Bull. Natn. Sci. Mus., Ser. C (Geol.), 1 (3), September 22, 1975

An Early Miocene Planktonic Foraminiferal Fauna from the Megami Formation, Shizuoka Prefecture

By

Hiroshi UJIIÉ

Department of Paleontology, National Science Museum, Tokyo

Introduction

The Megami Formation has become paleontologically famous since ISHIWADA (1894) described *Lithothamnium ramosissimum* REUSS, a calcareous alga, and *Turbo megamiensis* ISHIWADA, a gastropod, from limestone of the formation, despite of its limited exposure occurring as an inlier in the Sagara Group. The Sagara Group is developed well in the western part of Shizuoka Prefecture on the Pacific coast of central Japan. Limestone blocks of the formation contain not only abundant individuals of such calcareous algae as investigated thoroughly by ISHIJIMA (1932, 1933) but also rather common larger Foraminifera including *Lepidocyclina* (*Nephrolepidina*) *nipponica* (HANZAWA). This nephrolepidine was emended later on the basis of some isolated and well-preserved specimens by HANZAWA (1943), who assigned the geologic age of the Megami Formation to Burdigalian properly by the occurrence of *L.* (*N.*) *nipponica* and *Miogypsina kotoi* HANZAWA.

After World War II, planktonic foraminiferal biostratigraphy has rapidly progressed so that its chronostratigraphic role in the Tertiary has become superior to that of larger Foraminifera. However, the age assignment by a planktonic fauna which was found within the Megami Formation and will be given herein completely coincides with HANZAWA's age-determination (1943) based on larger Foraminifera. The result also supports my view (1962, 1963) and SAITO's prediction (1960) on the regional geology against those of MAKIYAMA (1939 et seq.) and others (e. g., IKEBE, 1954).

Aside from the contribution to the regional geology, the planktonic Foraminifera of the Megami Formation point out some faunal affinity to those of approximately the same age reported from the Sea of Japan coast by SAITO and MAIYA (1973), who published the first taxonomically detailed work on the Miocene materials from there.

The Material Studied

Along the road at Megami between Sagara-machi (Town) and Hagima (see Fig. 1), a small cliff exposes whitish gray hard limestone underlying less consolidated pale gray mudstone with a rather level plane in between. Even though this plane may represent a fault plane caused probably by the different hardness of the two rock types,

a stratigraphic gap inferred between the two may be meaningless from the viewpoint of planktonic foraminiferal zonation since a thin and irregular-shaped lense of quite similar mudstone is enclosed in the limestone. The mudstone bed and lense contain

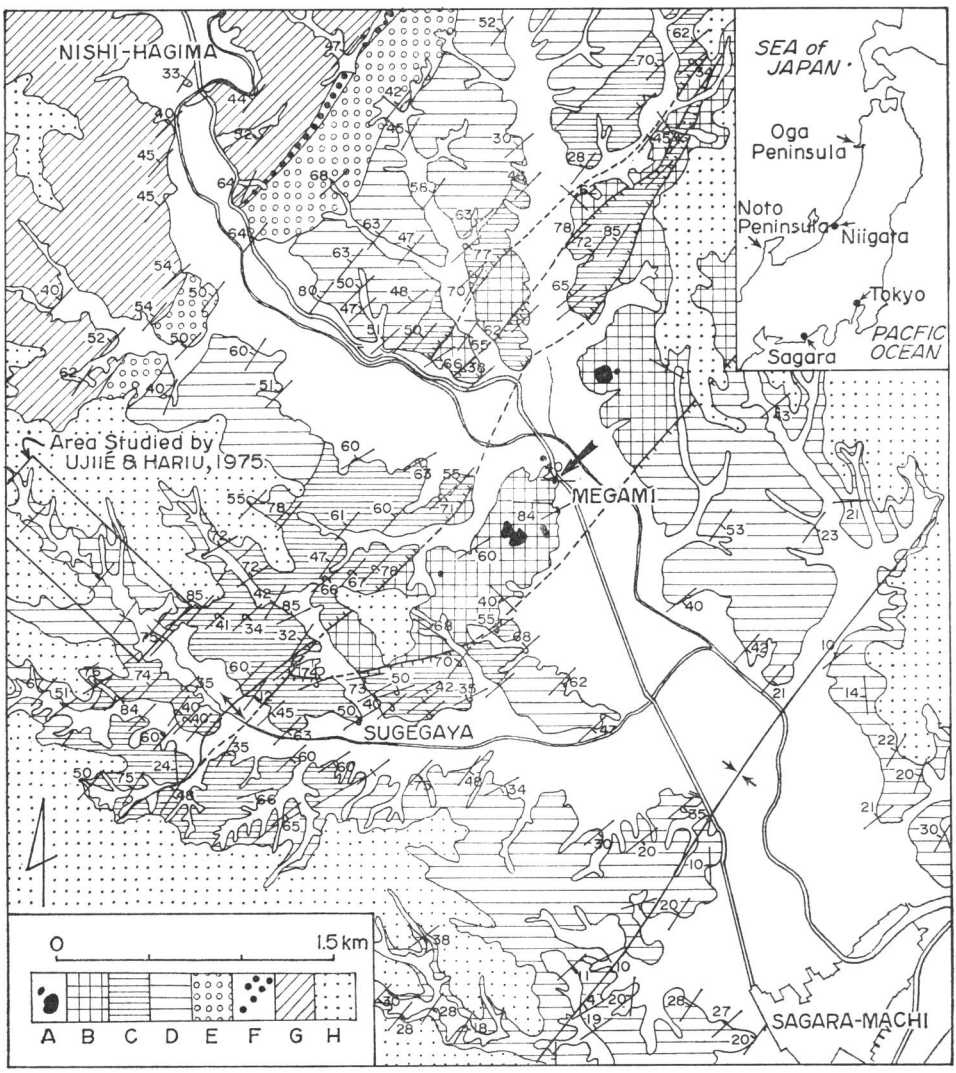


Fig. 1. Geologic map of the Megami area, Sagara-machi, showing the location of the planktonic foraminiferal fauna investigated (thick arrow).
The map is adopted from the originally 1/25,000 scale sheet, on which UJIIÉ's work (1962) was based.
A: limestone, B: Megami Formation [Mikasa Group], C: Sugegaya Alternation, D: Sagara Formation, E: Saguchi Conglomerate [Sagara Group], F: Kamiyashiro Conglomerate, G: Horinouchi Alternation [Kakegawa Group], H: Makinohara Group.

frequently limy nodules of the size of very coarse sand and are lime-rich in bulk chemical composition.

Although the shells were encrusted with a considerable amount of calcite, planktonic Foraminifera were recovered from the mudstone, in particular abundantly from the bed below the limestone, and their preservation was good enough for exact identification. Therefore, I treated 300 gr. of the rock from the bed by means of the maceration procedure employed previously (UJIIÉ and HARIU, 1965). About 700 isolated individuals of planktonic Foraminifera were picked out from the residues on the 100 mesh sieve, but the specimens other than the 247 listed here were so much deformed by diagenesis and crustal movement that most of them had to be excluded from the identification.

As a result, 247 specimens were classified under 31 taxa as follows:

1.	*Globigerina praebulloides* BLOW	10
2.	*Globigerina foliata* BOLLI	39
3.	*Globigerina foliata* BOLLI, var.	5
4.	*Globigerina falconensis* BLOW	2
5.	*Globigerina* aff. *druryi* AKERS	3
6.	*Globigerina nepenthoides* BRÖNNIMANN & RESIG	1
7.	*Globigerina* spp.	4
8.	*Globigerinita glutinata* (EGGER)	32
9.	*Globigerinita* cf. *glutinata* (EGGER)	3
10.	*Globigerinoides sicanus* DE STEFANI	10
11.	*Globigerinoides quadrilobatus* (D'ORBIGNY)	15
12.	*Globigerinoides japonicus* SAITO & MAIYA	10
13.	*Globigerinoides* cf. *ruber* (D'ORBIGNY)	13
14.	*Globigerinoides* cf. *subquadratus* BRÖNNIMANN	2
15.	*Globigerinoides* sp.	1
16.	*Praeorbulina* ? cf. *transitoria* (BLOW)	1
17.	*Prosphaeroidinella challengerae*, n. gen. et n. sp.*	10
18.	*Prosphaeroidinella challengerae*, var.	1
19.	*Globoquadrina altispira* (CUSHMAN & JARVIS)	1
20.	*Globoquadrina* aff. *altispira* (CUSHMAN & JARVIS)	1
21.	*Globoquadrina* aff. *globosa* BOLLI	2
22.	*Globoquadrina dehiscens dehiscens* (CHAPMAN, PARR & COLLINS)	24
23.	*Globoquadrina dehiscens advena* BERMÚDEZ	5
24.	*Globoquadrina* ? spp.	4
25.	*Globorotalia* (*Turborotalia*) *birnageae* BLOW	5
26.	*Globorotalia* (*Turborotalia*) *siakensis* LEROY	12
27.	*Globorotalia* (*Turborotalia*) *quinifalcata* SAITO & MAIYA	5
28.	*Globorotalia* (*Turborotalia*) *scitula scitula* (BRADY)	4
29.	*Globorotalia* (*Turborotalia*) cf. *praescitula* BLOW	4
30.	*Globorotalia* (*Turborotalia*) *peripheroronda* BLOW & BANNER	4
31.	*Globorotalia* (*Turborotalia*) aff. *peripheroronda* BLOW & BANNER	3
32.	*Globorotalia* (*Turborotalia*) aff. *lenguaensis* BOLLI	10
33.	*Globorotalia* (*Globorotalia*) *archaeomenardii* BOLLI	1
		247

* The new taxon will be described in another paper (UJIIÉ, in press).

Problem of Age Assignment

In tentatively applying BLOW's scheme (1969) of planktonic foraminiferal zonation to the fauna listed above, it must be noted first that this fauna indicates his zones N. 8 and N. 9 based upon the combination of ranges of taxa such as *Globigerinoides sicanus* (from basal N. 8 to basal N. 9), *Globorotalia* (*Turborotalia*) *birnageae* (middle N. 7 to near top of N. 9), *G.* (*T.*) *peripheroronda* (up to N. 11?), *G.* (*T.*) cf. *praescitula* (typical form ranges up to near top of N. 9), and *G.* (*G.*) *archaeomenardii* (middle N. 8 to middle N. 10). The ranges indicated in parentheses are after BLOW (1969) for the sake of the convenience.

The first-mentioned species seems to present a delicate problem for taxonomy when we distinguish it from some transitional forms between *Orbulina* species and *Praeorbulina* species or certain *Globigerinoides* species which are frequently encountered in the younger sediments; the difficulty might be serious particularly if poorly preserved specimens were treated in the same way as the present case. In the case of the distinctly younger sediments, however, the transitional forms are always associated with typical *Orbulina* species. The Megami material does not contain any *Orbulina* species, even if more than four hundreds of deformed specimens were taken into account aside from those listed above, so the specimens from the Megami Formation may be identical to real *Globigerinoides sicanus*. Therefore, the formation may belong to N. 8, rather than to N. 9.

The occurrence incompatible to this age assignment might be expected for *Globorotalia* (*Turborotalia*) aff. *lenguaensis* (typical form ranges from middle N. 12 to near top of N. 17), *Globigerina* aff. *druryi* (typical one from basal N. 11 to middle N. 14) and *Globigerinoides* cf. *ruber* (typical one from middle N. 16 to Recent). Concerning the former two, however, there is room to reconsider the validity of Blow's zones N. 10 through N. 13 as the global standard of planktonic foraminiferal zones as implied before (UJIIÉ, 1975, mainly based upon the materials from the Deep Sea Drilling Project Sites 292 and 296). These zones might not be recognized in the western North Pacific region, nor of a very short time duration.

An interesting feature of the Megami planktonic fauna is a certain faunal affinity to those of N. 8 (?)–N. 9 found in the Oga and Noto Peninsulas of the Sea of Japan coast. *Globigerinoides japonicus* was described only from the Nishikurosawa Formation of the Oga Peninsula by the original authors (SAITO and MAIYA, 1973). At about the same time, UJIIÉ and HATSUKARI (1973) recognized the species from the Nakanami Formation of the Noto Peninsula as variation of *Globigerina* ? *woodi* JENKINS, but later UJIIÉ and HARIU (1975) found quite similar forms in the Sagara Formation of the latest Middle Miocene to Lower Pliocene in the same region of the present report. A more important species must be *Globorotalia* (*Turborotalia*) *quinifalcata*, which was reported first from the Nishikurosawa, Nakanami and Nanatani (Niigata Prefecture) Formations by SAITO and MAIYA (op. cit.) and from the Nakanami Formation by UJIIÉ and HATSU-

KARI (op. cit.) under the name of *Globorotalia* n. sp. (Pl. 1, figs. 4, 5 and 7, not 6). A considerable number of specimens of this turborotaline taxon can be recovered at Site 296 of the Deep Sea Drilling Project in the northernmost part of the Philippine Sea. So far as the present knowledge is conserned, the taxon seems to be characteristic of N. 8 and N. 9 of Japan and its adjacent seas. In addition to the two species, we can recognize common occurrence of many other taxa between the Megami fauna and those of N. 8 (?) and N. 9 reported from the Sea of Japan coast, as revealed by the comparison of the faunal composition indicated heretofore with data given by SAITO and MAIYA (op. cit.), UJIIÉ and HATSUKARI (op. cit.) and MAIYA (1975). It is possible to conjecture that the Megami fauna was a link between the provincial fauna in the Sea of Japan coast and the subtropical to tropical one in the Pacific Ocean during the Early to earliest Middle Miocene age.

Significance for the Regional Geology

The Megami Formation is located in the core of a southwesterly plunging anticline (Megami Anticline) composed of the Sagara Group, on the southwest side of the River Ooigawa. Since the work of CHITANI (1926, 1932), many authors considered that the Megami Formation is folded with the same trend as the Megami Anticline. Such structure was seemingly inferred from some linear arrangements of several limestone blocks around the middle of the zonal distribution of the Megami Formation. This speculation (e. g., MAKIYAMA, 1941), however, is based upon the quite limited observation of lithology of the formation, which outcrops very poorly and consists of the mélange of limestone, sandstone, mudstone and shale. A few measurements of bedding planes in some clastic rocks and of clayey insertions in limestone suggest that the general trend of the structure of the Megami is apparently perpendicular to that of the surrounding Sagara Group as mentioned before (e. g., UJIIÉ, 1962).

Diverse opinions have been presented also about the stratigraphic relationship between the Sagara and the Megami. MAKIYAMA (1941 et seq.) regarded the relation as unconformable, which remains intact at least judging from the "arm-waving" boundary lines on his geologic map. On the other hand, a fault relation was supposed by CHITANI (1926, 1932) and others, and evidenced by an exposure showing the very contact accompanied by two fault planes (UJIIÉ, 1962). Moreover, as I pointed out already (op. cit.) it cannot be expected that such unconformable contact would be reserved in situ, because the steeply dipping, or sometimes overturned, bedding planes of the surrounding Sagara Group near the boundary indicate a remarkable upheaval of the Megami Formation resulting in the horst, and consequently any part of the Sagara Group once covered the Megami Formation must have been eroded out before the present time.

Merely from the microbiostratigraphic point of view, nevertheless, a distinct unconformity can be supposed between the Megami Formation and the Sagara Group. The former belongs to the planktonic foraminiferal zone N. 8 (latest Early Miocene),

while UJIIÉ and HARIU (1975) showed a continuous sequence from N. 19 through N. 14 (Lower Pliocene to late Middle Miocene) over the whole thickness of the Sagara Formation, upper member of the Sagara Group. The lower member, Sugegaya Alternation, may still belong to lower N. 14 as its lithofacies implies a very fast rate of deposition (see UJIIÉ and HARIU, op. cit., for further discussion). The Sugegaya Formation is rich in agglutinated benthic Foraminifera but barren of planktonic ones, so it is easily concluded that the planktonic fauna treated here is from the mudstone within the mélange of the Megami Formation, but not from the lowermost portion of the Sagara Group.

The Megami planktonic foraminiferal fauna can be correlated with the *Globigerinoides "bisphericus"* (=*sicanus*)/*Globigerinatella insueta* Zone observed by SAITO (1960) in the Shinzaike Green Tuff (=Kurami Green Tuff of UJIIÉ, 1958) and in the Saigo Mudstone; namely, in the upper portion of the Mikasa Group. The Mikasa is widely distributed at about 15 to 25 km northwest of Megami beyond the area of the Sagara Group and the overlying Kakegawa Group. The present zoning by SAITO (1960) is still effective in indicating the age of the latest Early Miocene, equivalent to N. 8, but his classification may not be satisfactory for the modern taxonomy of planktonic Foraminifera which has been much advanced in recent years. At any rate, it is noticed that both Megami and Shinzaike Formations yield larger Foraminifera *Lepidocyclina* (*Nephrolepidina*). Using isolated specimens from the Megami Formation, HANZAWA (1943) emended *L.* (*N.*) *nipponica* (HANZAWA) and regarded its age as Burdigalian, whereas another nephrolepidine was found from the Shinzaike Formation by MAKIYAMA (1947). Later, MORISHIMA (1949) described MAKIYAMA's samples as representing a new species, *L.* (*N.*) *makiyamai*. Because of its taxonomic affinity to *L.* (*N.*) *rutteni* which is popular in Indonesia, MORISHIMA assigned the age of the Shinzaike Formation (=MAKIYAMA's Tozawa Formation) to "Vindobonian". This assignment agrees with the idea of MAKIYAMA, his teacher, about the regional geology of the area; namely, MAKIYAMA (1941 et seq.) thought that the Saigo "Group" including the Tozawa as its basal member must be stratigraphically higher than the Megami Formation of the "Ooigawa Group". In the meantime, HANZAWA (1947) was inclined to lump together *L.* (*N.*) *nipponica* and *L.* (*N.*) *japonica* YABE (the latter is senior synonym) and, recently MATSUMARU (1971) seemed to accept HANZAWA's opinion (personal communication) in putting *L.* (*N.*) *makiyamai* into *L.* (*N.*) *japonica* (s. l.). The conspecific relationship between "*nipponica*" and "*makiyamai*" is also substantiated from the standpoint of the planktonic foraminiferal biostratigraphy discussed heretofore.

Some confliction in the stratigraphy of the area caused by MAKIYAMA (1941 to 1974) may be ascribed, at least partly, to that he included the Megami Formation into the Ooigawa Group. The typical Megami Formation exposed at Megami, Sagara-machi, and its environs shows perfectly isolated distribution apart from the so-called Megami Formation in the river-cliff and on the northeast side of the River Ooigawa (see geologic map by UJIIÉ, 1962), where the main portion of the Ooigawa Group is developed well. From the so-called Megami in the river-cliff, SAITO (1960) reported

a few planktonic Foraminifera indicative of the *Globigerina ampliapertura* Zone of Oligocene. The different zones indicated by this fauna and by the fauna from the typical Megami Formation as reported here completely correspond to their separate distributions in field. In other words, the Megami Formation in strict sense is correlatable with the Mikasa Group of Early Miocene, at least partly.

References

BLOW, W. H., 1969. Late Middle Eocene to Recent planktonic foraminiferal biostratigraphy. *Proc. 1st Internat. Conf. Plankt. Microfossils, Geneva 1959*: 1: 199–422, 54 pls.

CHITANI, K., 1926. The Tertiary in the vicinity of Kakegawa and Sagara, Totomi. *Jour. Geogr.*, **38**: 84–89 (In Japanese).

CHITANI, K., 1932. "Shizuoka"; An explanatory text of the geological map of Japan (in scale of 1: 75,000). 48 pp., Geol. Surv. Japan (In Japanese).

HANZAWA, S., 1943. Notes on some Miocene Foraminifera from the Sagara oil field, Japan. *Jour. Geol. Soc. Japan*, **50**: 125–134, pls. 7–11.

HANZAWA, S., 1947. Check list of Tertiary larger Foraminifera of Japan. *Jour. Paleont.*, **21**: 563–569.

IKEBE, N., 1954. Cenozoic biochronology of Japan. *Jour. Inst. Polytech., Osaka City Univ., ser. G*, **1**: 73–86.

ISHIJIMA, W., 1932. On two species of Coralinae from the Tertiary of Japan. *Jap. Jour. Geol. Geogr.*, **9**: 143–147.

ISHIJIMA, W., 1933. On three species of Corallinaceae lately obtained from the Megami-yama limestone, Sagara district, Province of Totomi. *Ibid.*, **11**: 27–30, pl. 5.

ISHIWADA, K., 1894. On some organic remains from the Tertiary limestone near Sagara, Totomi. *Jour. Coll. Sci. Imp. Univ. Tokyo*, **7**:

MAIYA, S., 1975. Late Cenozoic planktonic foraminiferal biostratigraphy in the oil fields of Northeast Japan. *Spec. Publ. Tech. Inst., JAPEX*, (35): 97 pp. (In Japanese).

MAKIYAMA, J., 1941. Tertiary stratigraphy and structure in the lower Ooigawa area. Mem. Lect. Commem. Prof. H. YABE's 60th Birthday, 13 pp. (In Japanese with English abstract).

MAKIYAMA, J., 1947. Discovery of *Lepidocyclina* from the Tozawa Formation, Shizuoka Prefecture. *Jour. Geol. Soc. Japan*, **53**: 115. (In Japanese).

MAKIYAMA, J., 1974. Chûbu-chihô [Central Province] (in the series-books on the regional geology of Japan). Asakura Publ. Co., Tokyo, 451 pp., 2nd ed. (In Japanese).

MATSUMARU, K., 1971. Studies on the genus *Nephrolepidina* in Japan. *Sci. Rep. Tohoku Univ., 2nd ser.*, **42**: 97–185, pls. 9–26.

MORISHIMA, M., 1949. A new Miocene *Lepidocyclina* from Shizuoka Prefecture, Japan. *Jour. Paleont.*, **23**: 210–213, pls. 44, 45.

SAITO, T., 1960. Tertiary stratigraphy of the Kakegawa district, central Japan and its planktonic Foraminifera. *Contr. Inst. Geol. Paleont., Tohoku Univ.*, (51): 45 pp. (In Japanese with English abstract).

SAITO, T. & S. MAIYA, 1973. Planktonic Foraminifera of the Nishikurosawa Formation, Northeast Honshu, Japan. *Trans. Proc. Palaeont. Soc. Japan, N. S.*, (91): 113–125, pls. 17–19.

UJIIÉ, H., 1958. Geological structure of the Sagara-Kakegawa Sedimentary Basin. Proc. Symposium on the Japanese Neogene Tertiary, Geol. Soc. Japan, 1–7 (In Japanese).

UJIIÉ, H., 1962. Geology of the Sagara-Kakegawa Sedimentary Basin in central Japan. *Sci. Rep. Tokyo Kyoiku Daigaku, ser. C*, (75): 123–188.

UJIIÉ, H., 1963. Some problems in the recent studies on the Neogene Tertiary of the western Shizuoka

Prefecture. *Kaseki* [*Fossils*], (5): 105–110 (In Japanese).

UJIIÉ, H., 1975. Planktonic foraminiferal biostratigraphy in the western Philippine Sea, Leg 31 of DSDP. *Initial Reports of the Deep Sea Drilling Project*. **31**: 677–692, 5 pls.

UJIIÉ, H., in press. New genus *Prosphaeroidinella*: probable ancestral form of *Sphaeroidinellopsis*. *Jour. Foram. Res.*

UJIIÉ, H. & S. HARIU, 1975. Early Pliocene to late Middle Miocene planktonic Foraminifera from the type section of the Sagara Group, central Japan. *Bull. Natn. Sci. Mus., ser. C*, **1**: 37–54, 3 pls.

UJIIÉ, H. & M. HATSUKARI, 1973. Nepionic acceleration and geologic distribution of the Japanese *Miogypsina*. *Mem. Geol. Soc. Japan*, (8): 95–105, 1 pl. (In Japanese with English abstract).

Explanation of Plates

(All figures ×100; a: spiral view, b: umbilical view, c: edge and apertural view)

Plate 1

(All specimens illustrated here come from the Megami Formation)

Fig. 1. *Globigerina* aff. *druryi* AKERS
Specimen different from the typical one in having more opened and deeply excavated umbilicus; Micropaleontology Collection Natn. Sci. Mus. 894.

Fig. 2. *Globigerinoides sicanus* DE STEFANI
Spiral view showing a slit aperture along the suture; Micropal. Coll. N. S. M. 895.

Fig. 3. *Globigerinoides japonicus* SAITO & MAIYA
Micropal. Coll. N. S. M. 896.

Fig. 4. *Globigerinoides* cf. *ruber* (D'ORBIGNY)
Representing probably the earliest occurrence of this Recent species; Micropal. Coll. N. S. M. 897.

Figs. 5, 6. *Globorotalia* (*Turborotalia*) *birnageae* BLOW
Micropal. Coll. N. S. M. 898 and 899.

Plate 2

(All specimens illustrated here come from the Megami Formation)

Figs. 1, 2. *Globorotalia* (*Turborotalia*) *siakensis* LEROY
Micropal. Coll. N. S. M. 900 and 901.

Fig. 3. *Globorotalia* (*Turborotalia*) *quinifalcata* SAITO & MAIYA
Seemingly most characteristic in the zones N. 8 and N. 9 of the western North Pacific region, particularly at its middle latitude; Micropal. Coll. N. S. M. 902.

Fig. 4. *Globorotalia* (*Turborotalia*) cf. *praescitula* BLOW
Somewhat different from the typical species in having thicker test; Micropal. Coll. N. S. M. 903.

Figs. 6, 7. *Globorotalia* (*Turborotalia*) *peripheroronda* BLOW & BANNER
Micropal. Coll. N. S. M. 904 and 905.

Fig. 8. *Globorotalia* (*Turborotalia*) aff. *peripheroronda* BLOW & BANNER
Micropal. Coll. N. S. M. 906.

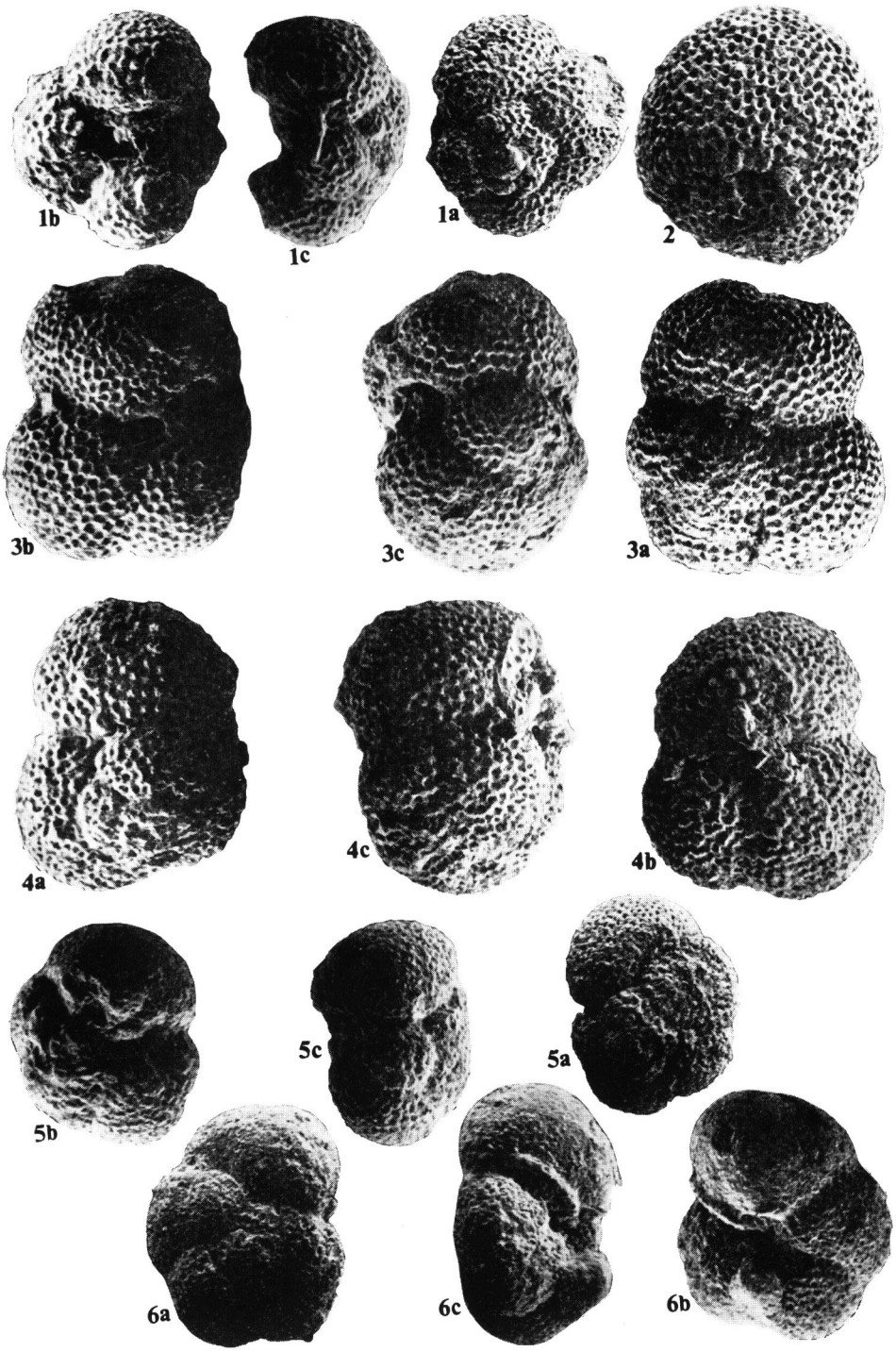
Plate 3

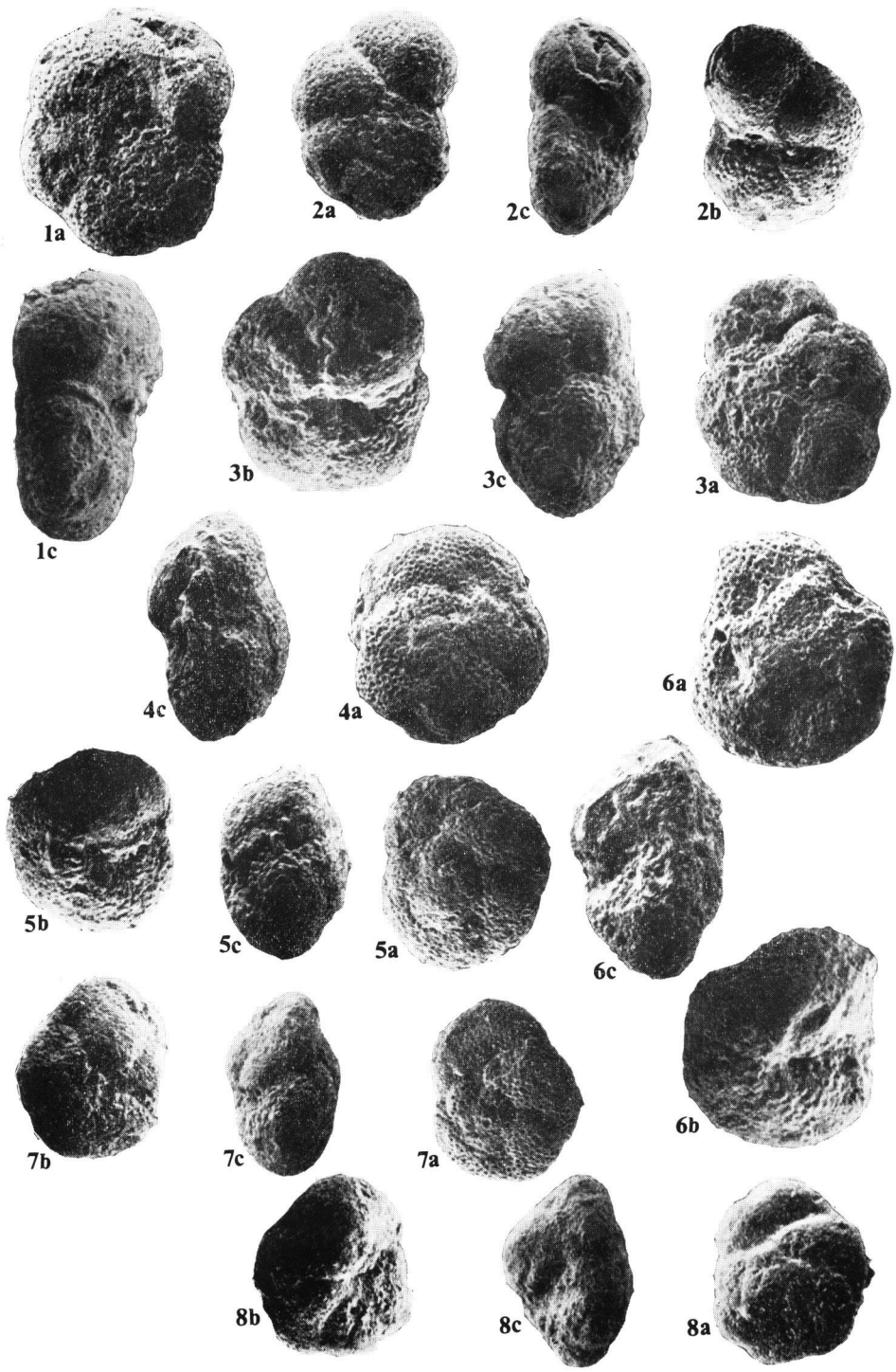
Fig. 1. *Globorotalia* (*Turborotalia*) cf. *continuosa* BLOW
From Sample 5 of the lowermost part (N. 15) of the Sagara Formation; Micropal. Coll. N. S. M. 890.

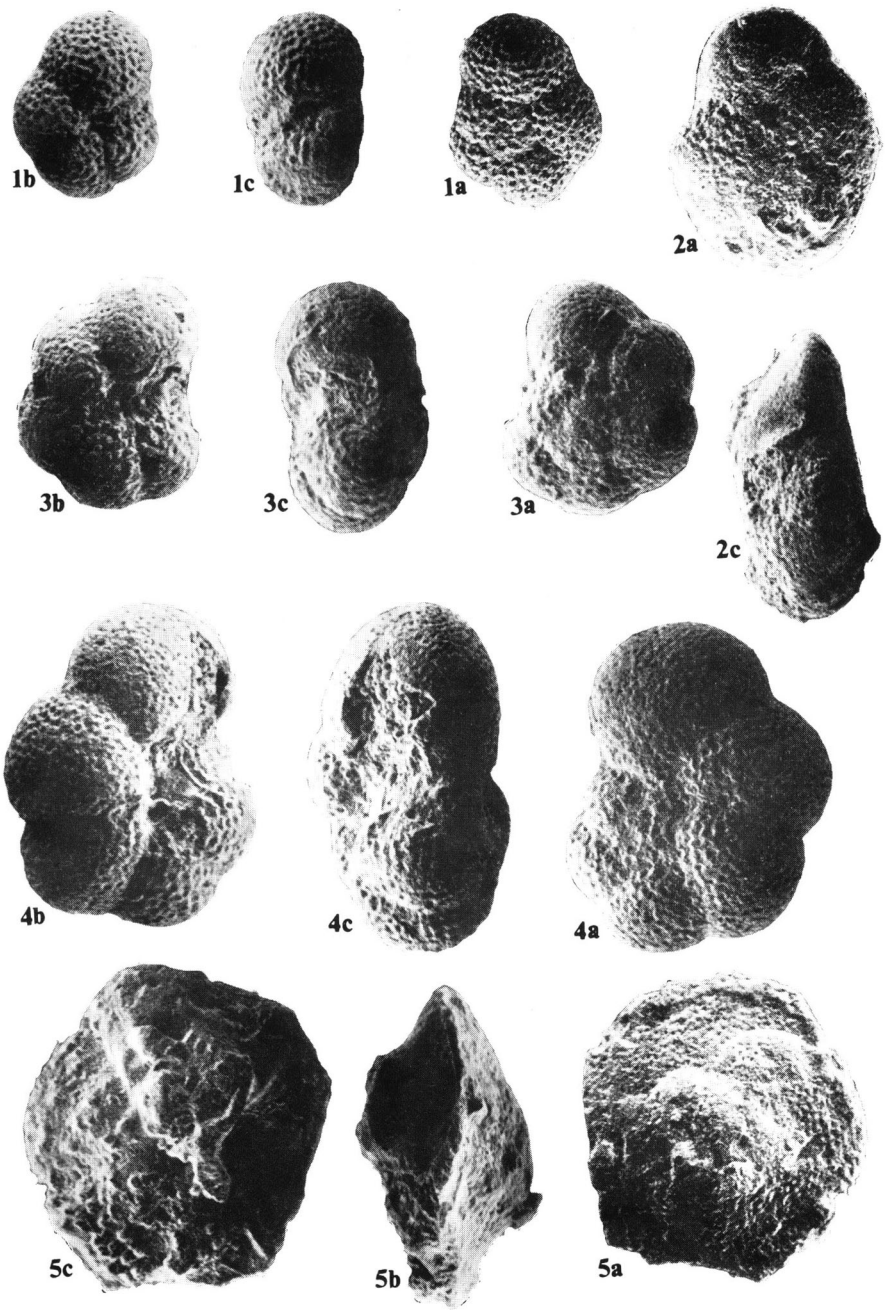
Fig. 2. *Globorotalia* (*Turborotalia*) aff. *peripheroacuta* BLOW & BANNER
Showing one of much delayed occurrences of this species; from Sample 7 (basal N. 15) of the Sagara Formation; Micropal. Coll. N. S. M. 891.

Figs. 3, 4. *Globorotalia* (*Turborotalia*) *siakensis* LEROY
Typical specimens occurred beneath the probable extinction datum of the species; from Sample 3 (near top of N. 14 of the Sagara Formation); Micropal. Coll. N.S.M. 888 and 889.

Fig. 5. *Globorotalia* (*Globorotalia*) *archaeomenardii* BOLLI
Specimen broken largely but still resembling the species; from the Megami Formation; Micropal. Coll. N. S. M. 907.


1b
1c
1a
2
3b
3c
3a
4a
4c
4b
5b
5c
5a
6a
6c
6b


1a
2a
2c
2b
1c
3b
3c
3a
4c
4a
6a
5b
5c
5a
6c
7b
7c
7a
6b
8b
8c
8a


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