Miocene Foraminifera from the Syôbara Basin, Hiroshima Prefecture.*

by

Yoshiro TAI

I Introduction

Since 1929, it has been well known among geologists that the Miocene formations bearing *Vicarya* are formed in some basins along the southern slope of the backbone of the Tyûgoku Provinces in Japan. In 1938, Y. ÔTUKA described the following Miocene molluscan fossils from the Syôbara basin in Hiroshima Prefecture:

Ostrea gravitesta OTUKA
Anadara daitokudoensis MAKIYAMA
Anadara aff. *setoensis* (YOKOYAMA)
Lucina yokoyamai OTUKA
Lucina k-hatai OTUKA
Cardium ogurai OTUKA
Joannisiella takeyamai OTUKA
Meretrix arugai OTUKA
Dosinia suketoensis OTUKA
Cyclina sinensis (GMELIN)
Siratoria siratoriensis (OTUKA)
Soletellina minoensis YOKOYAMA
Zozia uetanii OTUKA
Aloidis succincta (YOKOYAMA)
Turbo (*Lunella*) *ozawai* OTUKA
Natica aff. *meisensis* (MAKIYAMA)
Globularia nakamurai OTUKA
Vicarya callosa JENKINS
Proclava meisensis MAKIYAMA
Proclava ancisa (YOKOYAMA)
Cerithidea tokunagai OTUKA
Batillaria tateiwai MAKIYAMA
Batillaria yamanarii MAKIYAMA
Nassarius simizui OTUKA
Actaeon ozawai OTUKA
Actaeon ? ogurai OTUKA

But, at that time, the detailed stratigraphy of the Miocene deposits in the Tyûgoku Provinces was not well studied. Thereafter, in 1950, S. IMAMURA and the writer divided the Miocene deposits overlying unconformably the basement complex into the Lower and Upper formations, and recognized

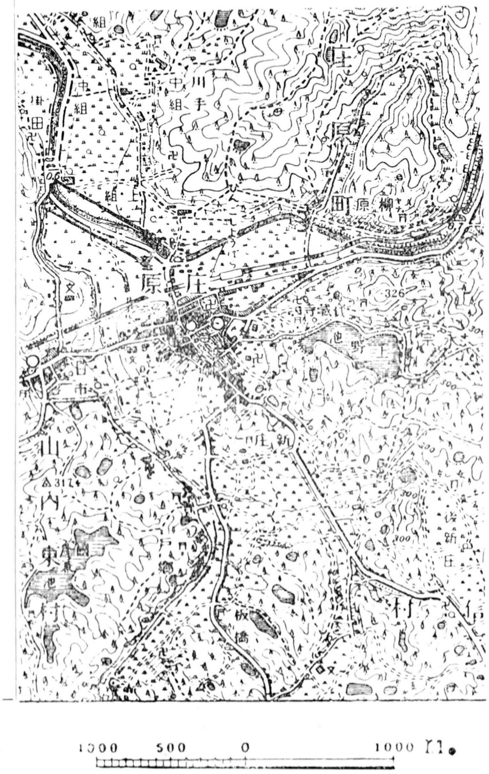
* Contribution from Geol. Inst., Fac. of Sci., Hiroshima Univ., No. 21

that the stratigraphical relation between both formations is slightly unconformable. As to the lithological characters of these formations, the Lower formation consists mainly of conglomerate and sandstone intercalated with lignite seams and is considered to have been deposited in a lake.

While the Upper formation, consisting of alternated beds of sandstone and grey shale with *Vicarya-Operculina-Miogypsina* fauna in the lower part, and of black shale containing few marine molluscan fossils in the upper part, is considered to be obviously a littoral or neritic deposit. In 1953, S. IMAMURA subdivided the Upper formation mentioned above into two formations, naming them the Middle and the Upper formation. The stratigraphical relation between both formations is conformable.

The Miocene formation bearing *Miogypsina* reported by H. YABE and S. MABUCHI (1934) from Kôyamaichi, Okayama Prefecture, and the beds containing the molluscan fossils studied by Y. ÔTUKA, may be correlated to the Middle formation after IMAMURA's lithological classification.

133° 0'10".4 E.



34° 50' N.

Fig. 1. Map showing the Locality.

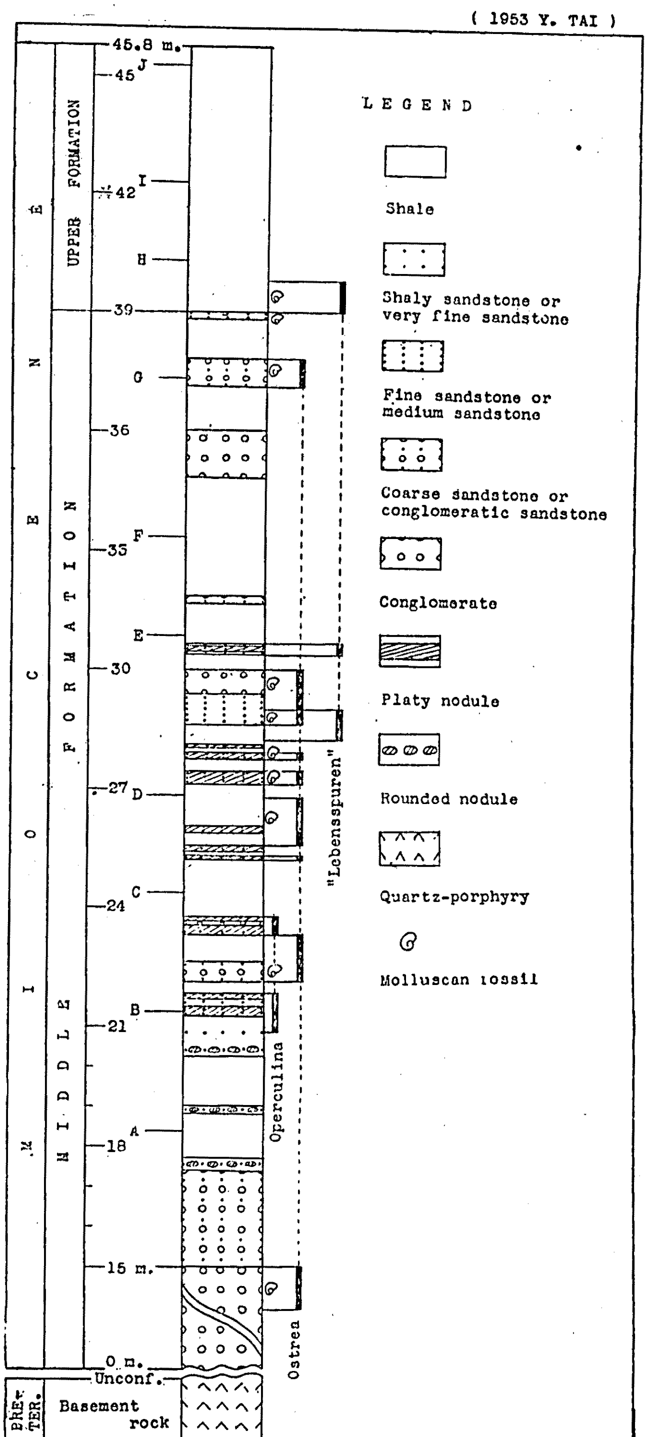
In the present paper, the writer intends to deal with the Miocene smaller foraminifera from the Middle and Upper formations, distributed along the southern side of the Saizyô River, NW of the Syôbara Railway Station (Fig. 1), and their stratigraphical significance.

In this work, 10 samples, each weighing 200 grams, were collected by the writer from the sampling points, as shown in the columnar section (Fig. 2), the intervals between adjacent sampling points being about 2-4 m. They were washed, sieved, and dried. In counting individuals of foraminifera, the dried materials were divided into eight equal parts, one part of which was examined under the binocular microscope.

The results are shown in the

Table 1

Species \ Horizons	A	B	C	D	E	F	G	H	I	J
Rhizamminidae:										
1. *Bathysiphon* sp.	—	—	—	—	—	—	2	4	—	—
2. *Bathysiphon?* sp.	—	—	—	—	—	—	—	—	—	1
Lituolidae:										
3. *Haplophragmoides* sp.	—	—	—	—	—	4	2	3	17	—
4. *Haplophragmoides?* sp.	—	—	—	—	—	6	—	7	1	17
5. *Cribrostomoides* cf. *kyushuense* Asano	—	—	—	—	—	—	1	—	—	—
6. *Cyclammina incisa* (Stache)	—	—	—	—	—	—	—	—	1	—
7. *Cyclammina* cf. *incisa* (Stache)	—	—	—	—	—	—	—	4	6	—
8. *Cyclammina pusilla* Brady	—	—	—	—	—	—	—	—	6	—
9. *Cyclammina* sp.	—	—	—	—	—	—	—	1	1	2
10. *Cyclammina?* sp.	—	—	—	—	—	—	—	—	5	2
Verneuilinidae:										
11. *Gaudryina* (*Pseudogaudryina*) *ishikiensis* Asano	—	—	—	-	—	45	10	—	—	—
Valvulinidae:										
12. *Goësella?* sp.	—	—	—	—	—	—	—	—	—	1
13. *Martinottiella communis* (d' Orbigny)	—	—	—	—	—	2	1	12	34	—
14. *Martinottiella?* sp.	—	—	—	—	—	—	—	1	—	—
Miliolidae:										
15. *Sigmoilina* sp.	—	—	—	—	—	—	—	2	9	—
16. *Sigmoilina?* sp.	—	—	—	—	—	—	—	1	—	—
Lagenidae:										
17. *Robulus* cf. *nikobarensis* (Schwager)	—	—	—	—	—	—	2	—	—	—
18. *Robulus pseudorotulatus* Asano	—	—	—	—	—	—	1	1	—	1
19. *Robulus* cf. *pseudorotulatus* Asano	—	—	—	—	-	4	—	—	—	—
20. *Robulus* sp.	-	18	—	—	—	49	57	15	—	132
21. *Robulus?* sp.	—	—	—	—	—	—	1	—	—	—
22. *Lenticulina?* sp.	—	—	—	—	—	—	2	—	—	1
23. *Saracenaria* sp.	—	—	—	—	—	—	1	—	—	—
24. *Saracenaria?* sp.	—	—	—	—	—	1	—	—	—	—
25. *Vaginulina bradyi* Cushman	—	2	—	—	—	1	8	13	4	—
26. *Marginulina masudai* Asano (MS.)	—	—	—	—	—	5	11	4	—	—
27. *Marginulina* sp.	—	—	—	—	—	1	—	—	—	—
28. *Lagenonodosaria* cf. *scalaris sagamiensis* Asano	—	—	—	—	—	—	4	—	—	—
29. *Lagenonodosaria* sp.	—	4	—	—	—	6	7	5	1	—
30. *Lagenonodosaria?* sp.	—	—	—	—	—	—	—	1	—	—
31. *Nodosaria* sp. A	—	—	—	—	—	2	4	2	—	—
32. *Nodosaria* sp. B	—	—	—	—	—	—	2	—	—	—
33. *Nodosaria* sp. C	—	—	—	—	—	1	3	—	2	1
34. *Dentalina emaciata* Reuss	—	—	—	—	—	—	7	1	—	1
35. *Dentalina* cf. *emaciata* Reuss	—	—	—	—	—	—	1	—	—	—
36. *Dentalina subsoluta* (Cushman)	—	—	—	—	—	—	1	1	2	1
37. *Dentalina* sp.	—	—	—	—	—	6	1	—	—	2
38. *Dentalina?* sp.	—	—	—	—	—	—	2	1	—	—
39. *Ellipsonodosaria lepidula* (Schwager)	—	—	—	—	—	79	24	10	10	2
40. *Ellipsonodosaria* sp.	—	—	—	—	—	—	—	—	—	2
41. *Plectofrondicularia* sp.	—	—	—	—	—	4	—	—	—	—
42. *Plectofrondicularia?* sp.	—	—	—	—	—	—	—	1	—	—
Polymorphinidae:										
43. *Guttulina irregularis* (d' Orbigny)	—	—	—	—	—	1	15	1	—	—
44. *Guttulina* cf. *kishinouyi* Cushman and Ozawa	—	—	—	—	—	—	2	—	—	—
45. *Guttulina* (*Sigmoidina*) *pacifica* (Cushman and Ozawa)	—	—	—	—	—	—	1	—	—	—
46. *Guttulina* cf. *problema* d' Orbigny	—	—	—	—	—	—	2	—	—	—
47. *Guttulina* cf. *sadoensis* (Cushman and Ozawa)	—	—	—	—	—	—	3	—	—	—
48. *Guttulina* sp.	—	—	—	—	—	3	—	2	—	—
49. *Guttulina?* sp.	—	—	—	—	—	—	2	—	1	—
50. *Globulina?* sp.	—	—	—	—	—	—	2	1	—	—
Nonionidae:										
51. *Nonion japonicum* Asano	11	—	13	1	—	1	4	—	—	—
52. *Nonion* cf. *japonicum* Asano	—	—	—	—	1	—	—	—	—	—
53. *Nonion* sp.	—	—	—	—	—	—	3	—	—	—
54. *Nonion?* sp.	—	—	—	—	—	1	1	—	—	—
55. *Elphidiella momiyamaensis* Uchio	—	—	—	—	—	—	1	—	—	—
Camerinidae:										
56. *Operculina ammonoides* (Gronovius)	—	368	—	—	—	—	—	—	—	—
Buliminidae:										
57. *Bulimina striata* d' Orbigny	—	—	—	—	—	7	11	1	—	—
58. *Bulimina* sp.	—	—	—	—	—	—	2	—	—	—
59. *Bolivina marginata* Cushman	—	—	—	—	—	—	—	1	—	11
60. *Uvigerina crassicostata* Schwager	—	—	—	—	—	14	8	9	4	—
61. *Uvigerina nitidula* Schwager	—	—	—	—	—	—	1	—	—	—
62. *Uvigerina* cf. *nitidula* Schwager	—	—	—	—	—	3	—	—	—	7
63. *Uvigerina* cf. *subperegrina* Cushman & Kleinpell	—	—	—	—	—	—	—	—	—	48
64. *Uvigerina* sp.	—	—	—	—	—	3	12	—	11	1
65. *Uvigerina?* sp.	—	—	—	—	—	—	1	—	—	—
Rotaliidae:										
66. *Discopulvinulina* sp.	—	—	—	—	—	—	1	—	—	—
67. *Eponides tanai* Uchio	—	—	—	—	—	—	—	—	1	—
68. *Eponides* cf. *tanai* Uchio	—	—	—	—	1	—	—	—	—	—
69. *Eponides* cf. *umbonatus* (Reuss)	—	—	—	—	—	—	—	—	5	5
70. *Eponides* sp.	1	—	—	—	—	18	21	8	33	27
71. *Eponides?* sp.	—	—	—	—	—	2	22	—	—	5
72. *Rotalia inflata* (Seguenza)	—	—	—	—	—	16	22	—	—	—
73. *Rotalia tochigiensis* Uchio	—	28	—	—	—	—	5	—	—	—
74. *Rotalia* sp.	5	2	30	—	—	14	1	—	—	—
75. *Baggina* sp.	—	—	—	—	—	—	6	5	—	—
Cassidulinidae:										
76. *Cassidulina laevigata carinata* Cushman	—	—	—	—	—	—	28	—	46	3
77. *Cassidulina* sp.	—	—	—	—	—	—	7	6	—	—
78. *Cassidulina?* sp.	—	—	—	—	—	—	3	1	—	—
Anomalinidae:										
79. *Planulina wuellerstorfi* (Schwager)	—	—	—	—	—	—	1	—	—	—
80. *Planulina* cf. *wuellerstorfi* (Schwager)	—	—	1	—	—	—	—	—	—	—
81. *Hanzawaia tagaensis* Asano	—	—	—	—	—	—	3	—	—	—
82. *Hanzawaia* sp.	—	—	—	—	—	3	—	—	—	—
83. *Hanzawaia?* sp.	—	—	—	—	—	—	3	—	—	—
84. *Cibicides* cf. *floridanus* (Cushman)	—	—	—	—	—	7	—	—	—	—
85. *Cibicides pseudoungerianus* (Cushman)	—	—	3	—	—	27	12	20	11	13
86. *Cibicides* sp.	—	—	—	—	2	6	—	6	23	42
87. *Cibicides?* sp.	—	—	—	—	—	—	6	—	—	—
The total amount of specimens (benthonic foram.)	17	422	47	1	4	342	367	151	234	328
Globigerinidae:										
88. *Globigerina* spp.	—	—	—	—	—	—	20	80	250	—



distribution chart (Table 1).

Unfortunately, 4 samples of the total 10 contain very few species of foraminifera.

Acknowledgement; The writer wishes to express his cordial thanks to Dr. Kiyoshi ASANO of the Institute of Geology and Paleontology, Tôhoku University, Sendai, for his kind advices on the determination of foraminifera and for his critical reading of manuscript, and to Professor Sotoji IMAMURA of the Institute of Geology, Hiroshima University, Hiroshima, for his kind encouragements for the present study, and also thanks are due to Mr. Mamoru FUJII who helped in the sampling and washing works.

Fig. 2. Geologic Columnar Section of the Miocene Formations, distributed along the Southern Side of the Saizyô River, in the Syôbara Basin.

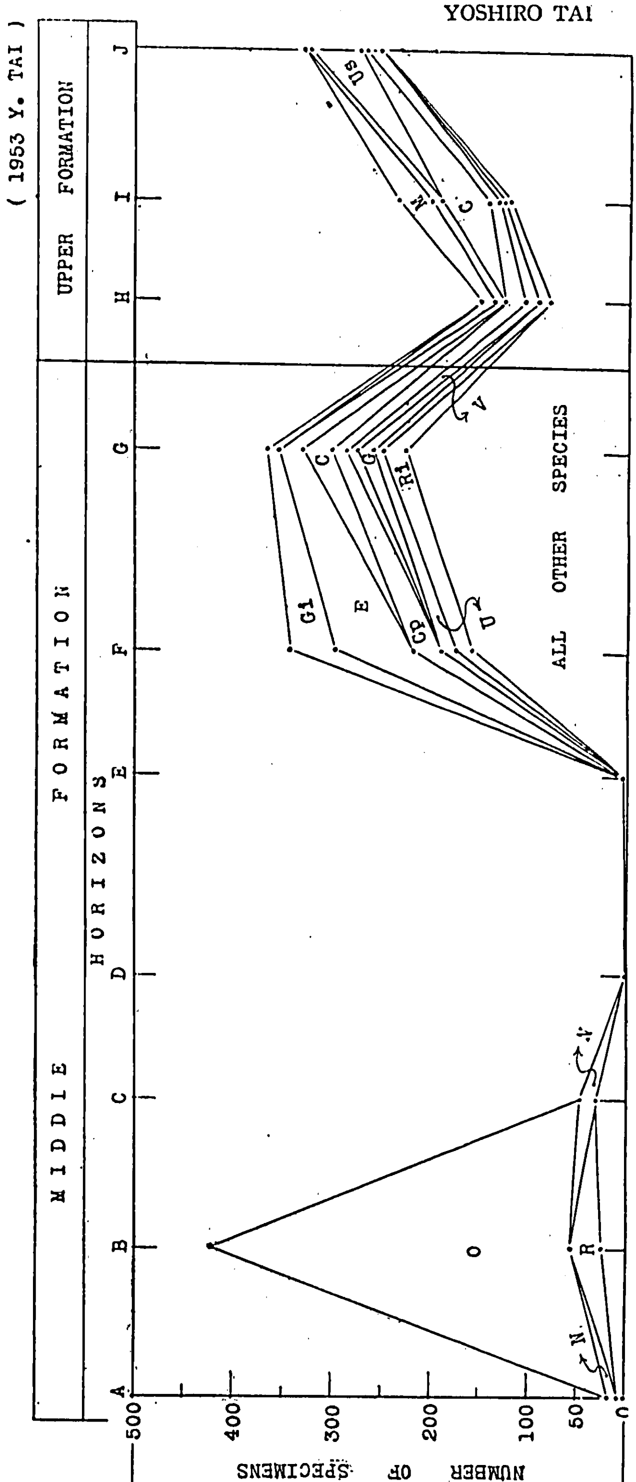


Fig. 3. Frequency Distribution of the Dominant Species (Benthonic Foraminifera) from the Horizons A–J. O : *Operculina ammonoides* ; N = *Nonion japonicum* ; R = *Rotalia tochigiensis* ; Gi = *Gaudryina ishikiensis*; E = *Ellipsonodosaria lepidula*; C = *Cassidulina laevigata carinata* ; Cp = *Cibicides pseudoungerianus* ; V = *Vaginulina bradyi* ; G = *Guttulina irregularis* ; U = *Uvigerina crassicostata* ; Ri = *Rotalia inflata* ; Us = *Uvigerina* cf. *subperegrina* ; M = *Martinottiella communis*.

II The Composition of the Foraminiferal Fauna

Many species of the foraminifera examined, were deformed by fossilization, so that the writer could not determine specific names of deformed ones. But, these foraminifers may be distinguished into 14 families, 35 genera, and 88 species, as shown in Table 1. The frequency distributions of dominant species, genera, and families, are shown in Fig. 3, 4, and 5, respectively. The letters (A–J) in the Figs. 3 — 5, and Table 1, correspond to the fossil horizons in the columnar section, Fig. 2. Namely, horizons A — G belong to the Middle formation, and horizons H — J to the Upper formation.

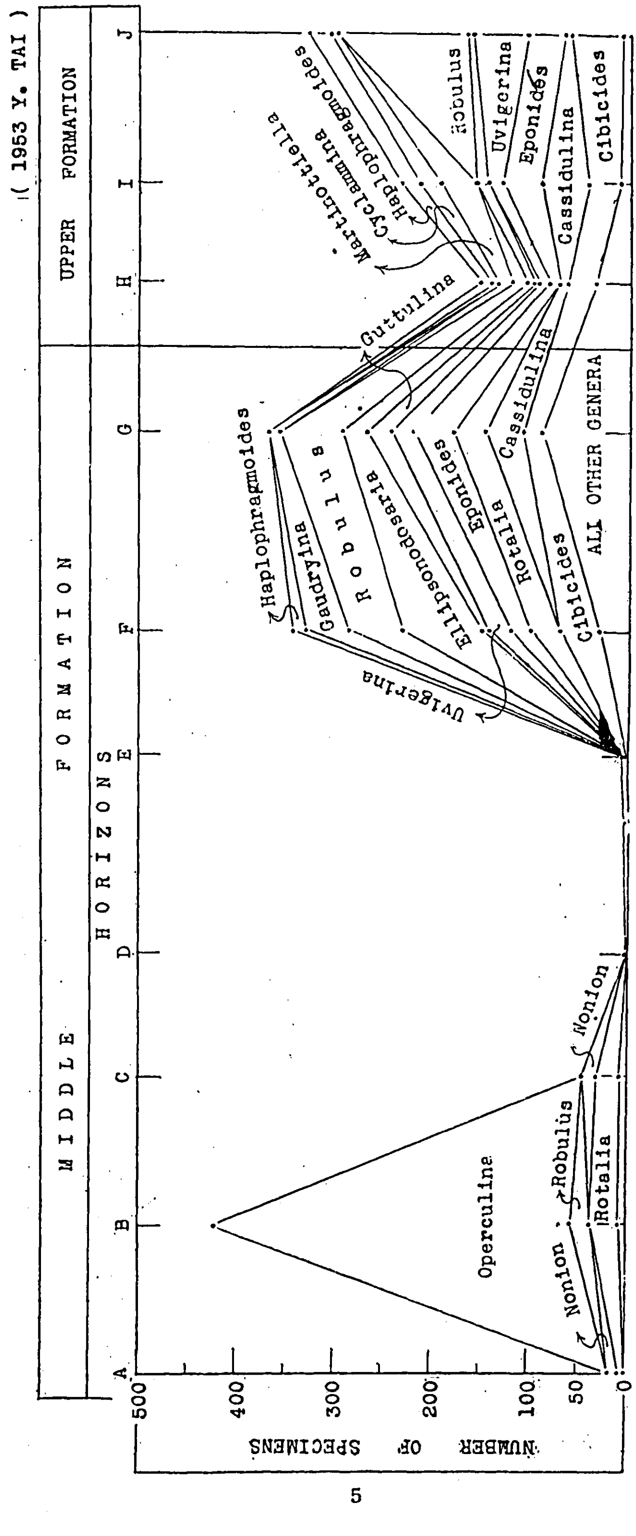


Fig. 4. Frequency Distribution of the Dominant Genera (Benthonic Foraminifera) from the Horizons A—J.

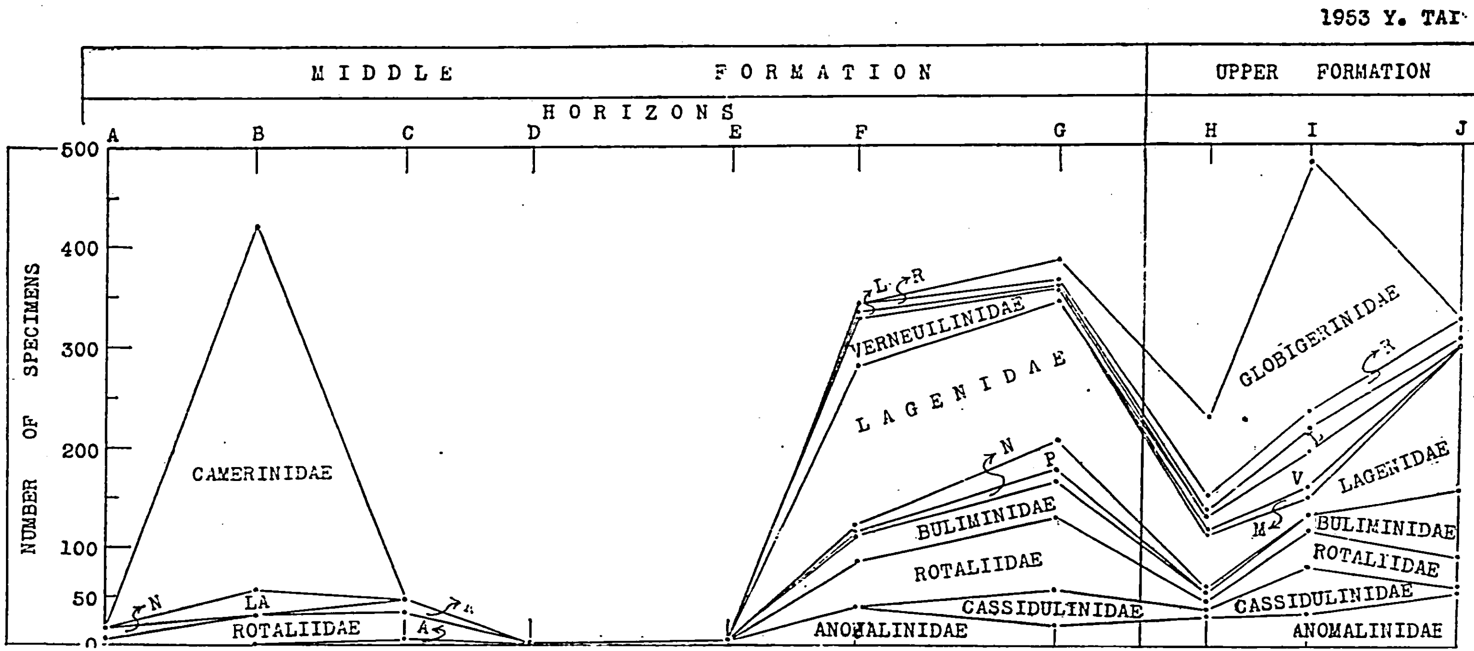


Fig. 5. Frequency Distribution of Families from the Horizons A—J.
N = NONIONIDAE; LA = LAGENIDAE; A = ANOMALINIDAE; L = LITUOLIDAE;
R = RHIZAMMINIDAE; P = POLYMORPHINIDAE; V = VALVULINIDAE; M = MILIOLIDAE.

As shown in the Figs. 3 -- 5, the decrease in specific and individual numbers, at the horizons A, C, D, and E, is conspicuous comparring with those of the other horizons.

This fact may be due to the unsuitable environment to the foraminifera.

While, at B, abundant individuals of *Operculina* suddenly appears accompanying with few species of *Robulus* and *Rotalia.*

Therefore, the horizon B is named "*Operculina* sandstone".

Then, at F, the abrupt increase in specific and individual numbers is characteristic. Particularly, the specific numbers of the Lagenidae, Rotaliidae and Verneuilinidae are dominant. Genera *Ellipsonodosaria, Robulus, Gaudryina, Rotalia* and *Cibicides* consist of dominant species. *Ellipsonodosaria lepidula, Gaudryina ishikiensis* and *Cibicides pseudoungerianus* are the most characteristic species at F.

At G, the Lagenidae and Rotaliidae remain as dominant as at F, and the appearance of the Cassidulinidae and Globigerinidae here may be noteworthy. Specific numbers of genera *Ellipsonodosaria, Gaudryina,* and *Cibicides* decrease, while the individuals of *Robulus, Eponides,* and *Cassidulina* occupy relatively large proportion. Among species at G, *Ellipsonodosaria lepidula, Cassidulina laevigata carinata* and *Rotalia inflata* are relatively dominant.

At H, the increase of the arenaceous foraminifera and Globigerinidae, and the decrease of the Lagenidae and Rotaliidae, which are remarkably dominant at F and G, are somewhat characteristic. The appearance of *Cyclammina,* the increase of *Haplophragmoides* and *Martinottiella,* and the disappearance of *Rotalia* and *Nonion,* are thought to have an important significance for the ecological and depositional environments.

Judging from the data mentioned above, in connection with the result of field geologic survey that the horizon H belongs to the black shale member of the Upper formation, as shown in columnar section (Fig. 2), and also with the absence of the mollusca of shallow water forms, such as *Ostrea* etc., the depositional environment of the horizon H may be represented by the sea that became gradually deeper, its temperature becoming cooler than those of the horizons A -- G. *Martinottiella communis, Ellipsonodosaria lepidula, Cibicides pseudoungerianus, Vaginulina bradyi* and *Uvigerina crassicostata* are the dominant species at H.

At I, the increase of *Cassidulina, Haplophragmoides, Cyclammina* and *Martinottiella,* and the abrupt increase of the Globigerinidae, suggest the similar change of depositional environment and climatic condition, as indicated at the horizon H. *Martinottiella communis* and *Cassidulina laevigata carinata* become the dominant and characteristic species of this horizon.

At J, the Lagenidae, the Buliminidae, the Anomalinidae, and the Rotaliidae are the main components. *Haplophragmoides*, *Robulus*, *Uvigerina*, *Eponides*, and *Cibicides* also become dominant. Among the species, *Uvigerina* cf. *subperegrina* is only remarkable, as shown in Fig. 3.

III Conclusion

Judging from the results of the distribution of foraminiferal association of the horizons A — J, the ecological environments of the Middle and Upper formations in the Syôbara basin are summarized as follows:

(1) The environments in the lower and middle parts of the Middle formation, which correspond to the horizons A — E, may be regarded as littoral or an inland sea, because of the dominant occurrence of shallow water forms, such as *Operculina* and *Nonion*.

This result agrees with that by Y. ÔTUKA, based upon the examination of mollusca.

The environments of the Upper formation, to which the horizons H—J belong, may be represented by the neritic or bathyal conditions, still deeper and cooler than those of the horizons A — E, because of the dominance of neritic or bathyal forms, such as *Robulus*, *Bolivina*, *Uvigerina*, *Cassidulina*, *Haplophragmoides*, *Cyclammina*, and *Martinottiella*, and also because of the abundant occurrence of pelagic foraminifera. The result of field survey that the Upper formation consists mainly of black shale, supports this view.

At the horizons F and G, which belong to the uppermost part of the Middle formation, the depositional environments may be represented by the conditions, gradually changing from those of inland sea to those of somewhat open sea, because of the mixed association of neritic and littoral forms.

(2) The occurrence of *Cyclammina incisa*, *Robulus pseudorotulatus*, *Marginulina masudai* (MS.), *Operculina ammonoides*, *Bolivina marginata*, *Uvigerina* cf. *subperegrina*, *Cassidulina laevigata carinata*, and *Hanzawaia tagaensis* affirms the view that the geological age of the Middle and Upper formations in the Syôbara basin may be middle Miocene, originally established by the study of mollusca.

REFERENCE

K. ASANO, 1949, On the Miocene Forms of *Cyclammina* from the Japanese Oil-fields (in Japanese with English Abstract): Jour. Geol. Soc. Japan, vol. **55**, no. 640, pp. 1-4.

K. ASANO, 1950-1951, Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera: Parts 1-15.

K. ASANO, 1951, Recent and Tertiary *Cyclammina* from Japan and the Adjacent Regions: Short Papers, IGPS, no. 3, pp. 13-24, pls. 3, 4.

K. ASANO, 1953, Miocene Foraminifera from the Shintotsugawa Area, Kabato-Gun, Hokkaidô: Trans. Proc. Palaeont. Soc. Japan, N. S., no. 10, pp. 45-54, 18 text-figs.

K. ASANO, 1953, Miocene Foraminifera from the Honya Shale, Jôban Coal-field: Trans. Proc. Palaeont. Soc. Japan, N. S. no. 11, pp. 55-59, 11 text-figs.

O. FUKUTA, and R. SHINOKI, 1952, Stratigraphical and Micropalaeontological Study of the Nishikatsura Group (in Japanese with English Abstract): Jour. Geol. Soc. Japan, vol. **58**, no. 681, pp. 191-202, pl. **6**.

S. IMAMURA, and Y. TAI, 1950, Outline of the Tertiary Formation in the Northern Part of Hiroshima Prefecture (in Japanese): Jour. Geol. Soc. Japan, vol. **56**, no. 656, pp. 299-300.

S. IMAMURA, 1953, Outline of the Tertiary Stratigraphy in the Central and Western Parts of Shimane Prefecture (in Japanese): Jour. Geol. Soc. Japan, West. Branch, no. 12, pp. 6-8.

S. MURATA, 1952, Smaller Foraminifera from the Miocene Deposits of the Miyosi and Tuyama Basin, Tyûgoku, West Japan (in Japanese): Jour. Geol. Soc. Japan, Short Comm., vol. **58**, no. 685, pp. 491-492.

Y. OTUKA, 1938, Mollusca from the Miocene of Tyûgoku, Japan: Jour. Fac. Sci. Imp. Univ. Tokyô, sect. 2, vol. **5**.

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

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

O. L. BANDY, 1953, Ecology and Paleoecology of Some California Foraminifera, Pt. 1, the Frequency Distribution of Recent Foraminifera off California: Jour. Pal., vol. **27**, no. 2, pp. 161-182, pls. 21-25, figs. 1-4.

F. B. PHLEGER, 1951, Ecology of Foraminifera, Northwest Gulf of Mexico, Pt. 1, Foraminifera Distribution: Geol. Soc. Amer., Mem. 46, pp. 1-88.