenia quinqueloba (Reuss)
Pyrgo murrhina (Schwager)
Uvigerina proboscidea Schwager

From the rather large number of genera and species occurring in the Miyoshian fauna and also in several geographically isolated areas in the Indo-Pacific regions, it seems evident that there exist some relations between them. Whether the microfaunas reported by LEROY, SCHWAGER, CUSHMAN, and TODD (loc. cit.) are nothing but correlatives of the Miyoshian or whether they merely suggest that the geological ages of the remote localities are close to one another, or whether they indicate contemporaneity, appear to be problems worthy of further study. However, that a large number of species identical between the very remote areas is a fact that can not be neglected. For more detail correlation between Japan and the Indo-Pacific regions, the writer is fully aware that additional data are necessary. But here he calls the attention to the facts above stated.

G. Correlation with the California Miocene of North America

Before attempting a correlation with the Miocene of the northwest coast of America, it may be appropriate to give a condensed summary of the salient features concerning the time-rock units established and discussed in the earlier pages of this work.

The following is repeated in order that a clearer understanding may be gained concerning the correlation of time-rock units of Japan with those of Northwest America. The time-rock units as established are thought to be basic to a more detailed correlation between remote areas.

Togarian. — Its distribution in typical form is restricted to the eastern Setouchi Province. The stage is characterized by comparatively minor transgression, variable faunal and lithologic facies and thickness; the clastic sediments contain such shallow-water Foraminifera as *Rotalia*, *Nonion*, and *Elphidium*, and such important megafossils as *Vicarya*, *Vicaryella*, and *Desmostylus*.

Miyoshian. — The stage is characterized by its uniform faunal and lithologic facies dominated by medium-depth faunas and by comparatively uniform thickness over wide areas, and by the most extensive transgression experienced in the Japanese Neogene. The Miyoshian fauna contains such tropical and subtropical elements as, *Miogypsina*, *Operculina*, and *Vicarya*, and a numerous smaller Foraminifera represented by the family Lagenidae. The stage includes the uppermost horizon of *Miogypsina* and *Vicarya* in the Japanese Islands. The pelagic Foraminifera represented by the family Globigerinidae occur in abundance throughout. The stage is unconformable with the underlying Togarian stage, although the time gap is probably negligible.

Iwami-Otan. — The relation with the underlying Miyoshian is conformable in West Honshû. The stage is characterized by the uniform faunal and lithologic facies, medium-depth fauna and by the hard black shale distributed along the Japan Sea coast in West Honshû, and by the extensive transgression succeeding from the Miyoshian age. The faunal change observable between the Iwami-Otan and the Miyoshian is the most pronounced one recognized in the West Honshû Miocene, notwithstanding the conformable relation between both stages. The Lagenidae and warmer-water elements mentioned in the Miyoshian all disappear, and only the arenaceous Foraminifera appearing first in the Miyoshian extend weakly into the Iwami-Otan. This sharp line between the Miyoshian and Iwami-Otan microfaunas is also recognized in other microfaunal sequences established locally in the Japanese Miocene, particularly in areas along the Japan Sea coast outside West Honshû. It should be added that some crustal movements occur in the upper Iwami-Otan stage in the San'in Province. These are shown by two unconformity, between the middle and upper horizons of the Iwami-Otan and between the Iwami-Otan and the superjacent Fujinan. The interval between these unconformities are represented mainly by large quantities of andesitic and basaltic flows and their pyroclastics. This violent volcanism in the Province, in general, is the most outstanding one during the recorded Miocene volcanisms in West Honshû.

Fujinan. — A different faunal facies is well distributed through the Fujinan stage, notwithstanding the uniform mudstone facies in which volcanic materials are lacking. The thickness is variable. These facts indicate that localization due to orogenic movement was in progress during the Fujinan age. An indication of such movement had

occurred already from about the middle Iwami-Otan age. The Fujinan microfauna on the whole is represented by the families Buliminidae and Lituolidae and its diversity suggests conditions of high relief during the Fujinan age. The stage is not so rich in Foraminifera as is the Miyoshian. The uppermost part of the stage is represented by a regressive phase and therefore underlies conformably the superjacent unnamed "Lower Pliocene" stage.

"*Lower Pliocene*". — The unnamed stage is characterized by the variable faunal and lithologic facies and thickness. The stage is evidently a regressive facies which has very local distribution. It contains some flows of olivine basalt in its middle part and coal seams in the upper and lower parts. Brackish or shallow water forms of meager Foraminifera and molluscs characterize the unnamed stage.

In order that correlation be attempted with the sediments on the northwest coast of America, it is first necessary to outline the various stages and their respective Foraminifera identified to be in common with those occurring from Japan. For this purpose the writer introduces the stages and fauna introduced by R. M. KLEINPELL, because his sequence is brought into comparison with that of West Honshû, Japan.

In 1938, R. M. KLEINPELL established excellent microbiostratigraphical units for the California Miocene of North America. Of the determined species distinguished by him from the California Miocene, the following occur in the West Honshû Miocene fauna;

Angulogerina occidentalis (Cushman)
Anomalina glabrata Cushman
Bolivina marginata Cushman
Bulimina inflata Seguenza
Bulimina ovata d'Orbigny
Bulimina pyrula d'Orbigny
Cassidulina laevigata carinata Cushman
Cassidulina margareta Karrer
Cassidulina subglobosa Brady
Cibicides floridanus (Cushman)
Cyclammina incisa (Stache)
Dentalina communis d'Orbigny
Dentalina spinosa d'Orbigny
Eponides umbonatus (Reuss)
Frondicularia foliacea Schwager
Globigerina bulloides d'Orbigny
Guttulina irregularis (d'Orbigny)
Gyroidina soldanii d'Orbigny
Haplophragmoides trullissatum (Brady)
Lagena acuticosta Reuss
Lagena globosa (Montagu)
Lagena perlucida (Montagu)
Lagena substriata Williamson
Lagena sulcata (Walker and Jacob)
Martinottiella communis (d'Orbigny)
Nodosaria longiscata d'Orbigny
Nodosaria pyrula d'Orbigny
Nonion umbilicatulum (Montagu)
Nonionella miocenica Cushman
Plectofrondicularia miocenica Cushman
Pullenia bulloides (d'Orbigny)
Pullenia salisburyi R. E. and K. C. Stewart
Robulus calcar (Linne')
Rotalia beccarii (Linne')
Sigmoilina tenuis (Czjzek)
Hopkinsina hispida (Schwager)
Uvigerina hootsi Rankin
Uvigerina proboscidea Schwager
Uvigerina segundoensis Cushman and Galliher
Uvigerina subperegrina Cushman and Kleinpell

In the same work, R. M. KLEINPELL (1938) established eight stages from the biostratigraphic units based on the sequence of the foraminiferal fauna of the California Miocene. Of these stages, the Relizian and Luisian combined are middle Miocene in

age, and the Mohnian and Delmontian combined are upper Miocene according to that author. He stated that the Relizian fauna is characterized in the lack of ecologic diversity presented by its constituent faunules, in which the Lagenidae are abundant, and furthermore stated "still another marked and significant change apparent in the Relizian fauna is the great number of specimens of the pelagic, open-sea genus *Globigerina*, which is almost universally present in considerable quantities" (KLEINPELL, 1938, p. 120).

As to the Luisian fauna, he stated "like the fauna of the Relizian, that of the Luisian is geographically widespread through California and is remarkable in the lack of ecologic diversity presented by its constituent faunules", and "------often also the open-sea *Globigerina* are dominant or characteristic genera" (KLEINPELL, 1938, p. 124). As to the climatic and depositional conditions of the Luisian, he stated as follows;

> The prevalence of *Siphogenerina* suggests tropical or warm-temperate zone conditions of deposition, as in the older Stages, but increasing numbers of *Bolivina*, *Cassidulina*, and *Uvigerina* indicate a climatic change in the direction of conditions now prevailing in the waters off the California coast.·····
>
> the nature and distribution of the Luisian Foraminifera in the California province suggest conditions of comparatively low relief during the Luisian age.··· (KLEINPELL, 1938, p. 124).

According to that author, the Luisian is the horizon yielding *Desmostylus* and its age is correlated with the Vindobonian by him.

As to the Mohnian fauna, he reported in the same work as follows;

> Although a number of Luisian species of Foraminifera are present in the lower Mohnian, the faunal change observable between the Luisian and the Mohnian is the most pronounced change recognized within the limits of the California Miocene. The *Lagenidae* have dwindled to minor importance, and the *Buliminidae* are dominant, types characteristic of the neritic zone being common; much of the foraminiferal rock of the Mohnian Stage, a large proportion of which is a characteristic conchoidally fracturing silicified mudrock, or so-called "brown shale", seems to have been deposited in this bathymetric zone.····· The warm-water elements characteristic of the subjacent Luisian Stage have disappeared by the middle of the Mohnian and there is a marked increase of cold-water forms such as *Cassidulina*, *Nonion pizarrensis*, and *Uvigerina*. As a Stage, the Mohnian is geographically widespread in the California province but, on the whole, it is not richly foraminiferal, as are the Relizian and Luisian (KLEINPELL, 1938, p. 128).

As to the Delmontian fauna, he explained "the faunules comprising the fauna of the Delmontian Stage are ecologically more diverse than those of the Mohnian Stage" and that its general composition is close to that of the subjacent Mohnian (KLEINPELL, 1938, pp. 133, 134).

Judging from the evidence mentioned in earlier lines, the Miocene foraminiferal sequence of West Japan has many features in common with those recognized by R. M. KLEINPELL (1938) in the Miocene California sequence of North America, notwithstanding the conspicuous differences in the geological conditions between the remote areas. Of the common features, a significant one is that a remarkable faunal change occurs between the Miyoshian and Iwami-Otan of the West Japan Miocene and this

is inferred to correspond to the important faunal change from the Luisian to the Mohnian in the California Miocene.

This mutual significant faunal change is recognized on both sides of the North Pacific by the disappearance of the tropical or subtropical elements, although the number of species in common between the remote areas are few.

S. IWASA and Y. KIKUCHI (1954) reported on the Miocene Sugota microfauna from the Sugota formation in Akita Prefecture, North Japan and it is known that from an equivalent formation, K. TAN (1951) discovered a tooth of *Desmostylus japonicus* TOKUNAGA and IWASAKI. At the same time, they mentioned that the Sugota formation and its correlatives correspond to the Vindobonian of the European standard and to the Luisian stage established by R. M. KLEINPELL. As mentioned in previous pages by the writer, this Sugota formation from its faunal characteristics is considered to correspond to the Miyoshian stage. Accordingly, the Miyoshian stage may occupy a horizon higher than that of the *Desmostylus* recorded from the Togarian stage.

From the available data it is evident that there exists a close similarity in the stable geologic conditions, general trend in transgression, and the associated occurrence of pelagic Foraminifera between the two remote areas. From such evidence besides others it may be said that the Miyoshian stage in the present report broadly corresponds to the Luisian of California.

To extend the inferred interrelationship another step, it appears evident and logical that the Iwami-Otan and Fujinan stages combined are most probable correlatives of the Mohnian and Delmontian combined.

R. L. PIERCE (1956) recorded 88 species of Foraminifera from the upper Miocene Modelo formation in the eastern Santa Monica Mountains, Los Angeles County, California. The Modelo formation which yielded the Foraminifera belongs to KLEINPELL's Mohnian stage. He stated that this Mohnian Foraminifera are characterized by the following more abundant and characteristic genera; *Bolivina*, *Uvigerina*, *Epistominella*, *Cassidulina*, *Bulimina*, and allied genera. Therefore, from a comparison based on the abundant genera the Mohnian microfauna seems to be similar to that of the type Fujinan, *Uvigerina subperegrina-Epistominella pulchella* zone in the present paper, although the species common between both microfaunas are only the following abundant five forms; *Uvigerina subperegrina* Cushman and Kleinpell, *Uvigerina hootsi* Rankin, *Eponides frigidus* (Cushman), *Pullenia salisburyi* R. E. and K. C. Stewart, and *Globigerina bulloides* d'Orbigny.

Finally it is to be added that if a correlation is attempted between the microfaunal units of West Honshû, Japan with the stages established by R. M. KLEINPELL and recognized by American paleontologists and geologists, the opinion is expressed that the one given above may serve as a working basis. It is well understood by the writer that additional data from other parts of Japan are of prime importance to strengthen the expressed view on inter-regional correlation and it is hoped that mutual cooperation will lead to the establishment of a more fine-cut result.

H. Remarks on the Distribution of the West Honshû Miocene Smaller Foraminifera in the Regions Other than the Pacific

Although no attempt is made to correlate the time-rock units established in West Honshû, Japan with those developed in regions other than the Pacific, it may be of interest to know where they have been reported from. For this reason the writer merely abridges the lithological units of regions outside of the Pacific area from where species identical with the West Honshû Miocene have been reported. The result is that there are many Miocene cosmopolitan species now extinct in the present seas but common in the remote regions mentioned. Whether these have value for inter-regional correlation is a problem to be settled by the universal cooperation of geologists and paleontologists.

In the Caribbean Sea coast, C. D. REDMOND (1953) recorded and illustrated 83 species and varieties of upper and middle Miocene Foraminifera from the Tubara beds of northern Colombia. Of the 83 species the following six occur from the West Japan Miocene;

Amphistegina lessonii d'Orbigny
Dyocibicides biserialis Cushman and Valentine
Lagena laevis (Montagu)
Nonion grateloupi (d'Orbigny)
Planulina wuellerstorfi (Schwager)
Rotalia beccarii (Linnaeus)

As an example from the Atlantic coast side, D. S. MALKIN (1953) treated the Ostracoda and the Foraminifera from the middle and upper Miocene beds of New Jersey, Maryland, and Virginia, North America. Of these Foraminifera, the following seven species are in common with those from Japan;

Angulogerina occidentalis (Cushman)
Bolivina marginata Cushman
Bulimina ovata d'Orbigny
Cibicides floridanus (Cushman)
Cibicides lobatulus (Walker and Jacob)
Guttulina problema d'Orbigny
Nonionella miocenica Cushman

H. N. CORYELL and F. C. RIVERO (1940) recorded and illustrated 111 species of the Foraminifera from the middle Miocene formation of Haiti at Port-au-Prince, West Indies. Of the determined species the following 14 also occur in the middle Miocene West Japan microfauna;

Amphistegina lessonii d'Orbigny
Bulimina inflata Seguenza
Cibicides floridanus (Cushman)
Eponides praecinctus (Karrer)
Eponides umbonatus (Reuss)
Lagena striata (d'Orbigny)
Nodosaria radicula (Linnaeus)
Nodosaria vertebralis (Batsch)
Nonion pompilioides (Fichtel and Moll)
Planulina wuellerstorfi (Schwager)
Pyrgo murrhina (Schwager)
Robulus calcar (Linnaeus)
Sigmoilina schlumbergeri Silvestri
Textularia lythostrota (Schwager)

R. SAID and M. A. BASIOUNT (1958) recorded 68 species of Miocene Foraminifera from the Suez region, Egypt. Of the determined species the following seven occur in the present Miocene fauna;

Bulimina ovata d'Orbigny
Cancris auriculus (Fichtel and Moll)
Cassidulina subglobosa Brady
Cibicides refulgens (Montfort)
Globigerina bulloides d'Orbigny
Gyroidina soldanii d'Orbigny
Nonion scaphum (Fichtel and Moll)

Thus, from the few examples showing the cosmopolitan distribution of the smaller Foraminifera which have been discriminated from the West Honshû Miocene, it may be possible that their discovery from regions situated closer geographically may lead to the construction of a detail inter-relationship of the microfaunas of the now remote regions mentioned. There always arises the question of whether such cosmopolitan species have any important bearing on inter-regional correlation because they generally include species having rather long geological range. However, it is thought probable that faunal assemblages or their associations as related with the cosmopolitan species may, if worked out with mutual cooperation, will eventually lead to the gaining of a more comprehensible knowledge with regard to the said problem.

CHAPTER V

DESCRIPTIONS OF NEW SPECIES

Family Lituolidae
Subfamily Lituolinae
Genus ***Cyclammina*** H. B. Brady, 1876
Cyclammina ezoensis okuharai Tai, n. subsp.
Pl. 40, figs. 1 a–c.

Test much compressed, nearly circular, somewhat asymmetrical in peripheral view, periphery acute, umbilical area depressed, much evolute; 17–15 chambers in last whorl, increasing gradually in size as added; sutures slightly depressed, sigmoid; wall coarsely arenaceous; aperture a curved slit at base of apertural face, with supplementary pores. Diameter up to 2.07 mm.

Holotype: Road side cutting at Kuchitagi, Taki-mura, Hinokawa-gun, Shimane Prefecture. Lat. 35°15′27″ N., long. 132°34′59.4″ E. Omori Formation, Miocene. IGMSH* coll.

Occurrence: Rare, found from the hard black shale facies of the Omori formation. Table XXXIII (Upper Iwami-Otan Stage).

Remarks: This subspecies is similar to *Cyclammina ezoensis* Asano, but differs from it by having a larger number of chambers in last whorl, sigmoid sutures, much compressed test, much evolute coil at the umbilical region, and asymmetrical shape in peripheral view. It is also distinguished from *Cyclammina japonica* Asano by the much compressed test and much evolute coil at the umbilical region. Further, it is distinguished from *Cyclammina incisa* (Stache) by a larger number of chambers in last whorl and much evolute coil at the umbilical region.

Family Verneuilinidae
Genus ***Gaudryina*** d'Orbigny, 1839
Gaudryina imamurai Tai, n. sp.
Pl. 39, figs. 1 a–b.

Test slightly longer than broad, tapering abruptly at the triserial acutely angled initial end, later and larger portions subquadrangular in transverse section; chambers of triserial portion small, no inflated, but later biserial ones very large and rather inflated; sutures fairly distinct, oblique, somewhat depressed; wall coarsely arenaceous, but sometimes smooth; aperture narrow, in a shallow sinus at base of inner margin of last chamber. Length up to 0.98 mm.

Holotype: Road side cutting at Takuno, Nima-machi, Ota City, Shimane Prefecture.

* IGMSH- Abbreviation for Institute of Geology and Mineralogy, Faculty of Science, Hiroshima University.

Lat. 35°9′38″ N., long. 132°24′37.4″ E. Kawai Formation, Miocene. IGMSH coll.

Occurrence: Common, found from the siltstone facies of the Kawai formation. Table XXI (Middle Miyoshian Stage).

Remarks: This species is very similar to *Gaudryina karihaensis* Asano, but differs from it by the subquadrangular shape in transverse section of later and biserial portions of test. It also is similar to *Gaudryina yabei* Asano, but differs from it by the same features just mentioned and the position of the aperture.

Gaudryina takunoensis Tai, n. sp.
Pl. 39, figs. 2a–b.

Test short and stout, early triserial portion very small and sometimes indistinct, later biserial portion large; chambers much inflated, increasing rather gradually in size as added; sutures depressed, nearly horizontal or very slightly oblique to axis; wall coarsely arenaceous and roughly finished; aperture narrow, in a shallow sinus at base of inner margin of last chamber. Length up to 0.68 mm.

Holotype: Road side cutting at Takuno, Nima-machi, Ota City, Shimane Prefecture. Lat. 35°9′38″ N., long. 132°24′37.4″ E. Kawai Formation, Miocene. IGMSH coll.

Occurrence: Very abundant, found from the siltstone facies of the Kawai formation. Table XXI (Middle Miyoshian Stage).

Remarks: This species is similar to *Gaudryina ogasaensis* Asano, but differs from it in the nearly horizontal sutures, much inflated chambers, and the subcircular shape in end view. It also is similar to *Gaudryina karihaensis* Asano, and *G. yabei* Asano, but differs from them in the shape of test and the position of the aperture.

Family Valvulinidae
Subfamily Eggerellinae
Genus ***Karreriella*** Cushman, 1933
Karreriella tanabensis Tai, n. sp.
Pl. 39, figs. 3a–b.

Test short and stout, about twice as long as broad, broadest at apertural end, nearly circular in cross section; earliest coil with 4 or more chambers, but sometimes indistinct, later triserial, then biserial chambers somewhat inflated; sutures somewhat depressed, nearly horizontal; wall rather coarsely arenaceous; aperture terminal, with distinct neck. Length up to 0.85 mm.

Holotype: Road cliff at Mori, Tanabe City, Wakayama Prefecture. Lat. 33°43′15″ N., long. 135°24′2.4″ E. Asso Formation, Miocene. IGMSH coll.

Occurrence: Very abundant, found from the hard black shale facies of the Asso formation. Table XXXI (Younger Miyoshian Stage).

Remarks: This species is similar to *Dorothia subrotundata* (Schwager), but differs from it by having aperture with a distinct neck.

Family Miliolidae
Genus ***Triloculina*** d'Orbigny, 1826
Triloculina okamotoi Tai, n. sp.
Pl. 39, figs. 4a–b.

Test slightly shorter than broad, periphery sharply angled, triangular in cross section; chambers inflated; sutures slightly depressed; aperture circular, with a bifid tooth. Length up to 1.04 mm.

Holotype: Road side cutting at Takuno, Nima-machi, Ota City, Shimane Prefecture. Lat. 35°9′38″ N., long. 132°24′37.4″ E. Kawai Formation, Miocene. IGMSH coll.

Occurrence: Common, found from the siltstone facies of the Kawai formation. Table XXI (Middle Miyoshian Stage).

Remarks: This species is similar to *Triloculina tricarinata* d'Orbigny, but differs from it by having inflated chambers.

Family Lagenidae
Subfamily Nodosariinae
Genus ***Robulus*** Montfort, 1808
Robulus izumoensis Tai and Okamoto, n. sp.
Pl. 39, figs. 5a–b.

Test subcircular in outline, compressed, involute; periphery with a thin, very broad keel; chambers about 5–6 in last whorl; umbonal area abruptly raised, sutures distinct, curved; wall smooth; aperture radiate with a ventral slit. Diameter up to 1.51 mm.

Holotype: Cliff along the Hiebara River in Nojiri south of Izumo City, Shimane Prefecture. Lat. 35°17′6″ N., long. 132°48′16.4″ E. Kawai Formation, Miocene. IGMSHcoll.

Occurrence: Common, found from a black shale facies of the Kawai and Kuri formations, south of Izumo City, Shimane Prefecture. Table XV (Middle and Upper Miyoshian Stage). Also from a fine-grained sandstone facies of the Toyoda formation in Fujiwara, south of Nara City, Nara Prefecture. Table XIII (Upper Miyoshian Stage).

Remarks: This species is similar to *Robulus yoshitakiensis* Chiji and Nakaseko, but differs from it by lacking a stellate pattern in the central portion of the test and the rhomboid shape of test in side view. This species was previously recorded as a manuscript name, *Robulus izumoensis* n. sp. (MS) (Table XV) and also recorded by the writer under the name of *Robulus* n. sp. α (Table XIII), and here the opportunity is taken to describe and figure it.

Genus ***Planularia*** Defrance, 1824
Planularia yokoii Tai, n. sp.
Pl. 40, figs. 2a–b.

Test much compressed, elongate; in earlier chambers surface ornamented with few

longitudinal sharply raised costae obliquely continuous across sutures and extending into later chambers; earliest chambers closely coiled, later ones becoming elongate; sutures strongly limbate; peripheral margin with a thin keel; wall smooth; aperture radiate, terminal. Length up to 0.38 mm.

Holotype: Cutting cliff at Shuku, Hiyoshi-mura, Toki-gun, Gifu Prefecture. Lat. 35°24′15″ N., long. 137°15′31.4″ E. Shukunohora Formation, Miocene. IGMSH coll.

Occurrence: Few, only found from a fine-grained sandstone facies of the Shukunohora formation. Table XVI (Middle Miyoshian Stage).

Remarks: This species is very similar to *Planularis tricarinella* (Reuss), but differs from it by having few distinctly raised longitudinal costae on the surface of the earlier chambers. This species was previously recorded by the writer under the name of *Planularia* n. sp. (Table XVI) and here the opportunity is taken to describe and figure it.

Genus ***Marginulina*** d'Orbigny, 1826

Marginulina mukaei Tai and Okamoto, n. sp.

Pl. 41, figs. 4a–b.

Test short, stout, nearly twice as long as broad, early chambers closely coiled, the later few uncoiled chambers increasing greatly in size as added, finally the last chamber rapidly becomes largest in size and much inflated, occupying about two-thirds of the test, covering the earlier chambers; sutures somewhat depressed; wall smooth; aperture radiate. Length up to 0.47 mm.

Holotype: Cliff along the Hiebara River in Nojiri south of Izumo City, Shimane Prefecture. Lat. 35°17′6″ N., long. 132°48′16.4″ E. Kawai Formation, Miocene. IGMSH coll.

Occurrence: Very abundant, found from a black shale facies of the Kawai and Kuri formations. Table XV (Middle and Upper Miyoshian Stage).

Remarks: This species is very similar to *Marginulina glabra* d'Orbigny, but differs from it by the characters of the last chamber. This species was previously recorded as a manuscript name, *Marginulina mukaei* n. sp. (MS), (Table XV) and here it is described and figured.

Family Nonionidae

Genus ***Nonion*** Montfort, 1808

Nonion mizunamiense Tai, n. sp.

Pl. 40, figs. 4a–b.

Test broadly oval, bilaterally symmetrical; about 5–6 chambers in last whorl, later ones slightly inflated; periphery broadly rounded; umbilical region rather depressed; sutures distinct, gently curved; wall somewhat coarsely perforate; aperture a narrow slit at base of apertural face. Diameter about 0.22 mm., thickness about 0.15 mm.

Holotype: Road cliff at Togari, Mizunami City, Gifu Prefecture. Lat. 35°22′14″ N., long. 137°14′31.4″ E. Yamanouchi Formation, Miocene. IGMSH coll.

Occurrence: common, found from a tuffaceous sandy siltstone facies of the Yamanouchi formation. Table XVI (Togarian Stage).

Remarks: This species seems to be restricted to the Togarian stage. This is similar to *Elphidium sendaiense* Takayanagi, but differs from it by having fewer chambers in last whorl, by lacking septal pores above the suture and by the characters of the aperture. This species was previously recorded by the writer as a manuscript name, *Elphidium* n. sp. B, (Table XVI) and here it is described and figured.

Nonion shukuense Tai, n. sp.
Pl. 41, figs. 1a–b.

Test planispiral, bilaterally symmetrical, entirely involute except that umbilical areas are deeply excavated; periphery very broadly rounded; 6–7 chambers in last whorl; sutures flush with surface, generally limbate; wall smooth, coarsely perforate; small subrounded aperture at central position of base of broad apertural face. Diameter about 0.28 mm., thickness about 0.16 mm.

Holotype: Cutting cliff at Shuku, Hiyoshi-mura, Toki-gun, Gifu Prefecture. Lat. 35°24′15″ N., long. 137°15′31.4″ E. Oidawara Formation, Miocene. IGMSH coll.

Occurrence: Common, found from a mudstone facies of the Oidawara formation. Table XVI (Middle Miyoshian Stage)

Remarks: This species is very similar to *Nonion pompilioides* (Fichtel and Moll), but differs from it by having a small subrounded aperture on the apertural face. This species was previously recorded by the writer as a manuscript name, *Nonion* n. sp., (Table XVI) and here it is described and figured.

Genus ***Pseudononion*** Asano, 1936
Pseudononion hashimotoi Tai, n. sp.
Pl. 41, figs. 2a–c.

Test asymmetrical, not depressed, dorsal side slightly convex with all whorls visible, ventral side with only last whorl visible; periphery broadly rounded; chambers distinct, about 6–7 in last whorl; sutures distinct, slightly depressed, gently curved; wall finely perforate; aperture a narrow slit at base of apertural face. Diameter about 0.24 mm., thickness about 0.13 mm.

Holotype: Road cliff of Togari, Mizunami City, Gifu Prefecture. Lat. 35°22′14″ N., long. 137°14′31.4″ E. Yamanouchi Formation, Miocene. IGMSH coll.

Occurrence: Common, found from a tuffaceous sandy siltstone facies of the Yamanouchi formation. Table XVI (Lower Togarian Stage).

Remarks: This species is similar to *Pseudononion japonicum* Asano, but differs from it

in the shape of the test and by having a fewer number of chambers in last whorl. This species was previously recorded by the writer as a manuscript name, *Pseudononion* n. sp., (Table XVI) and here it is described and figured.

Family Buliminidae
Subfamily Bulimininae
Genus ***Bulimina*** d'Orbigny, 1826
Bulimina imamurai Tai, n. sp.
Pl. 40, fig. 3.

Test slightly longer than broad, strongly tapering, consisting of about 2–3 whorl; chambers distinct, inflated, somewhat globular, later chambers increasing rapidly in size; sutures distinct, depressed; wall smooth; aperture loop-shaped, with a lip. Length up to 0.3 mm.

Holotype: 121.3 meters in depth of the boring well at Nishitakasaki, Nadazaki-machi, Kojima-gun, Okayama Prefecture. Lat. 34°32′45″ N., long. 133°53′32.4″ E. Upper Bihoku Group, Miocene. IGMSH coll.

Occurrence: Very abundant, found from a black shale facies of the Bihoku group, at a depth of 130–80 meters of the boring well. Table XVII (Middle and Upper Miyoshian Stage). This one also is found from a sandstone facies of the upper part of the Matsue formation, Matsue City, Shimane Prefecture. Table XXVI (Upper Unnamed "Lower Pliocene" Stage).

Remarks: This species is similar to *Bulimina nojimaensis* Asano, but differs from it by lacking spines at the base of earlier chambers.

Bulimina okayamaensis Tai, n. sp.
Pl. 41, figs. 3a–b.

Test elongate, nearly three times as long as broad, consisting of 5–7 whorl; chambers distinct, inflated; sutures distinct, depressed, running at right angles to axis of test; wall smooth, finely perforate; aperture loop-shaped, with a lip. Length up to 0.58 mm.

Holotype: 121.3 meters in depth of the boring well at Nishitakasaki, Nadazaki-machi, Kojima-gun, Okayama Prefecture. Lat. 34°32′45″ N., long. 133°53′32.4″ E. Upper Bihoku Group, Miocene. IGMSH coll.

Occurrence: Very abundant, found from a black shale facies of the upper Bihoku group, at a depth of 130-80 meters of the boring well. Table XVII (Middle and Upper Miyoshian Stage).

Remarks: This species is similar to *Bulimina pupoides* d'Orbigny, but differs from it by the shape of the elongate test and each chamber.

Subfamily Virgulininae
Genus ***Bolivina*** d'Orbigny, 1839
Bolivina hongoensis Tai, n. sp.
Pl. 40, figs. 5a–b.

Test about twice as long as broad, almost oval in transverse section; chambers distinct, slightly broader than high, arranged biserially; sutures distinct, straight, running at right angles to axis of test, making only a very small angle with the horizontal in the early portion, marked by strongly raised irregular parts of the shell, projecting somewhat at the peripheral margins; wall calcareous, coarsely perforate; aperture oval at the base of the last-formed chamber. Length up to 0.39 mm.

Holotype: Road cliff at Hongô, Tetsuta-machi, south of Niimi City, Okayama Prefecture. Lat. 34°55′36″ N., long. 133°28′4.4″ E. Upper Bihoku Group, Miocene. IGMSH coll.

Occurrence: Common, found from a black shale facies of the upper Bihoku group. Table VIII (Middle Miyoshian Stage).

Remarks: This species is similar to *Bolivina crassiseptata* Marks, from the upper middle Miocene of Austria, but differs from it by having the chambers not inflated. This species was previously recorded by the writer as a manuscript name, *Siphotextularia* n. sp., (Table VIII) and here it is described and figured.

Family Rotaliidae
Subfamily Rotaliinae
Genus ***Eponides*** Montfort, 1808
Eponides naraensis Tai, n. sp.
Pl. 42, figs. 1a–c.

Test biconvex, somewhat compressed, central portion of dorsal and ventral sides inflated with last whorl thinner; about 10 or more short and strongly retroverted chambers in last whorl; sutures distinct, strongly curved, not depressed; periphery extended into a distinct marginal keel variable in width; aperture a short rounded opening at ventral border of last chamber. Diameter up to 0.34 mm.

Holotype: Cliff of the Fujiwara Rifle-Range, south of Nara City, Nara Prefecture. Lat. 34°39′2″ N., long. 135°51′9.4″ E. Toyoda Formation, Miocene. IGMSH coll.

Occurrence: Very rare, only found from a fine-grained sandstone facies of the Toyoda formation, the upper division of the Fujiwara group. Table XIII (Middle Miyoshian Stage).

Remarks: This species is similar to *Eponides vortex* Galloway and Heminway, but differs from it by having a distinct marginal keel and by lacking an umbo at the central portion of ventral side. This species was previously recorded by the writer as a manuscript name, *Eponides* n. sp. β, (Table XIII) and here it is described and figured.

Family Cassidulinidae
Subfamily Cassidulininae
Genus ***Cassidulina*** d'Orbigny, 1826
Cassidulina imamurai Tai, n. sp.
Pl. 42, figs. 2a–b.

Test small, somewhat compressed, periphery broadly rounded, about 4–5 pairs of chambers making up the last whorl, diameter about twice the thickness in side view; chambers distinct, somewhat inflated, broad; sutures fairly distinct, somewhat depressed; wall smooth, umbonal region a stellate translucent area; aperture short and broad, in center of base of apertural face. Diameter up to 0.47 mm.

Holotype: 110.8 meters in depth in a boring well at Nishitakasaki, Nadazaki-machi, Kojima-gun, Okayama Prefecture. Lat. 34°32′45″ N., long. 133°53′32.4″ E. Upper Bihoku Group, Miocene. IGMSH coll.

Occurrence: Very abundant, found from the upper shale facies of the Bihoku group. Table XVII (Middle and Upper Miyoshian Stage).

Remarks: This species is similar to *Cassidulina margareta* Karrer, but differs from it by the distinct stellate translucent area in the umbonal region.

Family Anomalinidae
Subfamily Anomalininae
Genus ***Anomalina*** d'Orbigny, 1826
Anomalina kojimaensis Tai, n. sp.
Pl. 42, figs. 3a–b.

Test planispiral, biconvex, periphery bluntly rounded; about 14 chambers in last whorl, slightly more than one whorl visible dorsally, umbilical region usually raised, with clear shell material; sutures strongly limbate, slightly curved; wall distinctly perforate; aperture a narrow slit extending slightly to the ventral side. Diameter up to 0.49 mm.

Holotype: 100 meters in depth in a boring well, at Nishitakasaki, Nadazaki-machi, Kojima-gun, Okayama Prefecture. Lat. 34°32′45″ N., long. 133°53′32.4″ E. Upper Bihoku Group, Miocene. IGMSH coll.

Occurrence: Very rare, only found from the upper shale facies of the Bihoku group. Table XVII (Middle Miyoshian Stage).

Remarks: This species is similar to *Anomalina nipponica* Asano and Inomata, but differs from it by lacking a marginal keel and by having a larger number of chambers in last whorl. This is also similar to *Anomalina glabrata* Cushman, but differs from it by having distinctly limbate sutures.

Genus ***Planulina*** d'Orbigny, 1826
Planulina asanoi Tai, n. sp.
Pl. 43, figs. 1a–c.

Test much compressed, early stage trochoid, later ones spread out, periphery angled,

ventral side somewhat convex, dorsal side nearly flat or rather concave; chambers 7–8 in last whorl, narrow, strongly retroverted; sutures distinct, strongly limbate, curved very thick, raised and retroverted; wall rather finely perforate; aperture at periphery, with a slight lip. Diameter up to 0.23 mm.

Holotype: Cliff at Shuku, Hiyoshi-mura, Toki-gun, Gifu Prefecture. Lat. 35°24′15″ N., long. 137°15′31.4″ E. Oidawara Formation, Miocene. IGMSH coll.

Occurrence: Common, found from a tuffaceous mudstone facies of the Oidawara formation. Table XVI (Middle Miyoshian Stage).

Remarks: This species is similar to *Planulina wuellerstorfi* (Schwager), but differs from it by having a larger number of chambers in last whorl and by the sutures being very thick, raised and retroverted on the test. This species was previously recorded by the writer as a manuscript name, *Planulina* n. sp., (Table XVI) and here it is described and figured.

Subfamily Cibicidinae,
Genus ***Cibicides*** Montfort, 1808
Cibicides dogoensis Tai, n. sp.
Pl. 43, figs. 2a–c.

Test strongly plano-convex, periphery acute; 4 to 5 chambers in lest whorl, all chambers visible from flattened side, those of last whorl only visible from convex side; sutures distinct, very thick limbate, curved and raised; wall rather coarsely perforate; umbilical region filled with a rounded large mass of shell material; aperture a narrow curved slit on periphery, with a slight lip. Diameter up to 0.23 mm.

Holotype: Road side cutting at Tsuma, Tsuma-mura, Suki-gun, Dôgo, Oki Islands, Shimane Prefecture. Lat. 36°11′15.5″ N., long. 133°14′30″ E. Dôgo Formation, Miocene. IGMSH coll.

Occurrence: Abundant, found from the sandstone facies of the Dôgo formation. Table IV (Middle Fujinan Stage).

Remarks: This species is similar to *Cibicides refulgens* (Montfort), but differs from it by the character of the umbilical region of the test. This species was previously recorded by the writer as a manuscript name, *Cibicides* n. sp., (Table IV) and here it is described and figured.

Cibicides shukuensis Tai, n. sp.
Pl. 43, figs. 3a–c.

Test plano-convex, dorsal side flattened or even concave, ventral side very convex, periphery acute, 14–15 chambers in last whorl, earlier chambers somewhat indistinct on dorsal side; sutures distinct, very thick limbate, curved and somewhat depressed on ventral side; wall rather coarsely perforate; aperture peripheral, narrow slit at

base of last chamber. Diameter up to 0.6 mm.

Holotype: Cutting cliff at Shuku, Hiyoshi-mura, Toki-gun, Gifu Prefecture. Lat. 35°24′15″ N., long. 137°15′31.4″ E. Oidawara Formation, Miocene, IGMSH coll.

Occurrence: Very rare, only found from a tuffaceous mudstone facies of the Oidawara formation. Table XVI (Middle Miyoshian Stage).

Remarks: This species is similar to *Cibicides refulgens* (Montfort), but differs from it by the characters of the sutures on the dorsal side and by having a larger number of chambers in last whorl. This is also similar to *Cibicides dogoensis* Tai, but differs from it by having a larger number of chambers in last whorl and by lacking rounded shell material in the umbilical area. This was previously recorded by the writer as a manuscript name, *Cibicides* n. sp., (Table XVI) and here it is described and figured.

BIBLIOGRAPHY

ASANO, K., (1939): Pliocene (Upper Mizuho) Foraminifera from Japan: *Jour. Geol. Soc. Japan*, vol. 46, pp. 155-168 (in Japanese).

_____, (1949): New Miocene Foraminifera from Japan: *Jour. Paleont.*, vol. 23, no. 4, pp. 423-430, 2 text-figs.

_____, (1950-1952): Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera: pts. 1-15 and supplement 1.

_____, (1953a): Miocene Foraminifera from the Honya Shale, Jôban Coal-field: *Trans. Proc. Palaeont. Soc. Japan*, n. s. no. 11, pp. 55-59, 11 text-figs.

_____, (1953b): Miocene Foraminifera from the Noto Peninsula, Ishikawa Prefecture: *Short Papers*, IGPS, no. 5, pp. 1-12, pls. 1-3.

_____, (1953c): Miocene Foraminifera from the Shintotsugawa Area, Kabato-gun, Hokkaidô: *Trans. Proc. Palaeont. Soc. Japan*, n. s. no. 10, pp. 45-54, 18 text-figs.

CHIJI, M., (1955): On the Microbiostratigraphy of the Yatsuo Group in the Yatsuo District of Toyama Prefecture: *Jour. Geol. Soc. Japan*, vol. 61, pp. 162-172 (in Japanese).

_____, and NAKASEKO, K., (1950): New Species of Neogene Foraminifera from the Toyama Basin, Japan: *Jour. Geol. Soc. Japan*, vol. 56, pp. 519-522.

CORYELL, H. N., and RIVERO, F. C., (1940): A Miocene Microfauna of Haiti: *Jour. Paleont.*, vol. 14, no. 4, pp. 324-344, pls, 41-44.

CUSHMAN, J. A., (1934): Smaller Foraminifera from Vitilevu, Fiji: *Bernice P. Bishop Mus.*, Bull. 119, pp. 102-142, pls. 10-18.

FENTON, C. L., and FENTON, A. F., (1928): Ecologic Interpretation of Some Biostratigraphic Terms: *Am. Midland Natur.*, vol. 11, no. 1, pp. 1-23.

FUJIOKA, K., (1956): Studies on the "Green Tuffs": "*Kugaku*" (*Science*), vol. 26, pp. 440-446 (in Japanese).

FUJITA, K., and OGOSE, S., (1950): Lithologic Classification of the Cenozoic Strata in the Northern Area of Mizunami-machi, Toki-gun, Gifu Prefecture, Japan: *Jour. Geol. Soc. Japan*, vol. 56, pp. 481-492 (in Japanese).

_____, (1951): Ibid. (Continued): Ibid. vol. 57, pp. 99-110 (in Japanese).

FUJITA, Y., and ITÔ, S., (1957): A Study of the Foraminiferal Assemblages from the Miocene Formation, Date District, Fukushima Prefecture, Japan: *Jour. Geol. Soc. Japan*, vol. 63, pp. 497-513 (in Japanese).

FUKUTA, O., and SHINOKI, R., (1952): Stratigraphical and Micropaleontological Study of the Nishikatsura Group: *Jour. Geol. Soc. Japan*, vol. 58, pp. 191-202, 1 pl. (in Japanese).

GLAESSNER, M. F., (1943): Problems of Stratigraphical Correlation in the Indo-Pacific Region: *Proc. Roy. Soc. Victoria*, 55 (n. s.), pt. 1, pp. 41-80, table 1.

HANZAWA, S., (1932): Localities of *Operculina* and *Miogypsina* in Japan: *Jour. Geol. Soc. Tôkyô*, vol. 39, pp.

723-724 (in Japanese).
_____, (1935): Some Fossil *Operculina* and *Miogypsina* from Japan, and Their Stratigraphical Significance: *Sci. Rep. Tohoku Imp. Univ.*, ser. 2, vol. 18, no. 2, pp. 1-29, pls. 1-3.
_____, (1947): Check List of Tertiary Larger Foraminifera of Japan: *Jour. Paleont.*, vol. 21, pp.563-569.
IKEBE, N., (1948): On "Letter Nomination" of the Japanese Cenozoic: *Jour. Assoc. Geol. Collaboration*, vol. 2, no. 2, pp. 1-12 (in Japanese).
_____, (1949): Tertiary Stratigraphy of Western Toyama and Eastern Ishikawa Prefecture: *Sci. Earth*, vol. 1, pp. 14-26 (in Japanese).
_____, (1954): Cenozoic Biochronology of Japan: *Jour. Inst. Polytech. Osaka City Univ.*, ser. g, vol. 1, pp. 73-86.
_____, (1956): Cenozoic Geohistory of Japan: *Proc. 8th Pac. Sci. Congr.*, vol. 2, pp. 446-454.
_____, (1957): Cenozoic Sedimentary Basins in Japan: *Cenozoic Research*, no. 24-25, pp. 1-10 (in Japanese).
_____, et al(1947): Correlation of the Cenozoic Formations in Japan Using the "Letter Classification": *Jour. Geol. Soc. Japan*, vol. 53, pp. 90-91 (in Japanese).
IMAMURA, S., (1931): On the Occurrence of *Operculina* near Yatsuo, Toyama: *Jour. Geol. Soc. Tôkyô*, vol. 38, pp. 541-542 (in Japanese).
_____, (1951): Tertiary Formations in the Western Part of San'in District: *Jour. Geol. Soc. Japan.* vol. 57, p. 307 (in Japanese).
_____, (1957): New Miocene *Sassafras* from Shimane Prefecture: *Jour. Sci. Hiroshima Univ.*, ser. c, vol. 2, pp. 53-61 (in Japanese).
_____, and TAI, Y., (1950): Outline of the Tertiary Formations in the Northern Part of Hiroshima Prefecture: *Jour. Geol. Soc. Japan*, vol. 56, pp. 299-300 (in Japanese).
IMAMURA, S., et al (1952): Geotectonic Movement and Volcanism of the Later Cenozoic Era in Chûgoku District: *Jour. Geol. Soc. Japan*, vol. 58, pp. 346-347 (in Japanese).
_____, (1953): Geology of Kamine, Funasa, Miyoshi, Mirasaka, Shôbara, and Shôkôzan: *Inst. Geol. Miner. Fac. Sci. Hiroshima Univ. Guide-book* (in Japanese).
_____, (1954): "Green-Tuff" in the Central-Western Chûgoku District: *Jour. Geol. Soc. Japan*, vol. 60, pp. 288-289 (in Japanese).
_____, (1955): The so-called "Green-Tuff" in the San'in Province: *Jour. Geol. Soc. Japan*, vol. 61, p. 313 (in Japanese).
ISHIDA, S., et al (1954): Cenozoic Formations in Okuyamada, Kyôto Prefecture: *Jour. Geol. Soc. Japan*, vol. 60, pp. 160-166 (in Japanese).
IWASA, S., (1955): Biostratigraphy of the Ishizawagawa Group in Honjô and Its Environs, Akita Prefecture: *Jour. Geol. Soc. Japan*, vol. 61, pp. 1-18 (in Japanese).
_____, and KIKUCHI, Y., (1954): Foraminifera from the Sugota Formation, Akita Prefecture, Japan: *Trans.Proc. Palaeont. Soc. Japan*, n. s., no. 16, pp. 183-194, 8 text-figs.
KANAYA, T., (1957): Eocene Diatom Assemblages from the Kellog and "Sidney" Shales, Mt. Diablo Area, California: *Sci. Rep. Tohoku Univ.*, ser. II, vol. 28, pp. 27-124, 6 pls.
KLEINPELL, R. M., (1938): Miocene Stratigraphy of California: *Tulsa, Oklahoma, Am. Assoc. Petrol. Geol.*, 450 pp., 22 pls., 14 figs, 18 tables.
LEROY, L. W., (1941): Small Foraminifera from the Late Tertiary of the Nederlands East Indies: *Quart. Colorado Sch. Min.*, vol. 36, no. 1, pp. 1-132.
_____, (1944): Miocene Foraminifera from Sumatra and Java, Nederlands East Indies: *Quart. Colorado. Sch. Min.*, vol. 39, no. 3, pp. 1-113.
MAKIYAMA, J., (1931): Tertiary Formations in the Southern District of Nara City: *Chikyû* (*The Globe*), vol. 15, no. 1, pp. 46-56 (in Japanese).
_____, (1939): The Neogenic Stratigraphy of the Japan Islands: *Proc. 6th Pac. Sci. Congr.*, pp. 641-649.
_____, (1947): Two Stages of the Middle Miocene in Japan: *Mem. Coll. Sci. Kyôto Univ.*, ser. B, vol. 19, pp. 33-36.
MALKIN, D. S., (1953): Biostratigraphic Study of Miocene Ostracoda of New Jersey, Maryland, and Virginia: *Jour. Paleont.*, vol. 27, pp. 761-799, pls. 78-81, 14 text-figs.

MASUDA, K., (1954): On the Geology of Machino-machi, Najimi-mura, and Yanaida-mura, Fugeshi-gun, Ishikawa Prefecture: *Jour. Geol. Soc. Japan*, vol. 60, pp. 145-152 (in Japanese).

MORISHIMA, M., et al (1949): Micropaleontological Studies on the Tertiary Formations in Western Toyama (Part 1): *Jour. Jap. Assoc. Petr. Tech.*, vol. 14, pp. 2-8 (in Japanese).

MUKAE, M., (1954a): The Miocene in the Southern Area of Izumo City, Shimane Prefecture, Japan: *Jour. Sci. Hiroshima Univ.*, ser. c, vol. 1, pp. 33-50.

_____, (1954b): The Miocene Volcanic Activity in San'in District, Southwestern Japan: *Jour. Sci. Hiroshima Univ.*, ser. c, vol. 1, pp. 51-60.

_____, (1958): Volcanostratigraphical Study on the Miocene Volcanism in the Shimane Prefecture, Japan: *Jour. Sci. Hiroshima Univ.*, ser. c, vol. 2, pp. 129-172.

MURATA, S., (1951): Miocene *Cyclammina* in the Vicinity of Matsue City, Shimane Prefecture: *Jour. Geol. Soc. Japan*, vol. 57, pp. 509-510 (in Japanese).

_____, (1952): Smaller Foraminifera from the Miocene Deposits of the Miyosi and Tuyama Basins, Tyûgoku, West Japan: *Jour. Geol. Soc. Japan*, vol. 58, pp. 491-492 (in Japanese).

NAGAHAMA, M., (1952): Applied Micropaleontological Studies on the Tertiary Formation of the Sekidô Mountainland on the Ishikawa-Toyama Frontier: *Misc. Rep. Res. Inst. Nat. Res.*, no. 25, pp. 46-51 (in Japanese).

NAKASEKO, K., (1952): On the Microbiostratigraphy of the Yokawa Group of the Western "Toyama Basin": *Sci. Rep. Osaka Univ.*, no. 1, pp. 73-79 (in Japanese).

_____, (1953): On the Stratigraphy of the Upper Neogene Formation in the Southern Part of Toyama Prefecture: *Sci. Rep. Osaka Univ.*, no. 2, pp. 87-100 (in Japanese).

_____, (1954): Correction of the Stratigraphy of the Upper Neogene Formation in the Southern Toyama Prefecture: *Sci. Rep. Osaka Univ.*, no. 3, pp. 97-105 (in Japanese).

NISHIWAKI, M., and IMAMURA, S., (1956): On the Neogene Formations in the Environs of Taisei-mura, South-East of Tottori City: *Jour. Geol. Soc. Japan*, vol. 62, p. 390 (in Japanese).

NOMURA, S., and HATAI, K., (1936): Fossil from Yazawagi-mura, Ugo Province, Northeast Honshû, Japan: *Saito M. Res. Bull.*, no. 10, pp. 157-181 (in Japanese).

OGURA, T., (1921): The Geological Map (Scale 1: 75,000) of Shôbara and Its Explanatory Text: *Geol. Surv. Japan* (in Japanese).

OKAMOTO, K., (1959): Neogene Formations in the Area South-East of Izumo City, Shimane Prefecture: *Jour. Geol. Soc. Japan*, vol. 65, pp. 1-11 (in Japanese).

_____, and TAI, Y., (1957): Miocene Smaller Foraminifera from the Tamatsukuri Group in the Area South of Izumo City, Shimane Prefecture: *Jour. Geol. Soc. Japan*, vol. 63, pp. 340-356 (in Japanese).

OKUHARA, M., (1959): Microbiostratigraphic Study of the Neogene Formations in the Area North-East of Ota City, Shimane Prefecture: *Grad. Thes., Inst. Geol. Miner. Hiroshima Univ.* (MS) (in Japanese).

OTSUKA, S., (1895): The Geological Map (Scale 1: 200,000) of Okayama and Its Explanatory Text: *Geol. Surv. Japan* (in Japanese).

OTUKA, Y., (1938): Mollusca from the Miocene of Tyûgoku, Japan: *Jour. Fac. Sci. Imp. Univ. Tôkyô*, sec. 2, vol. 5.

PIERCE, R. L., (1956): Upper Miocene Foraminifera and Fish from the Los Angeles Area, California: *Jour. Paleont.*, vol. 30, pp. 1288-1314, pls. 137-144, 6 text-figs.

REDMOND, C. D., (1953): Miocene Foraminifera from the Tubara Beds of Northern Colombia: *Jour. Paleont.*, vol. 27, pp. 708-733, pls. 74-77, 1 fig.

SAID, R., and BASIOUNT, M. A., (1958): Miocene Foraminifera of Gulf of Suez Region, Egypt: *Bull. Amer. Assoc. Pet. Geol.*, vol. 42, pp. 1958-1977, 5 figs, 1 pl.

SAKAMOTO, T., (1955): Cenozoic Formations in the Southern District of Nara City: *Jour. Geol. Soc. Japan*, vol. 61, pp. 62-72 (in Japanese).

SCHWAGER, C., (1866): Fossile Foraminiferen von Kar Nikobar: *Novara-Exp., Geol. Theil*, 2, pp. 187-268, pls. 4-7.

SHIKAMA, T., (1936):On the Akashi Group: *Jour. Geol. Soc. Japan*, vol. 43, pp. 565-589, pls. 25-27 (in Japanese).

SUZUKI, B., (1896): The Geological Map (Scale 1 : 200,000) of Hamada and Its Explanatory Text: *Geol. Surv. Japan* (in Japanese).

TAI, Y., (1952): Stratigraphy and Geological Structure of the Central Area of Shimane Peninsula, Shimane Prefecture: *Jour. Geol. Soc. Japan*, vol. 58, pp. 573-583 (in Japanese).

———, (1953a): Miocene Foraminifera from the Shôbara Basin, Hiroshima Prefecture: *Jour. Sci. Hiroshima Univ.*, ser. c, vol. 1, no. 3, pp. 1-9.

———, (1953b): Stratigraphy and Geological Structure of the Central Area of Shimane Peninsula, Shimane Prefecture: *Jour. Geol. Soc. Japan*, vol. 59, pp. 93-98 (in Japanese).

———, (1954): Miocene Smaller Foraminifera from the Tsuyama Basin, Okayama Prefecture, Japan: *Jour. Sci. Hiroshima Univ.*, ser . c, vol. 1, no. 4, pp. 1-24, pl. 1.

———, (1955): Micropaleontological Study of the Furue Formation: *Jour. Geol. Soc. Japan*, vol. 61, pp. 407-420 (in Japanese).

———, (1956a): Miocene Smaller Foraminifera from Dôgo, Oki Islands: Ibid. vol. 62, pp. 212-213 (in Japanese).

———, (1956b): On the Microbiostratigraphy of the Cenozoic Strata in Chûgoku and Kinki Districts: *Earth Science* (*Chikyu Kagaku*), no. 30, pp. 9-18 (in Japanese).

———, (1956c): On the Microbiostratigraphy of the Neogene in the Main Areas of Chûgoku and Kinki Districts: *Jour. Geol. Soc. Japan*, vol. 62, p. 381 (in Japanese).

———, (1956d): The Latest Microbiostratigraphical Classification of the Cenozoic Strata in Chûgoku and Kinki Districts: *Foram.*, no. 6, pp. 41-52 (in Japanese).

———, (1957a): Cenozoic Sedimentary Provinces and Their Sequence in Japan-San'in Region: *Cenozoic Research* (*Shinseidai no Kenkyu*), no. 24-25, pp. 20-27 (in Japanese).

———, (1957b): Microbiostratigraphical Study of the Cenozoic Strata of the Western Setouchi Province, Japan: *Geol. Rep. Hiroshima Univ.*, no. 5, pp. 1-58 (in Japanese).

———, (1958): On "the Togarian Stage" -Miocene Microbiostratigraphy of the Setouchi Geologic Province: *Jour. Geol. Soc. Japan*, vol. 64, pp. 516-525 (in Japanese).

———, and URATA, H., (1950): Stratigraphy and Geological Structure of the Northeastern Area of Lake Shinji, Shimane Prefecture: Ibid., vol. 56, p. 300 (in Japanese).

———, et al (1953): The Neogene Strata in the Environs of Matsue City, Shimane Prefecture: Ibid., vol. 59, p. 358 (in Japanese).

TAKAYANAGI, Y., (1952): Foraminifera from the Hatatate Formation in the Sendai Basin: *Short Papers*, IGPS, no. 4, pp. 52-64.

TAKEYAMA, T., (1930a): Geology of the Tsuyama Basin, Mimasaka Province: *Chikyù* (*The Globe*), vol. 14, pp. 91-101 (in Japanese).

———, (1930b): Tertiary Stratigraphy of the Environs of Tanabe, Kii: *Chikyû* (*The Globe*), vol. 13, pp. 92-106 (in Japanese).

TODD, R., (1957): Geology of Saipan, Mariana Islands, Smaller Foraminifera: *Geol. Surv. Profes. Paper*, U. S. A., 280-H, pp. 265-320, pls. 64-93.

TOMITA, T., (1936): Geology of Dôgo, Oki Islands, in the Japan Sea: *Jour. Shanghai Sci. Inst.*, ser. II, vol. 2, pp. 37-146.

———, and SAKAI, E., (1938a): Cenozoic Geology of the Huzina-Kimati District, Izumo Province, Japan: Ibid. pp. 147-204.

———, (1938b): On the Miocene Series in the Vicinity of Matsue City: *Jour. Geol. Soc. Japan*, vol. 45, pp. 529-531 (in Japanese).

TSUSHIMA. K., et al (1954): The Geological Map (Scale 1 : 50,000) of Tomamae and Its Explanatory Text: *Geol. Surv. Japan* (in Japanese).

UCHIO, T., (1950): Tertiary Fossil Fauna from Tochigi Prefecture (1): *Jour. Geol. Soc. Japan*, vol. 56, pp. 455-458 (in Japanese).

WATANABE, K., and IWAHORI, S., (1952): Stratigraphical Studies of the Tertiary Strata in the Toki Basin, Gifu Prefecture: *Jour. Geol. Soc. Japan*, vol. 58, pp. 433-443 (in Japanese).

YABE, H., (1918): Notes on *Operculina*-Rocks from Japan, with Remarks on "*Nummulites*" *cumingi* CARPENTER:

Sci. Rep. Tohoku Imp. Univ., ser. 2, vol. 4, pp. 105–126.

_____, (1935a): New Find of *Miogypsina* in the Tertiary of Mino: *Proc. Imp. Acad. Tôkyô*, vol. 11, pp. 144–145, text-figs. 1–5.

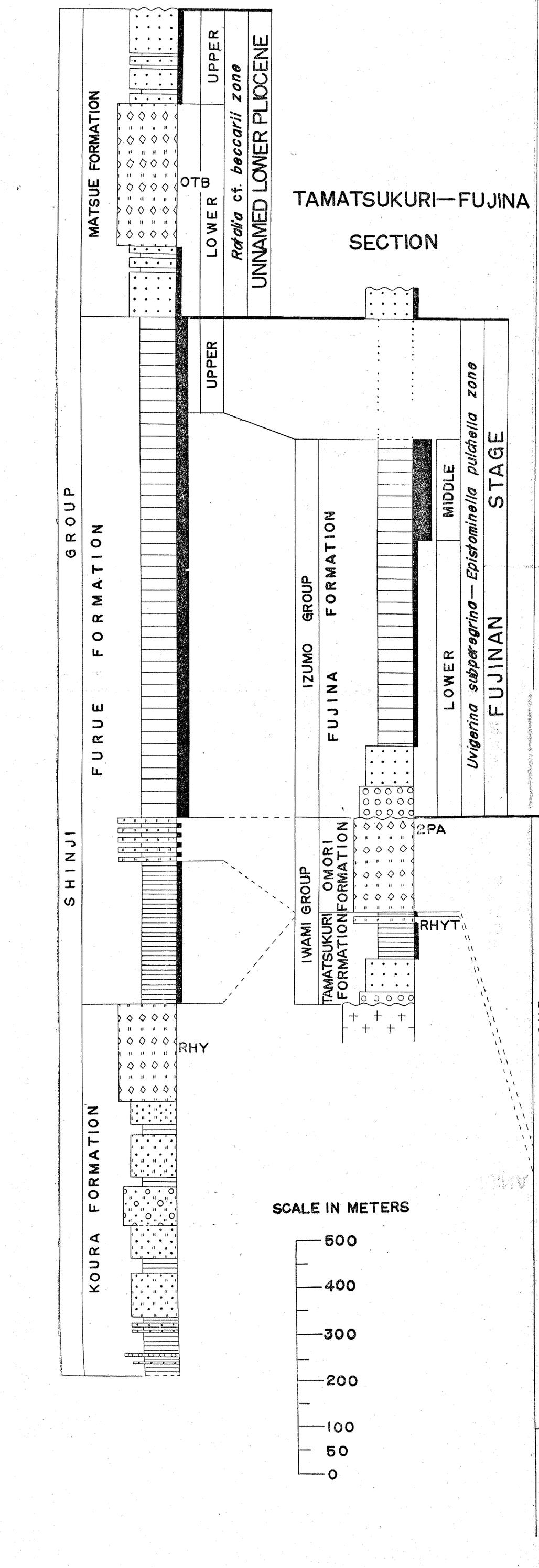
_____, (1935b): The Middle and Lower Mizuho Period: *Contr. Inst. Geol. Paleont. Tohoku Univ.*, no. 12, pp. 1–28 (in Japanese).

_____, and AOKI, R., (1924): Correlation of the Cenozoic Deposits of Japan: *Contr. Inst. Geol. Paleont. Tohoku Univ.*, no. 4, pp. 1–14 (in Japanese).

_____, and MABUCHI, S., (1934): Some Geological Observations in Nariwa District, Bittyû: *Jour. Geol. Soc. Tôkyô*, vol. 41, pp. 161–168 (in Japanese).

YAMAGATA, O., (1957): Geology of the Aterazawa-Oisawa District at the Western Part of the Yamagata Basin: *Bull. Yamagata Univ.* (*Natural Science*), vol. 4, pp. 217–228 (in Japanese).

PL. 37 Columnar sections at type localities of the West Honshû Miocene stages and zones.



LEGEND

MUDSTONE

SHALE

SANDSTONE

CONGLOMERATE

VOLCANIC AND PYROCLASTIC ROCKS

OTB OLIVINE TRACHYBASALT FLOW

2PA TWO PYROXENE ANDESITE FLOW

RHY RHYOLITE FLOW

RHYT RHYOLITIC TUFF

BASEMENT ROCKS

UNCONFORMITY

HORIZONS FROM WHICH FORAMINIFERA YIELD ABUNDANTLY

HORIZONS FROM WHICH FORAMINIFERA YIELD COMMONLY

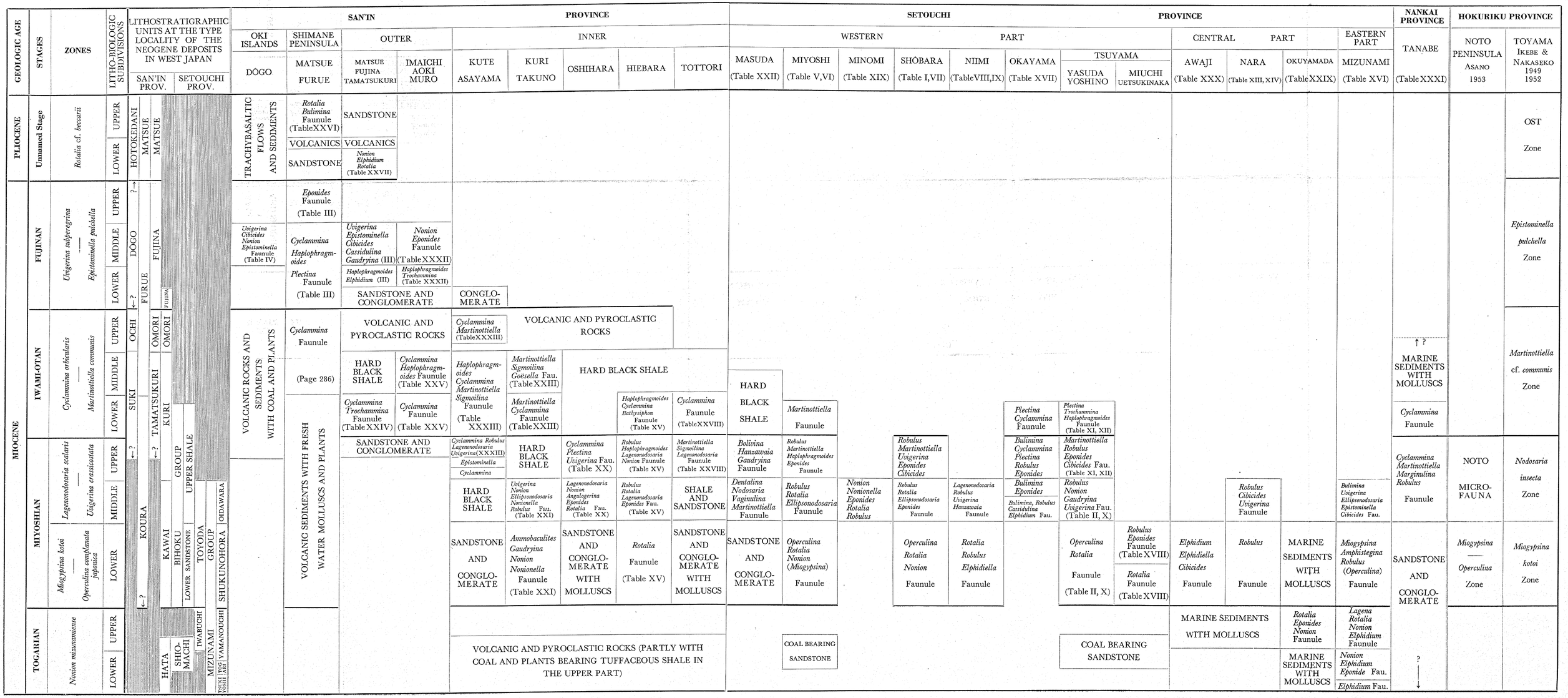
HORIZONS FROM WHICH FORAMINIFERA YIELD RARELY

HORIZONS WHICH ARE QUITE BARREN IN FORAMINIFERA

Ls—Uc z : *Lagenonodosaria scalaris—Uvigerina crassicostata zone*

MO : *Miogypsina kotoi—Operculina complanata japonica zone*

Nmz : *Nonion mizunamiense zone*



PL. 38 Correlation chart of the Neogene foraminiferal assemblages in the West Honshū, Japan, based upon microbiostratigraphic units.

Y. TAI

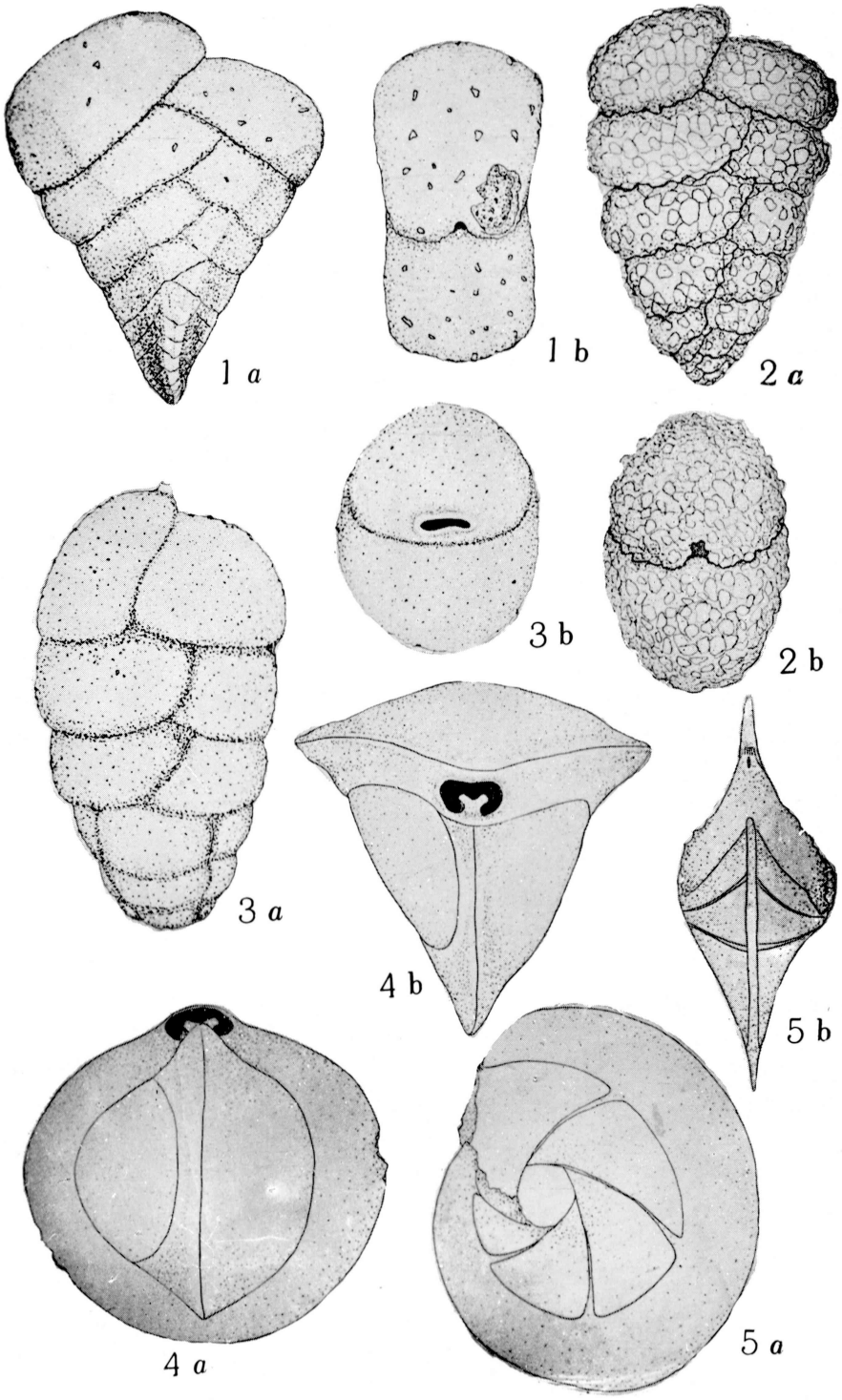
Miocene Microbiostratigraphy of West Honshû, Japan

PLATES 39–43

EXPLANATION OF PLATE 39

FIGS. 1 a-b, *Gaudryina imamurai* Tai, n. sp., Holotype ×57..... p. 382
FIGS. 2 a-b, *Gaudryina takunoensis* Tai, n. sp., Holotype ×79..... p. 383
FIGS. 3 a-b, *Karreriella tanabensis* Tai, n. sp., Holotype ×74..... p. 383
FIGS. 4 a-b, *Triloculina okamotoi* Tai, n. sp., Holotype ×46..... p. 384
FIGS. 5 a-b, *Robulus izumoensis* Tai and Okamoto, n. sp., Holotype ×36..... P. 384

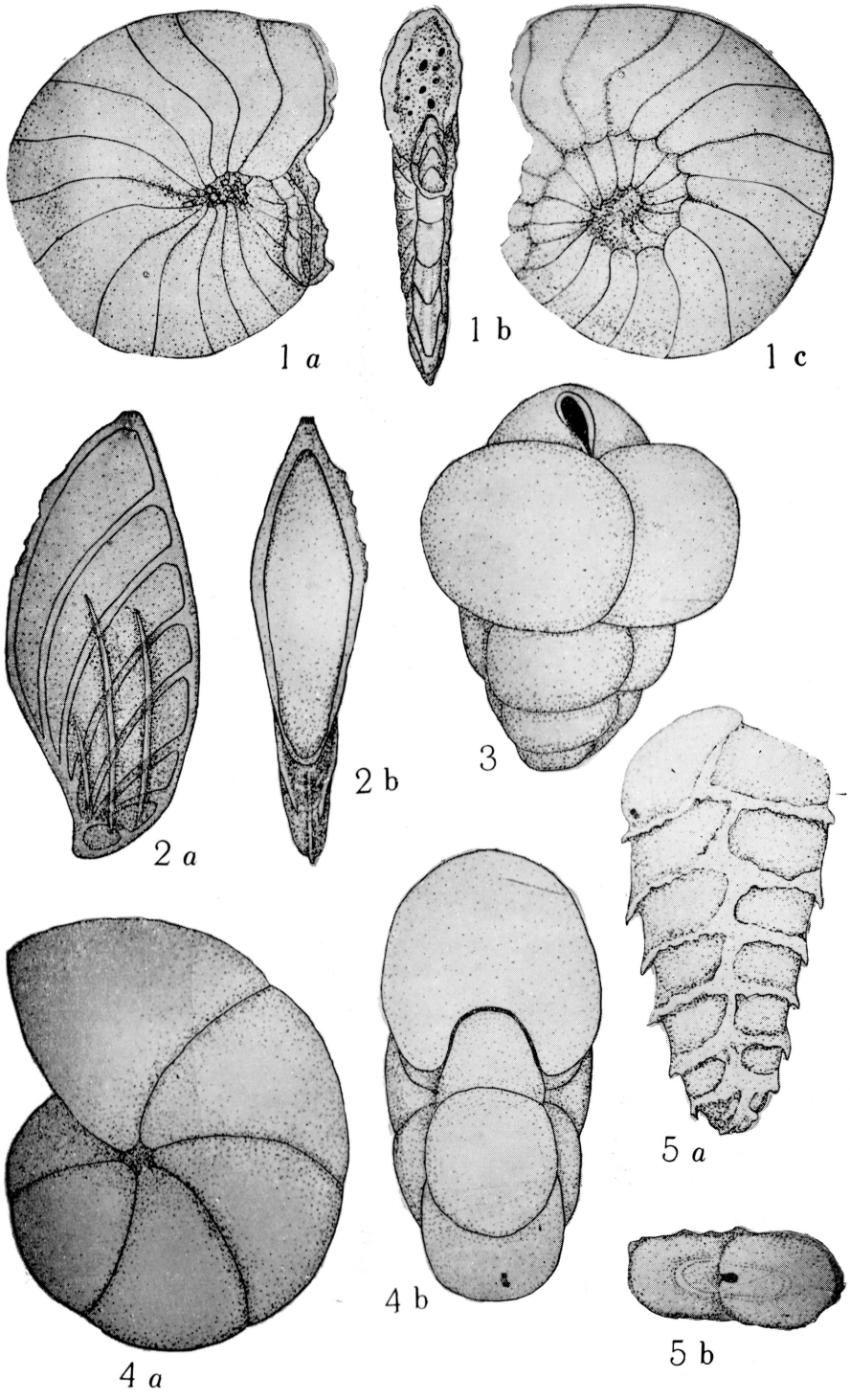
All specimens are deposited in the Institute of Geology and Mineralogy, Hiroshima University.


1 a
1 b
2 a
3 b
2 b
3 a
4 b
5 b
4 a
5 a

EXPLANATION OF PLATE 40

FIGS. 1 a-c, *Cyclammina ezoensis okuharai* Tai, n. subsp., Holotype ×26..... p. 382
FIGS. 2 a-b, *Planularia yokoii* Tai, n. sp., Holotype ×166..... p. 384
FIG. 3, *Bulimina imamurai* Tai, n. sp., Holotype ×180..... p. 387
FIGS. 4 a-b, *Nonion mizunamiense* Tai, n. sp., Holotype ×286..... p. 385
FIGS. 5 a-b, *Bolivina hongoensis* Tai, n. sp., Holotype ×154..... p. 388

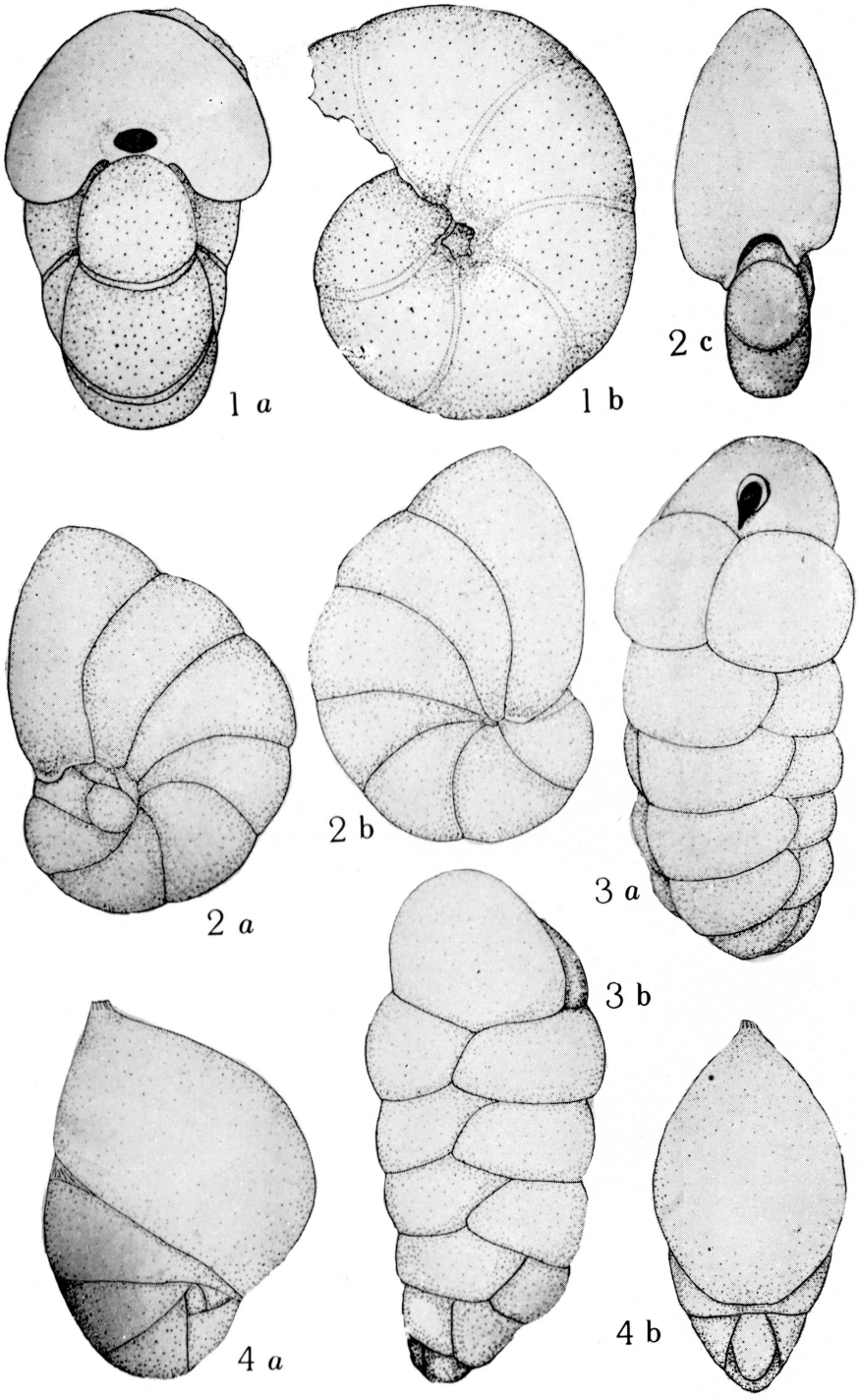
All specimens are deposited in the Institute of Geology and Mineralogy, Hiroshima University.


1 a
1 b
1 c
2 a
2 b
3
4 a
4 b
5 a
5 b

EXPLANATION OF PLATE 41

FIGS. 1 a-b, *Nonion shukuense* Tai, n. sp., Holotype ×204..... p. 386
FIGS. 2 a-c, *Pseudononion hashimotoi* Tai, n. sp., Holotype ×225..... p. 386
FIGS. 3 a-b, *Bulimina okayamaensis* Tai, n. sp., Holotype ×122..... p. 387
FIGS. 4 a-b, *Marginulina mukaei* Tai and Okamoto, n. sp., Holotype ×112..... p. 385

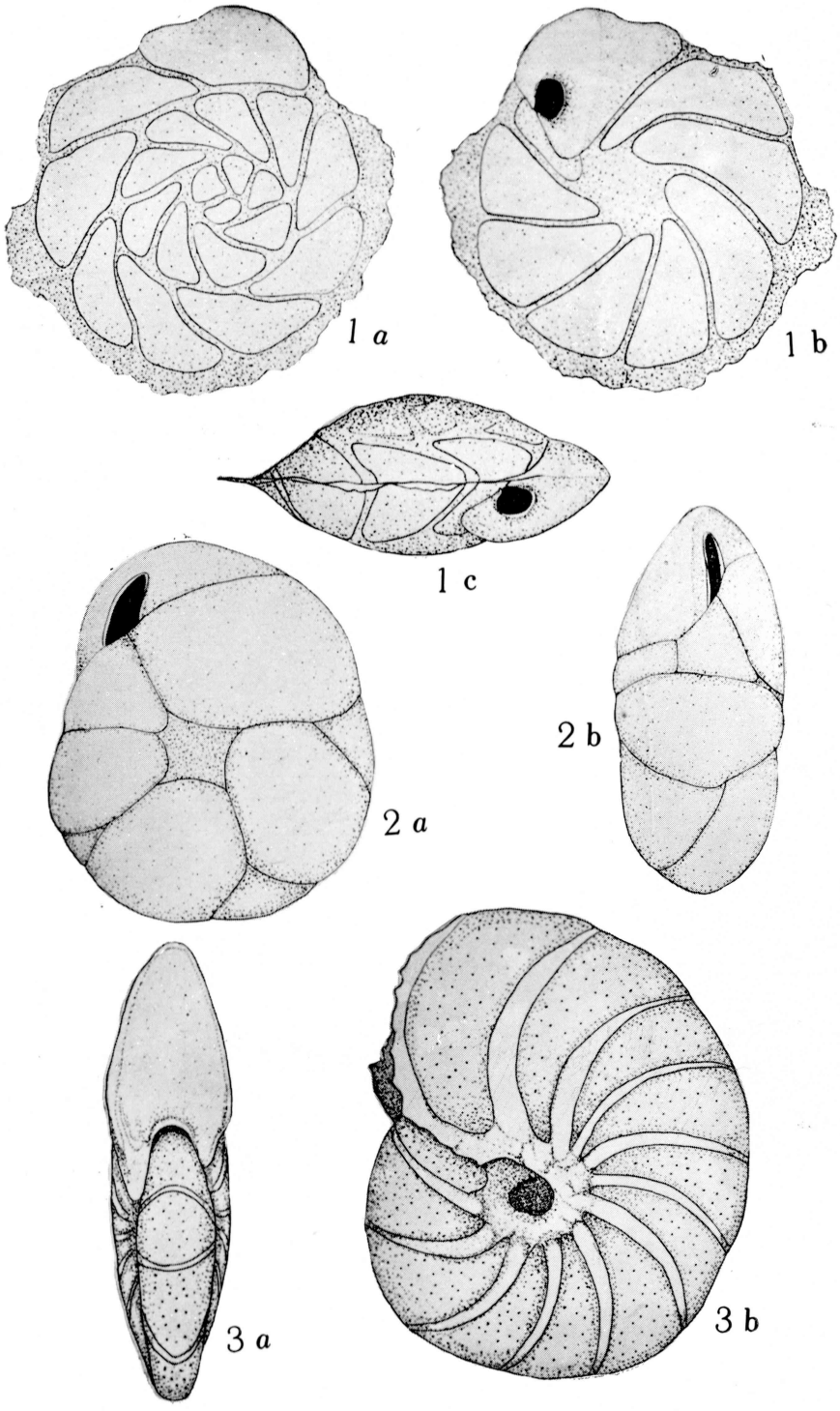
All specimens are deposited in the Institute of Geology and Mineralogy, Hiroshima University.


1 a
1 b
2 c
2 a
2 b
3 a
3 b
4 a
4 b

EXPLANATION OF PLATE 42

FIGS. 1 a-c, *Eponides naraensis* Tai, n. sp., Holotype ×159..... p. 388
FIGS. 2 a-b, *Cassidulina imamurai* Tai, n. sp., Holotype ×113..... p. 389
FIGS. 3 a-b, *Anomalina kojimaensis* Tai, n. sp., Holotype ×133..... p. 389

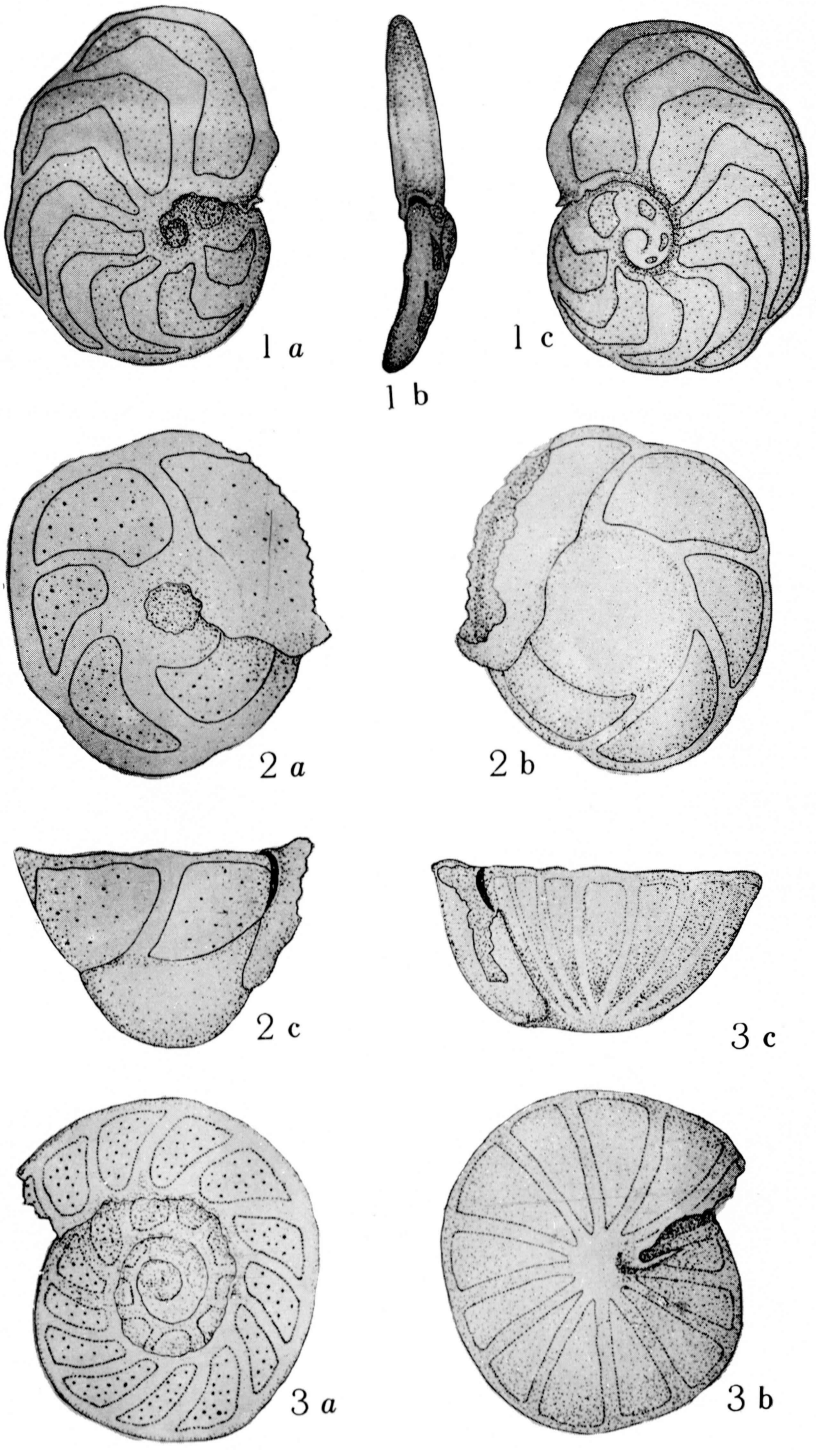
All specimens are deposited in the Institute of Geology and Mineralogy, Hiroshima University.


1 a
1 b
1 c
2 a
2 b
3 a
3 b

Explanation of Plate 43

Figs. 1 a–c, *Planulina asanoi* Tai, n. sp., Holotype ×213..... p. 389
Figs. 2 a–c, *Cibicides dogoensis* Tai, n. sp., Holotype ×209..... p. 390
Figs. 3 a–c, *Cibicides shukuensis* Tai, n. sp., Holotype ×78..... p. 390

All specimens are deposited in the Institute of Geology and Mineralogy, Hiroshima University.


1 a
1 b
1 c
2 a
2 b
2 c
3 c
3 a
3 b