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# Microfossils of the core sample GDP-11-15 from the Amami Plateau, the northern margin of the Philippine Sea*

By

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**Abstract**

The micropaleontological studies of a gravity core taken from a depth of 1,830 m on the Amami Plateau, situated at the northern margin of the Philippine Sea, have revealed a presence of hiatus between the late Pliocene and the late Pleistocene sediments. Furthermore, the conspicuous difference in the water depths of the accumulation of sediments is recognized between the portions above and below the hiatus. Consequently, it is considered that the plateau submerged with the amount of about 1,000 m during the latest Pliocene and early Pleistocene.

Lastly two foraminiferal species are described: *Globocassidulina ikebei* and *Pleurostomella delicata.*

## Introduction

Recently, the geological and paleontological informations of the Philippine Sea have rapidly increased in process of various research projects. Many results of micropaleontololical investigations on sediment cores collected by the R/V Vema and the D/V Glomar Challenger in the northern Philippine Sea, have already been published (ELLIS, 1975; KOIZUMI, 1970, 1975a, b; TAKAYAMA, 1969, 1970; UJIIE, 1975a, b, c; UJIIE and MIURA, 1970, 1971; THE SHIPBOARD SCIENTIFIC PARTY, 1975; LING, 1975a, b).

Nearly the same time, the eleventh research cruise of Japanese Geodynamics Project (GDP-11 Cruise) was excuted by the R/V Tokaidaigaku-maru II in the northern Philippine Sea in August, 1974. During this cruise, continuous echo sounding, contiuous seismic reflection profiling and frequent bottom sampling were carried

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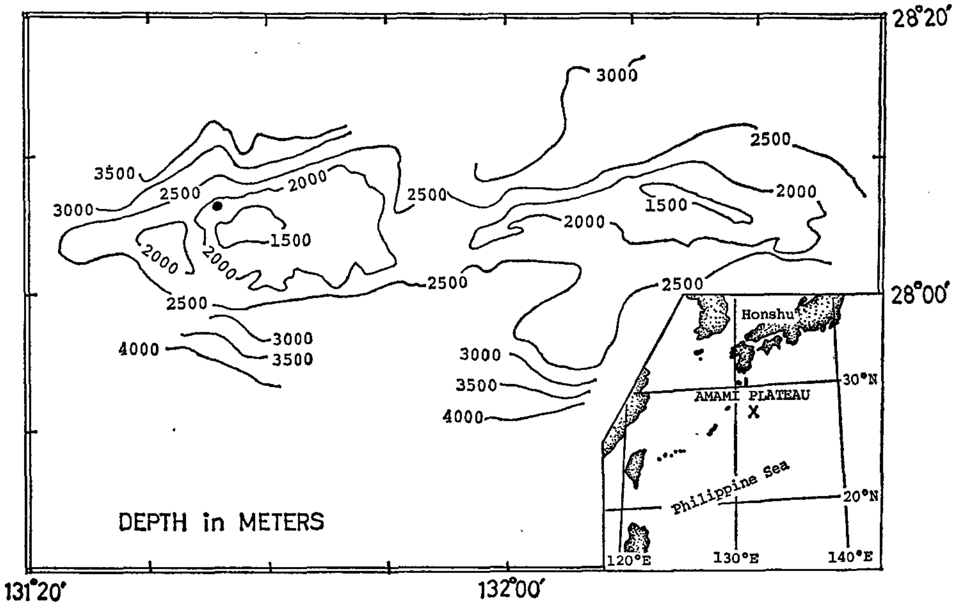


Fig. 1. Map showing the station GDP-11-15, after MISAWA and HOSHIZAWA (1975).

out. The geological and paleontologial results were reported at the Symposium "Geological Problems of the Philippine Sea Area" at the annual meeting of the Geological Society of Japan, Kyoto, April 3, 1975 and at other opportunities, and several synoptical reports have been presented (AOKI, 1975; AOKI *et al.*, 1975; KONDA, 1975; KONDA *et al.*, 1975; KONDA *et al.*, in press; MATSUDA *et al.*, 1975; RESEARCH MEMBERS OF GDP-11 CRUISE, 1975; SHIKI *et al.*, 1975; SHIKI *et al.*, 1975; SUWA and AOKI, 1975). Besides these papers, acoustic stratigraphy and submarine topography of the Amami Plateau and the Komahashi Seamount have been described in detail (MISAWA, 1975; MISAWA and HOSHIZAWA, 1975).

One of the most interesting samples obtained in this cruise is a sediment core taken by a gravity corer at the station GDP-11-15 (Latitude 28°06.2'N., Longitude 131°35.2'E., Water depth 1,830 m) on the westward flat of the major peak of the Amami Plateau (Fig. 1). The sample is composed of pale-creamy calcareous ooze and has a whole length of fifty centimeters. The biostratigraphical and paleoecological studies of this core suggest the abrupt submergence of the Amami Plateau.

The purposes of the present paper are 1) to establish the precise biostratigraphy of microfossils of this core, 2) to discuss the change of the environmental conditions inferred from the microfossils, and 3) to describe two new benthonic foraminiferal species.

## Material and Method

After the sample was taken out from the inner tube of the core sampler, its lithology, color *etc.* were described immediately on the shipboard (Fig. 2). The whole of the core sample is exclusively composed of calcareous ooze. The ooze is gradually consolidated downward. The sharp change of the color is observed at about fifteen centimeters below the top (near the boundary between the sample GDP-11-15-(17) and (18)). According to the observation under a binocular microscope, the composition of the sample is mostly foraminiferal tests and fine matrix, and siliceous micrososssils such as radiolaria are rarely found. Glassy fragments and mafic minerals are scattered in the upper part of the core.

Before the analysis of the microfossils, the sample was prepared by the following way.

i) The sample was cut longitudinally into two parts, and one part has been deposited in the Department of Geology and Mineralogy, Kyoto University, and the other one was used for microfossil analysis.

ii) The sample for microfossil analysis was further divided horizontally every one centimeter and these were numbered from the top to the bottom.

iii) Microfossil analysis was performed at stratigraphic interval of five centimeters, and at closer interval around the boundaries of microfossil assemblages.

iv) Each material was added with a small amount of distilled water and stirred up to be disintegrated.

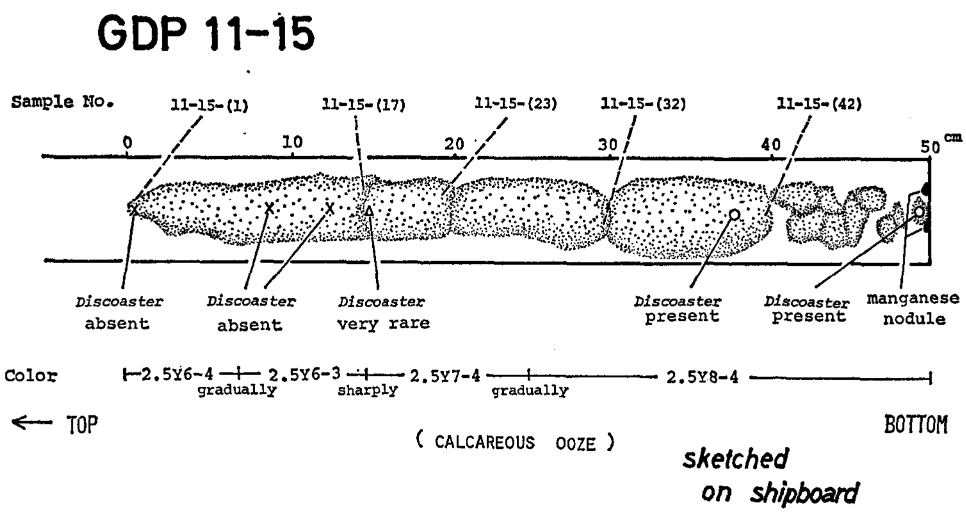


Fig. 2. Sketch of the core sample GDP-11-15.

v) The top of the water was decanted out and was provided for the analysis of calcareous nannoplanktons. The residue was used for foraminiferal analysis.

Analysis of calcareous nannoplanktons; In order to obtain nannoplanktons, suspended water samples were centrifuged. For the observation of a scanning electronmicroscope (SEM), after mounted on a glass, the samples were coated with carbon and gold. Under the SEM with TV apparatus, more than 300 specimens of calcareous nannoplanktons were identified and counted at random. Nannoplanktons were analyzed for seventeen samples, GDP-11-15-(1), (6), (7), (8), (9), (10), (11), (16), (17), (18), (21), (26), (31), (36), (41), (46), and (50).

Foraminiferal analysis; The sample for foraminiferal analysis was mechanically split into moderate fractions. Analyses of planktonic and benthonic foraminifers were performed separately using different fractions. Planktonic and benthonic specimens were picked up from the sieved residue of a 115 and 200 mesh screen respectively. Actual number of specimens per grams was not calculated. Both planktonic and benthonic foraminifers were analyzed for thirteen samples, GDP-11-15-(1), (6), (11), (16), (17), (18), (21), (26), (31), (36), (41), (46), and (50).

## Micropaleontology

1. Calcareous nannoplankton fossils

Well preserved calcareous nannoplanktons were abundantly contained throughout the present selected core samples. Identified taxa in the core sample are shown in Table 1 and Figure 3.

Based on the composition of these nannoplankton assemblages, the present nannoflora can be subdivided into three assemblages as follows in ascending oder; the assemblage I is GDP-11-15-(50) to (18), the assemblage II GDP-11-15-(17) to (11), and the assemblage III GDP-11-15-(10) to (1).

The assemblage I (GDP-11-15-(50)~(18))

The assemblage I is composed of *Reticulofenestra reticulata*, *R. reticulata* var., *Pseudoemiliania lacunosa*, *Cyclococcolithina macintyrei*, *C. leptopora*, *Discoaster pentaradiatus*, *D. surculus*, *D. brouweri* (5 and 6 ray forms), and *D. variabilis*. This nannoplankton assemblage is characterized by the abundant occurrence of *Reticulofenestra reticulata* and *R. reticulata* var., and the presence of *Discoaster pentaradiatus*, *D. surculus* and *Pseudoemiliania lacunosa*.

The assemblage II (GDP-11-15-(17)~(11))

This assemblage consists of *Gephyrocapsa oceanica*, *G. caribbeanica*, *Ceratolithus cristatus*, *Cyclococcolithina leptopora*, *Helicopontosphaera kamptneri*, *Pseudoemiliania lacunosa*, and *Reticulofenestra reticulata*. Among the above mentioned species, *Gephyrocapsa oceanica* occupies about 60 percent of this nannoplankton population.

Table 1. Occurrences of calcareous nannoplanktons. (Frequencies in percent)

| SPECIES / SAMPLE | GDP — 11 — 15 (1) | (6) | (7) | (8) | (9) | (10) | (11) | (16) | (17) | (18) | (21) | (26) | (31) | (36) | (41) | (46) | (50) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Ceratolithus cristatus* | 0.3 | + | 0.8 | 0.2 | | 0.2 | 2.6 | 1.5 | 0.3 | + | | | | | + | | |
| *C. rugosus* | + | + | | | | | + | + | 0.3 | | 0.3 | | + | | | | + |
| *Coccolithus adoriaticus* | | | | | | | | | 4.2 | | | 0.3 | | | | | |
| *C. pelagicus* | + | + | | | | | + | 0.3 | 0.9 | 2.8 | 1.9 | 1.2 | 1.6 | 0.9 | 2.3 | 1.1 | 1.1 |
| *C. productus* | 0.5 | 0.3 | | 0.2 | 0.4 | 0.5 | 0.6 | | | | 0.3 | | | | | + | |
| *Cyclococcolithina leptopora* | 11.7 | 14.7 | 12.5 | 11.7 | 8.9 | 13.6 | 15.6 | 12.6 | 9.0 | 10.8 | 6.4 | 6.1 | 6.4 | 7.6 | 10.3 | 9.6 | 9.2 |
| *C. macintyrei* | 1.3 | | | | | | 1.7 | 1.5 | 2.2 | 2.3 | 3.6 | 4.9 | 3.9 | 5.4 | 4.3 | 4.1 | 4.9 |
| *Cyclolithella annula* | | 0.3 | 0.7 | 0.2 | | | 0.3 | + | + | | 0.6 | 2.3 | 0.9 | 0.6 | 0.6 | 0.6 | 0.9 |
| *Discoaster brouweri* (5 ray) | + | + | | | | | + | + | 0.3 | 1.1 | 1.1 | 0.3 | 0.9 | 1.1 | 1.7 | 0.9 | 0.9 |
| *D. brouweri* (6 ray) | | | | | | | | + | 0.3 | 1.5 | 0.6 | 0.3 | 0.3 | 0.3 | 0.6 | 0.6 | 0.9 |
| *D. brouweri rutellus* | | | | | | | + | | + | 1.1 | 0.3 | 0.3 | 0.6 | 0.6 | 0.3 | 0.9 | 0.3 |
| *D. challengeri* | | | | | | | + | + | + | 0.3 | + | | + | + | + | + | + |
| *D. pentaradiatus* | + | + | | | | | + | + | 2.2 | 4.0 | 6.9 | 8.1 | 7.0 | 7.0 | 4.3 | 6.6 | 2.6 |
| *D. surculus* | | | | | | | + | + | 0.3 | 1.7 | 1.4 | 0.3 | 0.3 | 2.3 | 0.6 | 0.6 | 0.6 |
| *D. tamalis* | | + | | + | | | | + | | + | + | 1.5 | 0.3 | + | + | 0.3 | 0.6 |
| *D. variabilis* | | | | | | | | | | + | + | + | + | + | 0.3 | + | 0.6 |
| *Emiliania huxleyi* | 19.1 | 19.2 | 33.0 | 18.7 | 28.1 | 24.4 | 0.6 | | | | | | | | | | |
| *Gephyrocapsa caribbeanica* | 0.5 | 0.3 | | 0.7 | 1.8 | 0.7 | | | 3.1 | | | | | | | | |
| *G. oceanica* | 41.1 | 45.7 | 36.0 | 47.1 | 36.9 | 37.5 | 59.9 | 57.8 | 18.3 | 6.5 | | | | | | | |
| *Helicopontosphaera hyalina* | | 0.6 | | | | | | | | | | | | | | | |
| *H. kamptneri* | 5.6 | 7.4 | 3.7 | 6.4 | 4.9 | 4.9 | 6.5 | 11.3 | 6.7 | 1.4 | 1.7 | 2.0 | 1.8 | 2.8 | 3.2 | 1.7 | 2.6 |
| *H. sellii* | | | | | | | | | | | | | | + | | 0.9 | 0.9 |
| *H. wallichi* | 0.8 | 0.3 | 0.3 | | | 0.2 | 0.3 | + | + | + | 0.3 | 0.6 | 0.3 | 0.6 | + | 0.6 | 1.1 |
| *Isthmolithus fossilis* | 0.3 | | | | | | | | | | | | | | | | |
| *Pontosphaera alboranensis* | + | + | | | | | 0.3 | + | | | | + | | | | | |
| *P. discopora* | | + | | | | 0.2 | + | + | + | | 0.3 | + | 0.9 | + | + | + | 0.3 |
| *P. multipora* | | + | | | | | | | | | | | | | | | |
| *P. japonica* | 0.3 | + | | 0.5 | 0.2 | 1.2 | 0.3 | + | + | | | | | | | | 0.6 |
| *Pseudoemiliania lacunosa* | | | 0.3 | 0.5 | 0.2 | | 0.3 | 1.5 | 1.1 | 5.9 | 7.2 | 6.7 | 4.8 | 8.2 | 3.7 | 6.3 | 6.6 |
| *Reticulofenestra reticulata* | | | | 0.2 | 0.2 | | | | 39.1 | 55.1 | 52.4 | 42.4 | 50.0 | 40.3 | 50.3 | 50.0 | 54.9 |
| *R. reticulata* var. | | | | | | | | | | | 13.0 | 14.5 | 17.0 | 22.0 | 16.4 | 15.7 | 16.1 |
| *Rhabdosphaera clavigera* | 3.2 | 4.3 | 2.0 | 2.6 | 3.3 | 4.4 | 1.4 | 0.9 | 3.7 | 0.3 | | | 0.9 | | | | + |
| *Scyphosphaera pulcherima* | | | | | | | | | | | 0.3 | | | | | 0.6 | 0.3 |
| *Sphenolithus abies* | | | | | | | | | + | | | | | | | | |
| *Syracosphaera pulchra* | 1.0 | 1.7 | 0.8 | 0.7 | 1.3 | 1.6 | | | 0.3 | + | 1.4 | 0.6 | 1.5 | 0.6 | 0.9 | | 0.6 |
| *Thoracosphaera pelagica* | + | + | | | | | | | + | | | | | | | | |
| *Umbellosphaera tenuis* | 0.3 | 0.6 | | | 0.3 | | 0.9 | | 0.3 | | | | | | | | |
| *Umbilicosphaera mirabilis* | 10.9 | 9.1 | 10.0 | 9.8 | 13.1 | 9.9 | 9.9 | 12.5 | 12.9 | 4.8 | 0.6 | 0.9 | 0.6 | | | | |

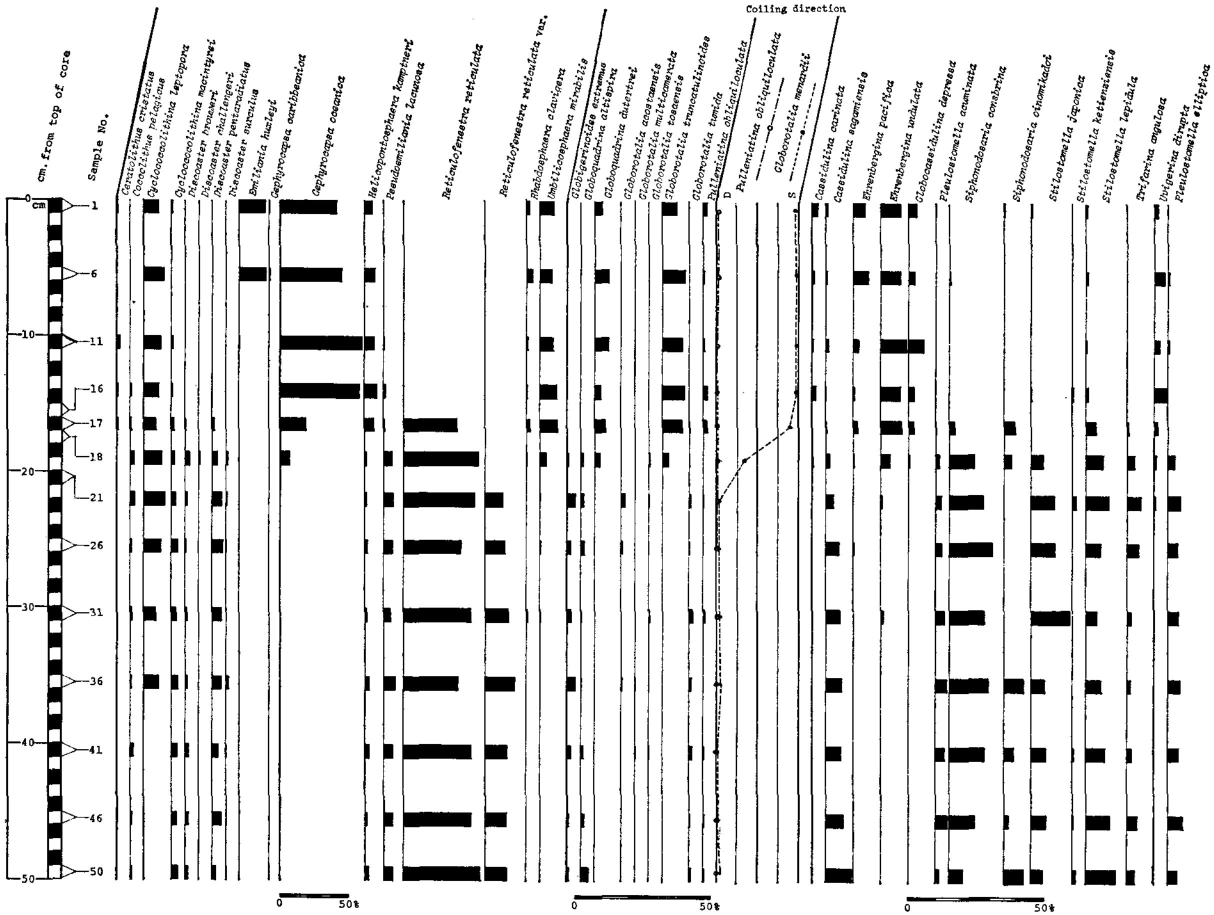


Fig. 3. Distributions of some impotant microfossils in selected samples.

There is no species of *Discoaster* spp. except for ill-preserved species possibly derived from the lower part.

The assemblage III (GDP-11-115-(10)~(1))

The assemblage III is made of *Emiliania huxleyi, Gephyrocapsa oceanica, Ceratolithus cristatus, Cyclococcolithina leptopora, Helicopontosphaera kamptneri, Rhabdosphaera clavigera,* and *Umbilicosphaera mirabilis. Emiliania huxleyi* is a dominant species and occupies 18 to 30 percent of the assemblage.

2. Planktonic foraminifers

In the present work, 26 species of planktonic foraminifers were identified. The results of the analysis are shown in Table 2 and Figure 3.

*Globigerina glutinata, Globigerinoides ruber, G. sacculifer,* and *Globorotalia inflata* commonly occur throughout the core. *Globigerina pachyderma, Globigerinella siphonifera,* and *Orbulina universa* are constantly found in a small amount. The core faunas can be divided into two assemblages as follows in ascending order; the assemblage A is GDP-11-15-(50) to (18), and the assemblage B GDP-11-15-(17) to (1).

The assemblage A (GDP-11-15-(50)~(18))

*Globigerinoides extremus, Globoquadrina altispira, Globorotalia acostaensis, G. multicamerata,* and *G. tosaensis* characterize this assemblage. The coiling directions of *Globorotalia menardii* and *Pulleniatina obliquiloculata* are predominantly dextral. *Globorotalia truncatulinoides,* which seems to be contaminated, is found in this assemblage within 0.4 percent of the total specimens.

The assemblage B (GDP-11-15-(17)~(1))

*Globoquadrina dutertrei* and *Globorotalia truncatulinoides* are characteristic species. The species characterizing the assemblage A occur in this assemblage within 1 percent of the total specimens and these seem to be derived from the lower part. The predominant coiling direction of *Globorotalia menardii* is sinistral and that of *Pulleniatina obliquiloculata* dextral in this assemblage.

3. Benthonic foraminifers

44 genera, 120 species and 8 subspecies of benthonic foraminifers were identified. These faunas are mostly composed of calcareous forms, and arenaceous ones are scarcely found throughout the whole section. Most of specimens are assumed to be indigenous, because they are fresh in appearance and are in well state of preservation.

The species of more than one percent frequency are listed in Table 3, and the frequency diagram of dominant and depth-diagnostic species are also shown in Figure 3.

Table 2. Occurrences of planktonic foraminifers. (Frequencies in percent)

| SPECIES / SAMPLE | GDP—11—15 (1) | (6) | (11) | (16) | (17) | (18) | (21) | (26) | (31) | (36) | (41) | (46) | (50) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Candeina nitida* D'ORBIGNY | | | | | | | | | 0.4 | | | | |
| *Globigerina pachyderma* (EHRENBERG) | 0.9 | 1.2 | 3.1 | 3.1 | 3.6 | 3.0 | 1.8 | 3.5 | 0.9 | 1.7 | | 0.9 | 2.3 |
| *G. quinqueloba* NATLAND | 1.8 | | 1.0 | 0.6 | 0.2 | | 0.3 | | | 0.2 | | | |
| *G.* spp. | 47.3 | 29.0 | 31.9 | 34.0 | 26.7 | 38.7 | 36.2 | 41.2 | 41.9 | 24.3 | 45.1 | 31.3 | 29.1 |
| *Globigerinella siphonifera* (D'ORBIGNY) | 0.9 | 1.2 | 0.5 | | 1.4 | 0.5 | 0.5 | 1.0 | 2.6 | 2.1 | 0.7 | 0.4 | 0.3 |
| *Globigerinita glutinata* (EGGER) | 7.3 | 4.4 | 3.1 | 8.6 | 0.2 | 9.9 | 8.4 | 8.2 | 7.0 | 7.6 | 6.9 | 7.5 | 3.0 |
| *Globigerinoides conglobatus* (BRADY) | 0.9 | 0.4 | 0.3 | 1.2 | 0.5 | 1.0 | | 0.4 | 0.4 | 0.4 | | | 0.5 |
| *G. extremus* BOLLI | | | | | | 0.7 | 3.1 | 1.6 | 1.7 | 3.0 | 1.5 | 0.4 | 0.8 |
| *G. ruber* (D'ORBIGNY) | 8.2 | 17.1 | 14.6 | 8.0 | 13.7 | 8.4 | 10.2 | 10.1 | 4.4 | 10.6 | 4.7 | 10.6 | 11.0 |
| *G. sacculifer* (BRADY) | 5.5 | 6.3 | 4.4 | 3.1 | 3.6 | 4.4 | 8.4 | 7.3 | 7.9 | 6.4 | 3.6 | 7.9 | 6.8 |
| *Globoquadrina altispira* (CUSHMAN *et* JARVIS) | 0.5 | | 0.3 | 0.6 | | 1.0 | 1.3 | 1.5 | 0.4 | 0.1 | 1.1 | 1.3 | 2.5 |
| *G. dutertrei* (D'ORBIGNY) | 3.2 | 5.6 | 5.7 | 2.5 | 4.1 | 2.2 | | | | | | | |
| *Globorotalia acostaensis* BLOW | | | | | | | 1.8 | 0.6 | | 0.5 | | | 2.0 |
| *G. crassaformis* (GALLOWAY *et* WISSLER) | 1.4 | 1.2 | 1.0 | | 5.0 | 1.7 | 1.0 | 2.1 | 6.1 | 7.6 | 2.9 | 2.6 | 4.5 |
| *G. hirsuta* (D'ORBIGNY) | | | | | 0.2 | | | | | | | | |
| *G. inflata* (D'ORBIGNY) | 10.5 | 17.9 | 20.4 | 22.8 | 24.6 | 20.7 | 20.9 | 17.3 | 15.7 | 25.3 | 24.0 | 30.0 | 28.8 |
| *G. menardii* (D'ORBIGNY) | 0.5 | 0.4 | 0.3 | 0.6 | 0.2 | 2.2 | 2.6 | 3.4 | 1.7 | 3.9 | 4.4 | 3.5 | 4.5 |
| *G. multicamerata* CUSHMAN *et* JARVIS | | | | | | | | | | 0.2 | 0.4 | | |
| *G. scitula* (BRADY) | 0.9 | 2.4 | 2.1 | 0.6 | 2.3 | 0.7 | 0.3 | 0.5 | 2.2 | 2.4 | 1.5 | 1.8 | 1.0 |
| *G. tosaensis* TAKAYANAGI *et* SAITO | 0.5 | | | | | 0.5 | 0.3 | 0.2 | 0.4 | 0.1 | 0.4 | | |
| *G. truncatulinoides* (D'ORBIGNY) | 5.5 | 8.3 | 7.8 | 8.6 | 7.5 | 2.2 | 0.8 | 0.2 | 1.3 | 0.4 | 0.4 | 0.4 | 1.0 |
| *G. tumida* (BRADY) | | | | | 0.2 | 0.2 | 0.8 | 0.4 | 1.3 | 0.7 | 1.1 | 0.4 | 0.8 |
| *Orbulina bilobata* (D'ORBIGNY) | | | | | | | | | 0.4 | | | | |
| *O. suturalis* BRÖNNIMANN | | | | | | | | | | | 0.4 | | |
| *O. universa* D'ORBIGNY | 1.8 | 0.8 | 1.8 | 1.9 | 2.7 | 1.2 | 0.3 | 0.2 | 1.3 | 0.2 | 0.4 | | 0.5 |
| *Pulleniatina obliquiloculata* (PARKER *et* JONES) | 1.8 | 0.4 | 0.8 | 1.9 | 1.6 | | 0.3 | 0.2 | 0.9 | 0.1 | 0.4 | 0.4 | 0.3 |
| *Sphaeroidinella dehiscens* (PARKER *et* JONES) | | | 0.5 | | | 0.2 | 0.3 | 0.1 | | 0.7 | | 0.4 | 0.5 |
| unidentified specimens | 0.9 | 3.6 | 0.3 | 1.9 | 1.6 | 0.5 | 0.8 | | 0.9 | 1.4 | 0.4 | | |
| Total number of specimens | 220 | 252 | 383 | 162 | 439 | 406 | 392 | 822 | 229 | 803 | 275 | 227 | 399 |
| Coiling direction | | | | | | | | | | | | | |
| *G. menardii* — number of specimens | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 28 | 20 | 31 | 20 | 20 | 20 |
| *G. menardii* — dextral percent | 90 | 100 | 100 | 95 | 85 | 40 | 5 | 4 | 10 | 6 | 0 | 0 | 5 |
| *P. obliquiloculata* — number of specimens | 20 | 20 | 20 | 20 | 20 | 20 | 6 | 12 | 20 | 4 | 3 | 3 | 7 |
| *P. obliquiloculata* — dextral percent | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 95 | 100 | 100 | 100 | 100 |

Table 3. Occurrences of benthonic foraminifers.
(Frequencies in percent)
(Species of less than 1.0% frequencies are excluded in this list.)

| SPECIES / SAMPLE | GDP-11-15 (1) | (6) | (11) | (16) | (17) | (18) | (21) | (26) | (31) | (36) | (41) | (46) | (50) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Bolivinita* cf. *minuta* (NATLAND) | 4.7 | | 3.8 | 2.3 | 3.1 | 0.8 | | | 0.3 | | 0.1 | 0.9 | |
| *Brizalina pacifica* (CUSHMAN *et* MCCULLOCH) | | | 0.4 | | 2.2 | | | | | | | | |
| *B. pussilla* (SCHWAGER) | | 1.3 | 1.3 | 1.0 | 0.4 | 0.4 | | | 0.3 | | | | |
| *Bulimina rostrata* BRADY | 0.4 | 0.9 | 2.6 | 1.7 | 1.8 | 1.2 | | 1.1 | 1.0 | 0.9 | 0.4 | 2.1 | 3.7 |
| *B. translucens* PARKER | | | | 1.0 | 0.4 | 0.4 | | | | | | | |
| *Carpenteria balaniformis* GRAY | 2.2 | 0.9 | 0.4 | 1.7 | | 0.4 | | | | | | | |
| *Cassidulina carinata* SILVESTRI | 1.7 | 4.3 | 2.6 | 2.0 | 3.5 | 0.8 | | | | | | | |
| *C. neocarinata* THALMANN | | | | | | | 1.7 | 1.1 | 1.3 | | 0.1 | 0.9 | |
| *C. sagamiensis* ASANO | 0.9 | 0.4 | 1.3 | 0.3 | 0.4 | 1.7 | 3.0 | 5.0 | 5.1 | 6.0 | 5.8 | 6.4 | 9.7 |
| *Civicidoides bradyi* (TRAUTH) | 1.7 | 0.9 | 0.9 | 1.3 | 1.3 | 0.4 | | 0.4 | 0.3 | 0.4 | | | |
| *C. pseudoungerianus* (CUSHMAN) | 3.0 | 1.3 | 0.4 | 1.3 | 0.9 | | | 0.4 | 0.3 | | 0.5 | 0.4 | 0.7 |
| *C. wuellerstorfi* (SCHWAGER) | 1.7 | 1.7 | 1.7 | 3.0 | | | | | 0.7 | 0.4 | 0.4 | | |
| *Ehrenbergina pacifica* CUSHMAN | 4.7 | 5.6 | 2.1 | 0.7 | 1.8 | 0.4 | | 0.4 | | | | | |
| *E. undulata* PARKER | 7.3 | 7.3 | 9.8 | 7.3 | 7.9 | 3.7 | 0.4 | | 1.0 | | | | |
| *Epistominella exigua* (BRADY) | 0.9 | 0.4 | 1.3 | 0.7 | 3.1 | | | | | | | | |
| *E. pulchella* FUSEJIMA *et* MARUHASI | 0.4 | 2.2 | 2.1 | 0.3 | | | | | | | | | |
| *Fissurina formisa* (SCHWAGER) | | | | 1.0 | | | | | | | | | |
| *F. orbignyana* (SEGUENZA) | 0.9 | 0.9 | 0.4 | 0.3 | | 1.2 | | | | 0.4 | | 0.4 | |
| *Gavelinopsis translucens* (PHLEGER *et* PARKER) | 0.4 | 2.6 | 1.7 | | 2.2 | 0.4 | 2.2 | 1.8 | 1.0 | | 0.9 | 2.1 | 0.7 |
| *Globocassidulina depressa* (ASANO *et* NAKAMURA) | 3.4 | 2.6 | 6.0 | 2.3 | 2.2 | 0.8 | | | | | | | |
| *G. elegans bosoensis* (KUWANO) | 1.3 | 5.6 | 1.3 | 6.6 | 1.8 | 2.5 | 0.9 | 1.1 | 1.3 | | 0.9 | 0.4 | 0.7 |
| *G. ikebei* KONDA sp. nov. | | 2.2 | | 1.0 | | 0.4 | | | | 0.4 | | | 0.7 |
| *G. pacifica* (CUSHMAN) | 9.1 | 6.0 | 3.8 | 0.7 | 0.4 | 0.8 | 1.3 | 3.5 | 1.3 | 3.4 | 0.6 | 3.3 | 1.5 |
| *G. subglobosa* (BRADY) | 14.2 | 9.9 | 10.7 | 6.6 | 7.9 | 6.6 | 5.6 | 7.4 | 7.7 | 6.4 | 7.8 | 4.7 | 5.2 |
| *Gyroidina orbicularis* (D'ORBIGNY) | | | 5.1 | 4.0 | 3.5 | 1.2 | | | 1.7 | 0.4 | 0.8 | 0.4 | 0.7 |
| *Laticarinina halophora* (STACHE) | 1.3 | 0.4 | 0.4 | 0.3 | | | | | | | 0.1 | | |
| *Melonis affinis* (REUSS) | 1.3 | 0.4 | | 1.3 | 0.9 | | | | | | | | |
| *Oridosalis umbonatus* (REUSS) | 1.3 | 1.7 | 1.7 | 1.7 | 1.8 | 0.4 | 1.3 | 1.4 | 1.0 | 2.6 | 1.3 | 3.4 | 2.2 |
| *Orthomorphina challengeriana* (THALMANN) | | | | | | | | 0.4 | 2.0 | 0.4 | 0.8 | | 1.5 |
| *Osangularia bengalensis* (SCHWAGER) | 0.4 | 0.4 | 0.4 | | 0.4 | 0.4 | 0.9 | 0.4 | | 0.4 | 0.8 | 1.3 | 2.2 |

Table 3. (continued)

| SPECIES \ SAMPLE | GDP—11—15 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (6) | (11) | (16) | (17) | (18) | (21) | (26) | (31) | (36) | (41) | (46) | (50) |
| *Parafissurina ovalis* TODD | | 0.4 | 0.4 | 1.0 | | | 0.4 | 0.4 | 0.3 | | 0.4 | | |
| *Pleurostomella acuminata* CUSHMAN | 0.4 | | | | 0.4 | 1.7 | 2.2 | 2.5 | 3.3 | 4.3 | 3.6 | 4.7 | 1.5 |
| *P. brevis* SCHWAGER | | | | | | | | | 0.3 | | 0.9 | 1.3 | 1.5 |
| *P. elliptica* GALLOWAY *et* HEMINWAY | | 0.4 | 0.4 | | | 2.5 | 4.8 | 3.5 | 3.7 | 4.3 | 4.0 | 5.5 | 3.7 |
| *P. delicata* KONDA sp. nov. | | | | | | | 0.9 | | 1.4 | | 0.3 | 0.9 | |
| *P. praegerontica* CUSHMAN *et* STAINFORTH | | | | | | 2.1 | 0.4 | | 0.7 | 0.4 | 1.6 | 1.3 | |
| *P. rapana recens* DERVIEK | | | | | | | | | | | 0.1 | 0.4 | 1.5 |
| *Pullenia apertula* CUSHMAN | 0.4 | 0.4 | 1.7 | | 0.4 | | | | 0.3 | | | | |
| *P. bulloides* (D'ORBIGNY) | 2.2 | 1.7 | 0.9 | 1.0 | 1.8 | 1.2 | 0.4 | 1.8 | 1.0 | 1.3 | 1.6 | 1.7 | 3.7 |
| *P. quinqueloba* (REUSS) | 0.4 | 0.4 | | 0.7 | 0.4 | 0.8 | 0.4 | 0.4 | 1.0 | | 1.0 | 0.4 | |
| *Pyrgo murrhina* (SCHWAGER) | 0.4 | 0.4 | 1.7 | 1.3 | 0.9 | 1.7 | 0.9 | 0.4 | 0.7 | 0.4 | 0.8 | | |
| *Sigmoilina edwardsi* (SCHLUMBERGER) | | 2.2 | 1.3 | 0.3 | 0.4 | | 0.4 | | | 0.9 | 0.8 | 1.3 | |
| *Siphonodosaria consobrina* (D'ORBIGNY) | | 0.4 | | | 2.2 | 9.1 | 12.6 | 16.0 | 13.1 | 14.5 | 13.1 | 9.4 | 5.2 |
| *S. oinomikadoi* (ISHIZAKI) | 0.4 | | | | | 4.1 | 3.0 | | | 7.3 | 3.8 | 1.7 | 7.5 |
| *Siphouvigerina ampullacea* (BRADY) | 6.5 | 3.4 | 3.0 | 10.6 | 10.1 | 9.5 | 6.5 | 5.0 | 9.4 | 5.6 | 4.0 | 3.4 | 2.2 |
| *Sphaeroidina bulloides* D'ORBIGNY | | 0.9 | | 1.7 | 0.9 | 0.4 | | | 0.3 | | 0.3 | | |
| *Stilostomella bradyi* (CUSHMAN) | | | | | | | | | 2.0 | 0.9 | 0.3 | 0.4 | |
| *S. hayasakai* (ISHIZAKI) | | | | 0.3 | | 0.4 | 1.3 | | 0.3 | | 0.3 | 0.4 | |
| *S. hyugaensis* (ISHIZAKI) | | | | | | | | 1.1 | | | | 0.4 | |
| *S. japonica* (ISHIZAKI) | 0.4 | | | 0.3 | | 4.6 | 8.7 | 8.9 | 14.1 | 5.1 | 5.6 | 5.5 | 4.5 |
| *S. ketienziensis* (ISHIZAKI) | | | | 0.7 | | | 1.7 | | | | 0.9 | 0.4 | 1.5 |
| *S. lepidula* (SCHWAGER) | 0.9 | 0.9 | 0.4 | 1.0 | 4.0 | 6.6 | 8.7 | 5.7 | 4.0 | 6.4 | 7.1 | 8.9 | 11.2 |
| *Trifarina angulosa* (WILLIAMSON) | | | | | 0.4 | 2.9 | 5.2 | 4.6 | 1.7 | 1.3 | 1.9 | 3.8 | 3.0 |
| *T. bradyi* CUSHMAN | | | | | | 0.4 | 1.3 | 1.8 | 1.0 | 2.1 | 0.3 | 0.4 | |
| *Uvigerina auberiana* D'ORBIGNY | 1.3 | 1.7 | 1.3 | 2.0 | 1.8 | 1.7 | | 0.4 | | | 0.1 | | 0.7 |
| *U. dirupta* TODD | 1.7 | 3.9 | 2.1 | 4.6 | 1.3 | 0.8 | 0.4 | | | | | | |
| *U. proboscides* SCHWAGER | 0.9 | | 1.3 | 0.3 | 0.4 | | 0.4 | | 0.3 | | | | |
| Total number of specimens | 232 | 232 | 234 | 302 | 227 | 241 | 231 | 282 | 297 | 234 | 773 | 235 | 134 |

Throughout the whole section, *Globocassidulina subglobosa* and *Siphouvigerina ampllacea* are found with 8 and 6 percent on the average respectively, accompanied with *Globocassidulina pacifica*. However, the faunal assemblages of this core are divided into two types; namely, the assemblage α is GDP-11-15-(50) to (18), and the assemblage β GDP-11-15-(17) to (1).

The assemblage α (GDP-11-15-(50)~(18))

This assemblage is characterized by common occurrence of *Siphonodosaria consobrina*, *S. oinomikadoi*, *Stilostomella japonica*, *S. lepidula*, *Pleurostomella acuminata*, *P. elliptica*, *Cassidulina sagamiensis*, and *Trifarina angulosa* in oder of abundance. Furthermore, *Cassidulina neocarinata*, *Orthomorphina anbigua*, *O. challengeriana*, *O.* cf. *obituensis*, *Pleurostomella praegerontica*, *P. brevis*, *P. rapana recens*, *Stilostomella bradyi*, *S. hayasakai*, and *Trifarina bradyi* are contained only in this assemblage, though each frequency of them is relatively low.

The assemblage β (GDP-11-15-(17)~(1))

In this assemblage, species characterizing the assemblage α as mentioned above are completely replaced by *Ehrenbergina undulata*, *E. pacifica*, *Globocassidulina depressa*, and *Cassidulina carinata*. Besides these species, rare but continuous occurrence of *Bolivina* cf. *minuta*, *Brizalina pussilla*, *Laticarinina halophora*, *Melonis affinis*, *Uvigerina dirupta*, and species of *Epistominella* spp. is remarkable.

Table 4. Relationship among the assemblages of calcareous nannoplanktons, planktonic and benthonic foraminifers.

| Sample No. | | Nannoplankton fossils | | Foraminifers: planktonic | | Foraminifers: benthonic | Age |
|---|---|---|---|---|---|---|---|
| GDP 11-15 | (1)–(10) | III | NN 21 | B | N. 22 – N. 23 | β | late Pleistocene |
| | (11)–(17) | II | NN 20 | | | | |
| | (18)–(50) | I | NN 16 | A | N. 21 | α | late Pliocene |

4. Other microfossils.

Organic-walled microfossils such as dinoflagellates, acritarchs, pollen grains and spores were not found in these selected core samples. A small amount of siliceous microfossils of radiolaria, sponge spicules, diatoms and ebridians were contained in several samples; GDP-11-15-(36), (26), (18), (17), and (16).

The relationship among the assemblages of calcareous nannoplanktons, planktonic and benthonic foraminifers is shown in Figure 3 and Table 4.

## Conclusion

On the basis of nannoplanktons and planktonic foraminifers, the geological age of the present core is considered as follows.

The nannoplankton flora in this core is subdivided into three assemblages as mentioned above.

The assemblage I, judging from the coexistence of *Discoaster pentaradiatus* and *D. surculus,* belongs to the *Discoaster surculus* Zone, NN 16 (MARTINI and WORSELY, 1970) indicated by the interval from the last occurrence of *Reticulofenestra pseudoumbilica* to that of *Discoaster surculus*. In the range chart of calcareous nannoplankton datum indicators presented by MARTINI (1971), the first appearance of *Pseudoemiliania lacunosa* is recorded in the middle part of the *Discoaster surculus* Zone. A lack of *Reticulofenestra pseudoumbilica* and a few but continuous occurrence of *Pseudoemiliania lacunosa* from the lowest part in this core suggest that this assemblage may occupy the middle to upper part of the *Discoaster surculus* Zone.

Rare and sporadic occurrence of *Discoaster brouweri, D. pentaradiatus, D. tamalis* and *Pseudoemiliania lacunosa* of the assemblage II, suggests that these nannoplankton fossils might be contaminated and/or derived from the lower part. Based on the presence of *Gephyrocapsa oceanica* and the lack of *Emiliania huxleyi,* this assemblage is assigned to the *Gephyrocapsa oceanica* Zone, NN 20.

Abundant occurrence of *Emiliania huxleyi* in the assemblage III indicates that this assemblage belongs to the *Emiliania huxleyi* Zone, NN 21.

Accordingly, the *Discoaster pentaradiatus* Zone, NN 17, the *Discoaster brouweri* Zone, NN 18, and the *Pseudoemiliania lacunosa* Zone, NN 19, are lacking in this core.

NISHIDA (1976) noticed that *Gephyrocapsa protohuxleyi* is a valuable marker species in the middle to late Pleistocene in and around Japan. But there is no specimen of *G. protohuxleyi* in the assemblage II or III either. Consequently, it might be possible that sediments are lacking just below the appearance of *Emiliania huxleyi.*

As for the planktonic foraminifers, the assemblage A is thought to be of Zone N. 21 proposed by BLOW (1969), judging from the presence of *Globorotalia tosaensis* and *Globoquadrina altispira*. The assemblage B represents Zone N. 22 to N. 23 because of the frequent occurrence of *Globorotalia truncatulinoides*. The change of coiling direction of *Globorotalia menardii* supports this assignment. Furthermore, it is noticeable that specimens of *Pulleniatina obliquiloculata* are mostly dextral throughout the core. In other deep sea cores (Lamont Core V21–98; DSDP Leg 7 Site 62, 63, 64, 65) taken from the Philippine Sea and the western equatorial Pacific, the sinistral coiling *Pulleniatina obliquiloculata* have been predominantly recognized within Zone N. 21 and the lower part of Zone 22 (BRÖNNIMAN and RESIG, 1971; TAKAYAMA, 1973; UJIIE and MIURA, 1970, 1971). In comparison with these results, it is considered that the upper part of Zone N. 21 and the lower part of Zone N. 22 are lacking in the present core, corresponding to the result from the study of the nannoplanktons.

Thus, it is concluded that there is a hiatus between the upper Pliocene and the upper Pleistocene corresponding to a time gap of about 2 million years in this core.

On the benthonic foraminiferal fauna, a remarkable break is observed between the late Pliocene assemblage $\alpha$ and the late Pleistocene assemblage $\beta$.

In comparison with the depth distribution of Recent benthonic foraminiferal assemblage in the Philippine and adjacent seas (CUSHMAN, 1921; FUSEJIMA *et al.*, 1943; POLSKI, 1959; YABE and HANZAWA, 1925), the assemblage $\alpha$ is considered to be of the upper bathyal zone, perhaps at depth of several hundred meters, under a warm water condition. Whereas, the assemblage $\beta$ is regarded to be of the present depth. Therefore, the locality of the core is considered to have been under the bathyal condition in the late Pliocene. Subsequently, the sea bottom subsided relatively with the amount of about 1,000 m and in the late Pleistocene, this area had come to be at the present water depth.

In the Philippine Sea, some biostratigraphic gaps and paleoenvironmental changes have been discovered in the core sections during Leg 31 of Deep Sea Drilling Project (ELLIS, 1975; THE SHIPBOARD SCIENTIFIC PARTY, 1975; UJIIE, 1975b, c). According to UJIIE (1975c), the disconformity in the early to middle Miocene at Site 292 might have been caused by submarine erosion, and thereby reflected in lithologic change. In the present core, the fairly distinct lithologic change is observed between the portions above and below the hiatus. However, we cannot prove sufficiently the submarine erosion only with that change. Besides, KOIZUMI (1975a) recognized four cold-climate epochs and the corresponding sea level lowering after the Jaramillo Event on the basis of diatom distribution in the Lamont Core V21–80 taken from the Shikoku Basin.

However, nothing has been known on the hiatus and the environmental change during the period from the late Pliocene to the late Pleistocene in the northern Philippine Sea. The results reported here are the first which elucidate them during that period.

We have not sufficient data to discuss the origin of environmental change. Late Cenozoic sea level changes and/or crustal movements in the Philippine Sea and adjacent land areas have been discussed by HOSHINO (1975), KIZAKI and TAKAYASU (1976), IKEBE (1976), and OKUDA *et al.* (1976) from various points of view. More data of the similar kind to this paper should be necessary at various stations in the Philippine Sea and other areas to prove the geologic events. Therefore, benthonic fauna of depth indicators would be as significant as planktonic fossils of age indicators in the future investigation of the micropaleontology of deep sea cores.

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## Description of New Species

by Isao KONDA

Family CASSIDULINIDAE D'ORBIGNY, 1839
Genus *Globocassidulina* VOLOSHINOVA, 1960
*Globocassidulina ikebei* n. sp.
(Pl. 5, Figs. 1, 2, 3; Pl. 6, Figs. 1a, b, c, 2a, b, c)

Description: Test free, small, subglobular in outline, periphery broadly rounded, slightly lobulated; wall smooth; chambers few, inflated, three pairs composing adult test, alternate chambers extending to the umbilicus on one side with only a small triangular portion visible on the opposite side; sutures flush with surface in early portion, later very slightly depressed; aperture large and broad, but nearly covered by a large crescent lip.

Dimension: Length of holotype 0.390 mm; breadth 0.341 mm.

Holotype: Department of Geology and Mineralogy, Faculty of Science, Kyoto University, Coll. Cat. No. JC1011, from the sample GDP-11-15-(6), picked up from 5.0–6.0 cm depth under the surface in the gravity core GDP-11-15, Lat. 28°06.2′N., Long. 131°35.2′E., at a water depth 1,830 m.

Remarks: This new species resembles *Cassidulina caudriae* described by CUSHMAN and STEINFORTH (1945) from the Oligocene Cipero Marl Formation of Trinidad, West Indies. However, compared with the figured holotype of *C. caudriae*, this new species is distinguished from *C. caudriae* by its much smaller size and its different aperture nearly covered by its large crescent lip. The tribal name of this new species is dedicated to Professor Emeritus Nobuo IKEBE of Osaka City University in recognition of his work on the Japanese Neogene biostratigraphy and chronology.

Occurrence: Rare in core samples GDP-11-15-(50), (36), (18), (16), and (6).

Famly PLEUROSTOMELLIDAE REUSS, 1860

Genus *Pleurostomella* REUSS, 1860

*Pleurostomella delicata* n. sp.

(Pl. 5, Figs. 8a, b; Pl. 6, Figs. 3a, b, c, 4)

Description: Test free, small, elongate-oval in outline, nearly twice as long as broad, circular in cross section; wall thin, smooth, translucent; chambers few, each chamber covering major portion of preceeding one, reaching nearly to the base of test; sutures slightly depressed, indistinct in early stage; aperture small, with two small teeth on one side, and internal tube.

Dimension: Length of holotype 0.415 mm; breadth 0.220 mm.

Holotype: Department of Geology and Mineralogy, Faculty of Science, Kyoto University, Coll. Cat. No. JC1012, from the sample GDP-11-15-(21), picked up from 20.0–21.0 cm depth under the surface in the gravity core GDP-11-15, Lat. 28°06.2′N., Long. 131°35.2′E., at a water depth 1.830 m.

Remarks: This new species can be easily distinguished from other species of the genus in having a elongate-oval test. It is also characterized by a few chambers reaching nearly to the base of test.

Occurrence: Rare in core samples GDP-11-15-(50), (41), (31), and (21).

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## Explanations of Plates

**Plate 3**

(Scanning photomicrographs of planktonic foramnifers)

Figs. 1a, b: *Globorotalia truncatulinoides* (D'ORBIGNY),
from the sample GDP-11-15-(11), ×60.

Figs. 2a, b: *Globorotalia acostaensis* BLOW,
from the sample GDP-11-15-(21), ×90.

Figs. 3a, b: *Globorotalia tosaensis* TAKAYANAGI *et* SAITO,
from the sample GDP-11-15-(18), ×100.

Figs. 4, 5: *Globoquadrina altispira* (CUSHMAN *et* JARVIS),
4; from the sample GDP-11-15-(41), ×75.
5; from the sample GDP-11-15-(50), ×75.

Figs. 6a, b: *Globigerinoides extremus* BOLLI,
from the sample GDP-11-15-(21), ×100.

Figs. 7a, b: *Globorotalia multicamerata* (CUSHMAN *et* JARVIS),
from the sample GDP-11-15-(41), ×40.

**Plate 4**

(Scanning photomicrographs os benthonic foraminifers)

Figs. 1, 2: *Ehrenbergina undulata* PARKER,
from the sample GDP-11-15-(16), ×75.

Figs. 3, 4: *Cassidulina neocarinata* THALMANN,
3; from the sample GDP-11-15-(21), ×100.
4; from the sample GDP-11-15-(26), ×100.

Fig. 5: *Stilostomella lepidula* (SCHWAGER),
from the sample GDP-11-15-(50), ×45.

Figs. 6, 7: *Stilostomella ketienziensis* (ISHIZAKI),
from the sample GDP-11-15-(41), ×40.

Figs. 8, 9: *Ehrenbergina pacifica* CUSHMAN,
8; from the sample GDP-11-15-(6), ×90.
9; from the sample GDP-11-15-(1), ×85.

Fig. 10: *Stilostomella japonica* (ISHIZAKI),
from the sample GDP-11-15-(31), ×40.

Fig. 11: *Orthomorphina challengerina* (THALMANN),
from the sample GDP-11-15-(31), ×50.

Fig. 12: *Trifarina angulosa* (WILLIAMSON),
from the sample GDP-11-15-(46), ×100.

Fig. 13: *Trifarina bradyi* CUSHMAN,
from the sample GDP-11-15-(26), ×100.

Fig. 14: *Uvigerina auberiana* D'ORBIGNY,
from the sample GDP-11-15-(16), ×75.

Fig. 15: *Uvigerina dirupta* TODD,
from the sample GDP-11-15-(16), ×50.

Figs. 16, 17: *Siphonodosaria consobrina* (D'ORBIGNY),
16; from the sample GDP-11-15-(46), ×50.
17; from the sample GDP-11-15-(46), ×30.

**Plate 5**

(Scanning photomicrographs of benthonic foraminifers)

Figs. 1, 2, 3: *Globocassidulina ikebei* KONDA, n. sp., paratypes,
1; from the sample GDP-11-15-(16), ×90.
2; from the sample GDP-11-15-(36), ×90.
3; from the sample GDP-11-15-(6), ×120.

Figs. 4, 5: *Cassidulina sagamiensis* ASANO *et* NAKAMURA,
4; from the sample GDP-11-15-(31), ×100.
5; from the sample GDP-11-15-(18), ×90.

Figs. 6, 7: *Globocassidulina depressa* ASANO *et* NAKAMURA,
from the sample GDP-11-15-(16), ×200.

Figs. 8a, b: *Pleurostomella delicata* KONDA, n. sp., paratype,
from the GDP-11-15-(31), a; ×150, b; ×500.

Figs. 9, 10: *Cassidulina carinata* SILVESTRI,
9; from the sample GDP-11-15-(16), ×100.
10; from the sample GDP-11-15-(6), ×125.

Fig. 11: *Laticarinina halophora* (STACHE),
from the sample GDP-11-15-(1), ×50.

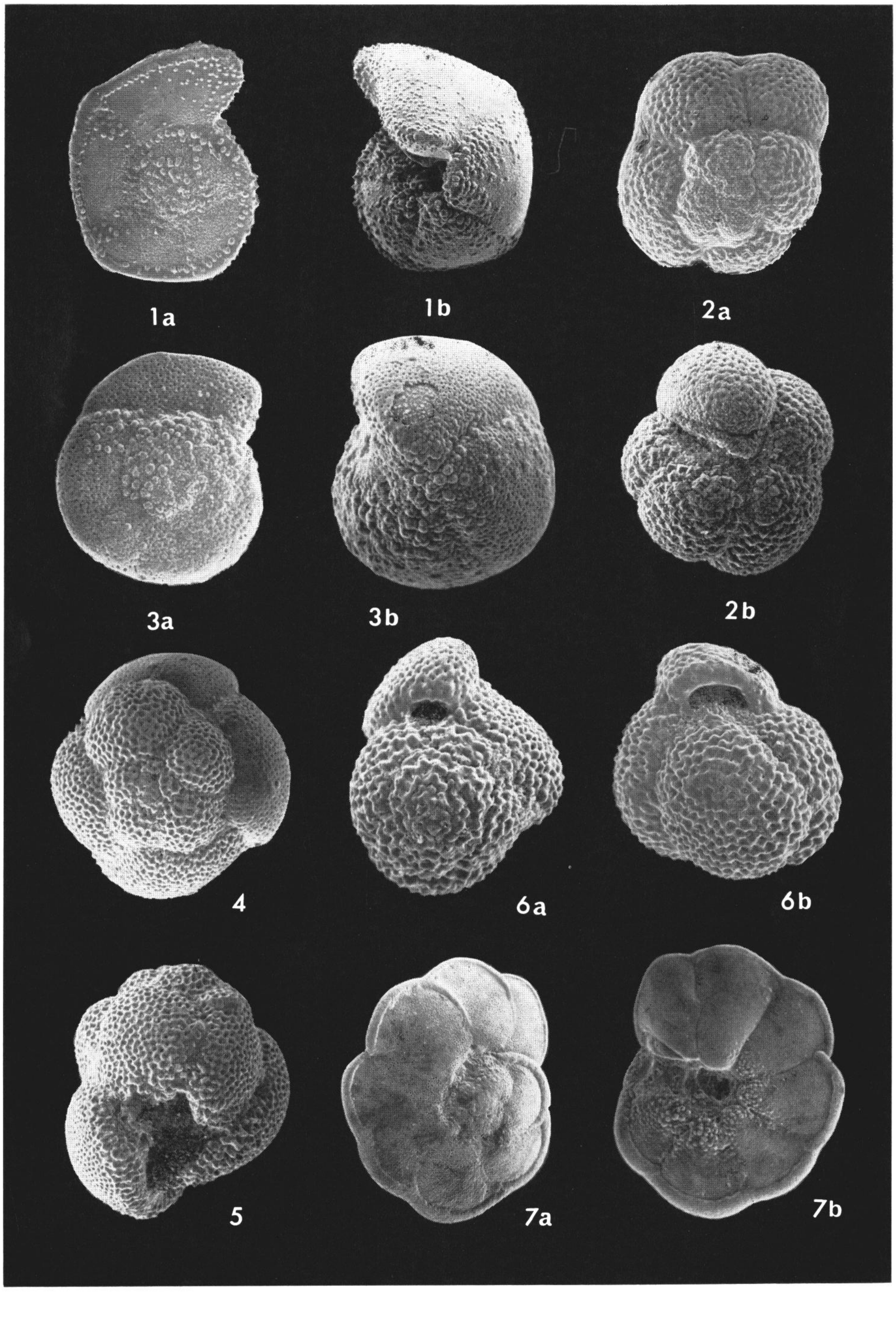
**Plate 6**

Figs. 1a, b, c: *Globocassidulina ikebei* KONDA, n. sp., holotype,
from the sample GDP-11-15-(6), ×110, a, c; side view b; edge view.

Figs. 2a, b, c: *Globocassidulina ikebei* KONDA, n. sp., paratype,
from the sample GDP-11-15-(16), ×110, a, c; side view, b; edge view.

Figs. 3a, b, c: *Pleurostomella delicata* KONDA, n. sp., holotype,
form the sample GDP-11-15-(21), ×110, a, c; side view, b; edge view.

Fig. 4: *Pleurostomella delicata* KONDA, n. sp., paratype,
from the sample GDP-11-15-(31), ×110, aperture side.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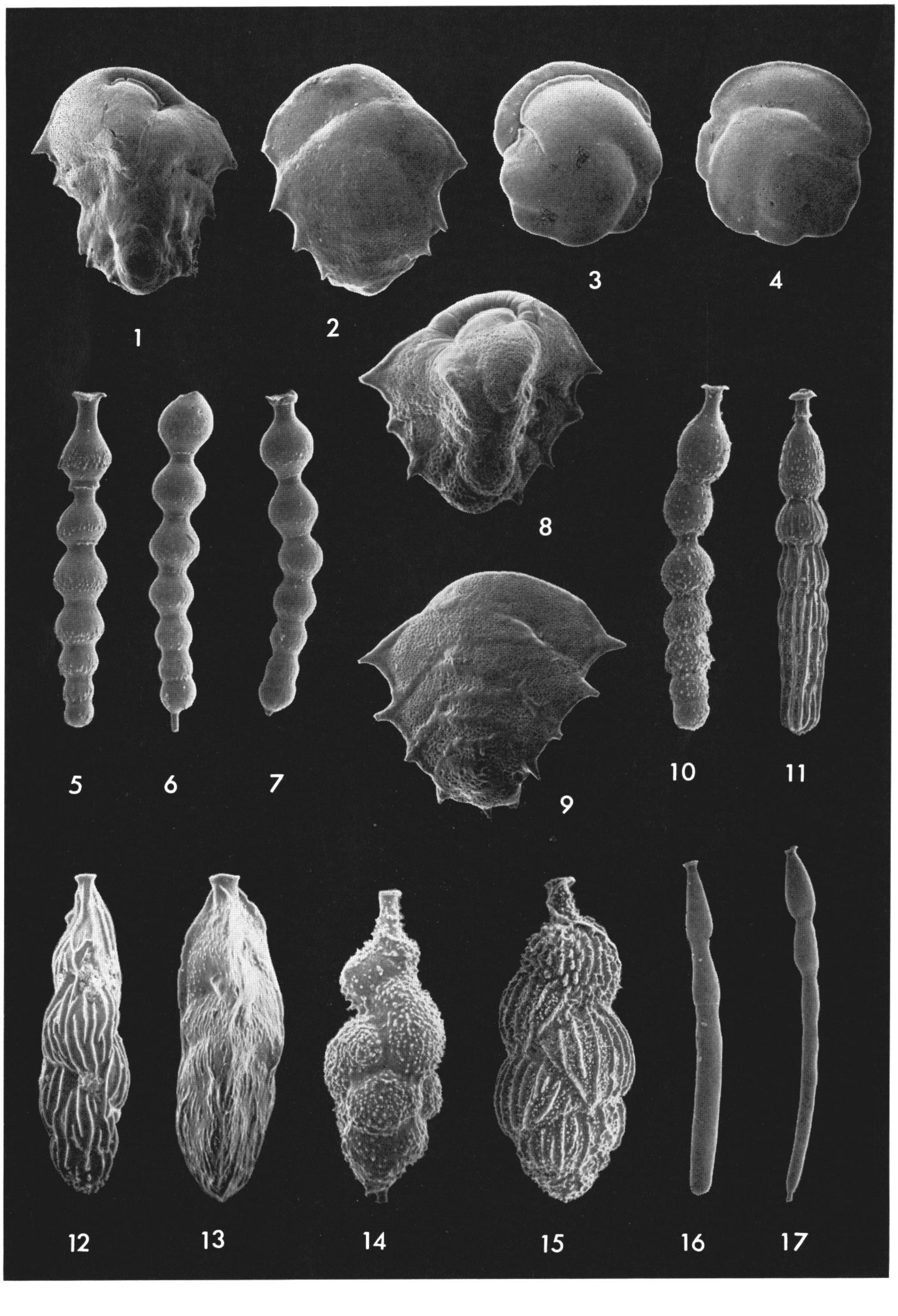
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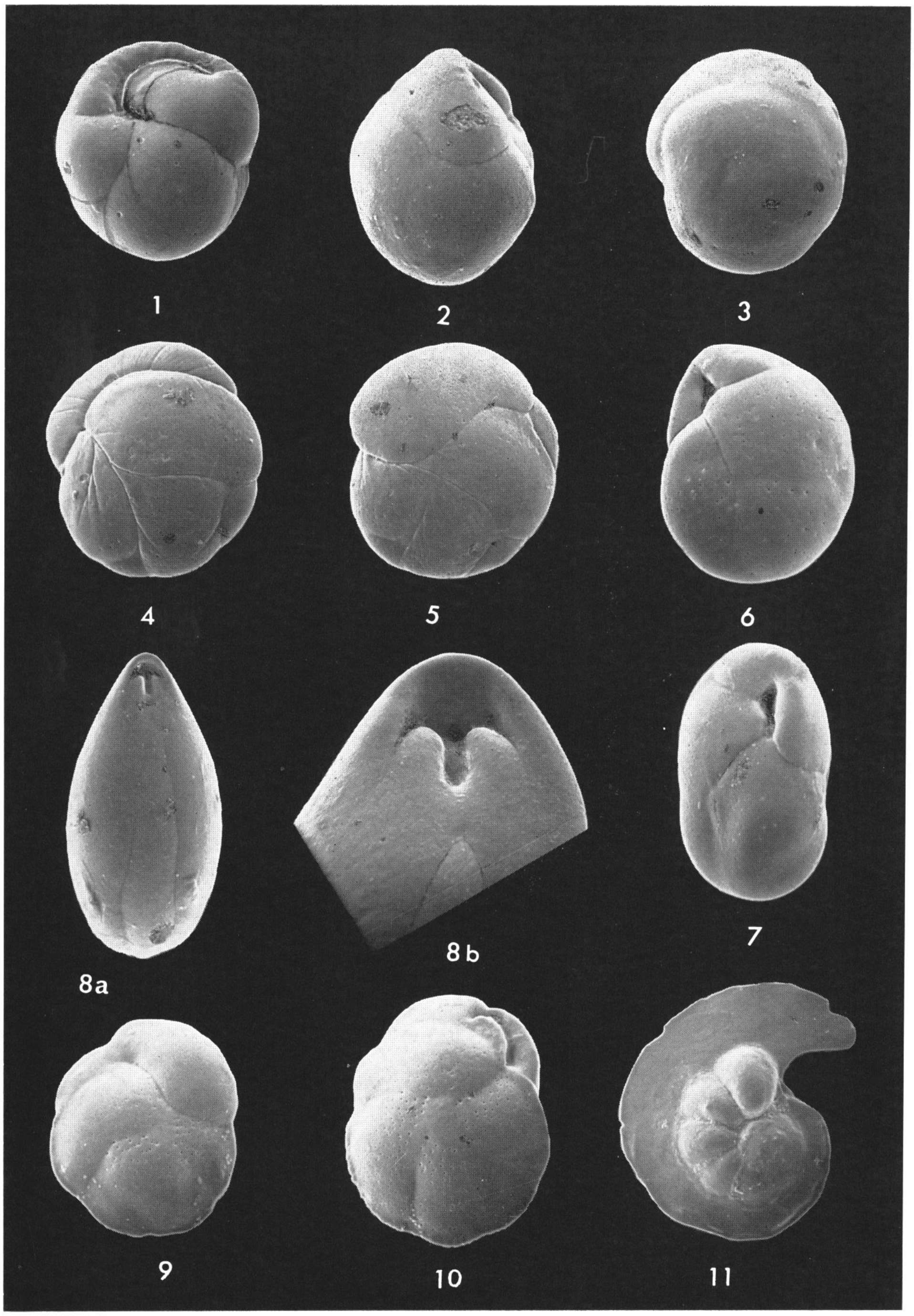
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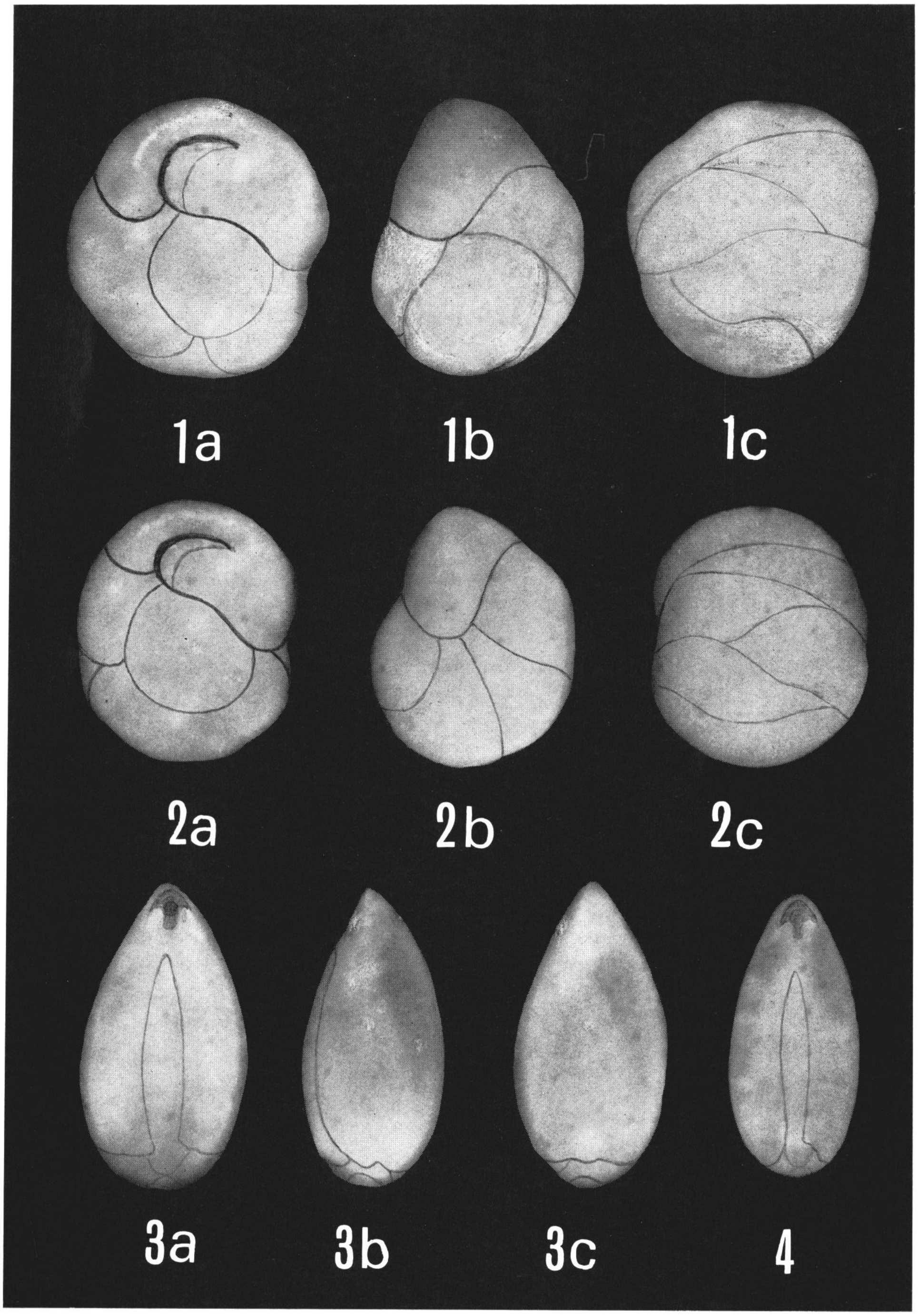
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