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GEOLOGICAL SURVEY OF JAPAN

EOCENE FORAMINIFERA FROM THE KYORAGI BEDS IN SHIMO-SHIMA, AMAKUSA ISLANDS, KUMAMOTO PREFECTURE, KYUSHU, JAPAN

By

Osamu Fukuta

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Abstract

The Kyōragi beds is widely distributed in Shimo-shima, Amakusa Islands, and mainly consists of shale with thickness of more than 900 meters. The materials upon which this study is based came from 5 localities, 4 of which belong to a richly foraminiferous zone about 50 meters below the top of the Kyōragi beds, and remaining one is about 50 meters or less above the base of this beds. From these localities, the writer found about 60 forms of Foraminifera belonging to 26 genera and 15 families. Among these forms, 9 are believe to be new species.

There is no essential difference in the faunas from 4 localities belonging to the upper richly foraminiferous zone. These faunas suggest rather uniform environment of temperate waters at the bathyal depth, strictly speaking, several hundred meters depth. The fauna from the remaining locality seems to be indicative of shallower than those from above-mentioned 4 localities. Judging from previously known occurrence of *Nummulites amakusensis* Yabe and Hanzawa and other larger Foraminifera in the nearly same horizon of this fauna, the lowest part of the Kyōragi beds seems to have been deposited in warm waters connecting with the Tethyan sea. The connection with Tethyan sea through Formosa seems to have been persisted in the later stage of deposition of the Kyōragi beds, because *Cyclammina formosensis* Yabe and Hanzawa and *Cyclammina tani* Ishizaki are found together in the upper richly foraminiferous zone.

Although the benthonic faunas found in the upper richly foraminiferous zone are closely related to those of the upper Eocene Cowlitz formation and its equivalents, the writer wishes to consider that the Kyōragi beds is upper Ypresian to Lutetian in age, because the planktonic faunas found in the same zone suggest middle Eocene age. *Plectofrondicularia packardi* Cushman and Schenck and its allied species are characteristic in the Sakasegawa shale, but they are not found in the Kyōragi beds. Some elements of the foraminiferal faunas of the Cowlitz formation and its equivalents seem to have occurred earlier in Japan than in Washington.

I. Introduction

This study is concerned with Foraminifera occurring in the Eocene Kyōragi beds in Shimo-shima, Amakusa Islands, Kumamoto prefecture, Kyūshū, Japan. Shimo-shima is the largest one in the Amakusa Islands, and lies between north latitudes 32° 11′ and 32° 33′, and east longitudes 129° 58′ and 130° 13′. In this paper the writer systematically records and discusses the stratigraphical significance of Foraminifera from the Kyōragi beds.

The materials which form the basis of this work are collected by the writer and Dr. Y. Takai. Here, the writer expresses his cordial thanks to Dr. Y. Takai for submitting his collection to the present study. The writer is also greatly indebted to Otake Coal Mining Co., Asahi Anthracite Mining Co. and Ushibuka Coal Mining Co. for giving aid to his field work. Further acknowledgement is due to Dr. K. Asano for offering many helpful suggestions.

The types are deposited in the Paleontological Collection, Geological Survey of Japan.

II. Geological Notes

According to T.Nagao (1922 a,b; 1926 a–e), who made detailed stratigraphic studies in the Amakusa Islands, a condensed summary of the Paleogene stratigraphy of Shimo-shima is as follows, in descending order:

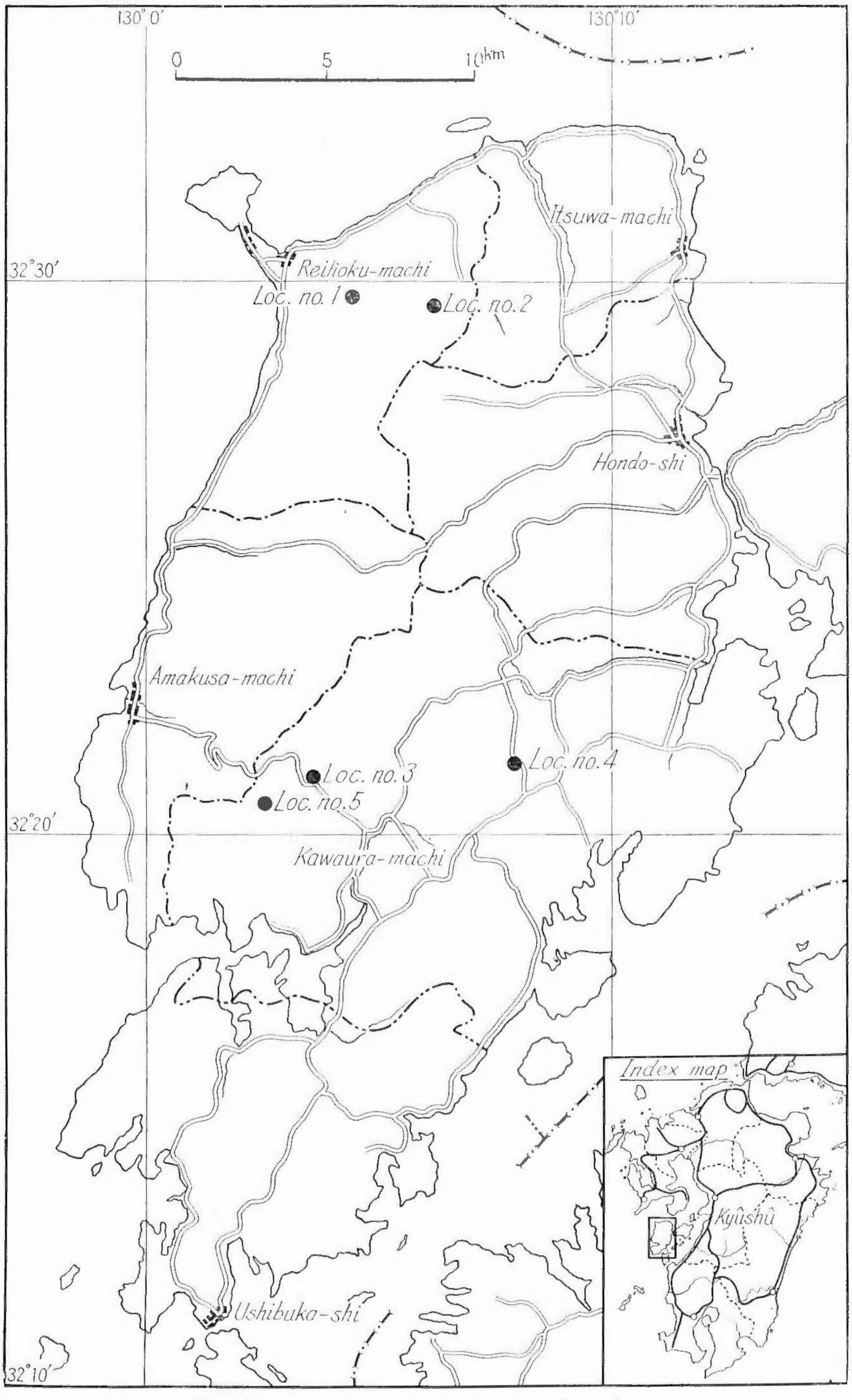
Sakasegawa group
  Sakasegawa shale : Shale and alternation of sandstone and shale.
  Itchōda sandstone : Glauconitic sandstone.
Hondo group
  Toishi beds : Sandstone, coal-bearing.
  Kyōragi beds : Shale.
Miroku group
  Fukami sandstone : Sandstone intercalating shale and conglomerate.
.................Unconformity.................
Upper Cretaceous

Afterwards, H. Matsushita (1949) gave a new name "Fukuregi formation" to the upper part of Nagao's Fukami sandstone. According to H. Matsushita and others (1959), the Fukuregi formation overlies the Fukami formation (middle and lower parts of Nagao's Fukami sandstone) with unconformity. On the other hand, N. Hatae (1959 a, b) gave his assent to Nagao's opinion.

The Sakasegawa shale is over 1000 meters in thickness, and is characterized by *Ctenamussium amakusaensis* Omori (M. Omori, 1955) and *Plectofrondicularia nogataensis* Asano and Murata (K. Asano, 1958). The Itchōda sandstone is generally 6 to 15 meters in thickness (T. Nagao, 1926 d), and is characterized by *Crassatellites nipponensis* (Yokoyama), *Venericardia nipponica* Yokoyama and other many molluscs (M. Yokoyama, 1911; T. Nagao 1926 d; 1928 a, b; H. Matsushita, 1949).

The Toishi bed is 300 to 400 meters in thickness (T. Nagao, 1926 c), and has two workable coal seams, one of which is 0.4 meters and the other is 1.0 meters in thickness. The coal is generally raised to a higher rank (anthracite) by a intrusion of igneous rocks and faulting (Geological Survey of Japan, 1960). The Kyōragi beds is over 900 meters in thickness (personal communication of Y. Takai), and contains *Venericardia nipponica* Yokoyama and other a few molluscs (H. Matsushita, 1949), and many foraminifers discussed in this paper.

The Fukuregi formation of H. Matsushita (1949), that is, the upper part of Nagao's Fukami sandstone, is slightly over 100 meters in thickness (H. Matsushita and others, 1959, fig. 1), and is characterized by *Turritella okadai* Nagao (T. Nagao, 1926 b; 1928 a, b; H. Matsushita, 1949) and *Nummulites amakusensis* Yabe and Hanzawa (H. Yabe and S. Hanzawa, 1925; H. Hanzawa, 1947). The Fukami formation of H. Matsushita (1949), that is, the middle and the lower parts of Nagao's Fukami sandstone is 450 to 650 meters



Text-figure1 Map showing the location of samples in thickness (H. Matsushita and others, 1959, p. 32), and contains smaller foraminifers in black shale (H. Matsushita, 1949).

III. Materials

The materials upon which this study is based came from 5 localities in Shimo-shima. Their location and horizon are shown in fig. 1 and table 1. All materials were collected from the Kyōragi beds by the writer and Y. Takai. There is a richly foraminiferous zone about 50 meters below the top of the Kyōragi beds. The localities no. 1, no. 2, no. 3 and no. 4 belong to this zone. The locality no. 5 is about 50 meters or less above the base of the Kyōragi beds. *Nummulites amakusensis* Yabe and Hanzawa and other larger Foraminifera have been known from nearly same horizon in the southeastern part of Shimo-shima (H. Yabe and S. Hanzawa, 1925; T. Nagao, 1926 a; H. Matsushita, 1949; N. Hatae, 1956; 1959 a, b; H. Matsushita and others, 1959).

Table 1 List of Localities

Loc. no	Location	Horizon	Collector
Loc. no. 1	500 m west of Shiki-yama, Reihoku-machi (lat. 32°29′45″, long. 130°4′26″)	Uppermost part of the Kyōragi beds	O. Fukuta
Loc. no. 2	Take, Reihoku-machi (lat. 32°29′39″, long. 130°6′21″)	Uppermost part of the Kyōragi beds	O. Fukuta
Loc. no. 3	Tsuzurakawachi, Kawaura-machi (lat. 32°21′0″, long. 130°3′41″)	Uppermost part of the Kyōragi beds	O. Fukuta
Loc. no. 4	Torigoe, Kawaura-machi (lat. 32°21′ 20″, long. 130°8′3″)	Uppermost part of the Kyōragi beds	O. Fukuta
Loc. no. 5	Oyama, Kawaura-machi (lat. 32°20′ 37″, long. 130°2′34′)	Lowermost part of the Kyōragi beds	Y. Takai

IV. Method of Study

About 500 grammes of each rock sample is roughly crushed by iron mortar and pestle. From the material crushed, about 80 grammes is taken up by quartering division. About 80 grammes of each sample is finely crushed by a roller-mill. Finally, the finely crushed sample is washed through a 160 mesh sieve and dried. Thus, all tests of Foraminifera contained in about 80 grammes of each sample are ready to be picked up from the residue prepared by the above-mentioned method.

V. Composition of Fauna

The distribution of Foraminifera from the Kyōragi beds is shown in table 2. The figures in table 2 indicate the individual number of each species found in about 80 grammes of each sample prepared by above-mentioned method. However, the sample from locality no. 5 is so highly consolidated that an about half has not been disintegrated. On the other hand, the samples from localities no. 1, no. 2, no. 3 and no. 4 were nearly thoroughly disintegrated.

The fauna consists of about 60 forms belonging to 26 genera and 15 families. Of these forms, 18 are identified with species previously described; 16 are compared with species previously described, but it is not possible to identify them positively; 9 are believed to be new species.

The family Lituolidae is represented by the largest number of species and individuals. In this family, the genus *Cyclammina* contains the majority of species and individuals. Although the family Nodosariidae is represented by the largest number of genera, most of species and individuals are confined to the genus *Robulus*. The family Trochamminidae are fairly well represented, but the genus *Trochammina* contains the majority of individuals. The family Verneuilinidae are also fairly well represented, but all individuals belong to the genera *Eggerella* and *Plectina*. The planktonic Foraminifera is fairly rich in the number of forms, but it is not possible to identify them positively for their deformation of tests. The remainder of the fauna is somewhat irregularly distributed among 9 families.

VI. Environmental Conditions

There is no essential difference in the faunas from 4 localilies belonging to a richly foraminiferous zone about 50 meters below the top of the Kyōragi beds. The arenaceous Foraminifera is represented by the largest number of families, genera, species and individuals. Particularly, the genus *Cyclammina* is represented by the largest number of species and individuals. Among them, *Cyclammina formosensis* Yabe and Hanzawa is most important in the paleoecological point of view. This species is very similar to *Cyclammina compressa* Cushman, and may be synonymous with the latter. Li-Sho Chang (1953) preferred to consider *C. formosensis* as the exceedingly compressed form of *C. compressa*. *Cyclammina compressa* Cushman was originally described from off the Philippines in 1025 meters depth. According to J. A. Cushman (1921), this species seems, like other species of the genus, to be widely distributed; the depth range is from 600 to 2, 990 meters and the bottom temperature range is 2. 7 to 4. 5°C. Besides the genus *Cyclammina*, the genera *Haplophragmoides*, *Trochammina*, *Plectina*, *Eggerella* and *Ammodiscus* are fairly well represented.

The family Nodosariidae is represented by the largest number of genera, and the individuals of this family are found in fairly great numbers. Among them, the genus *Robulus* is represented by the largest number of species and individuals, but there is no species characterized by highly ornamented test. The genus *Robulus* and its allied genera are generally developed the highly ornamented tests in tropical or subtropical waters.

It is apparent that only generalized paleoecological interpretations are possible, but on the whole the fauna found in a richly foraminiferous zone about 50 meters below the top of the Kyōragi beds suggests rather uniform environment of temperate waters at the bathyal depth, strictly speaking, several hundred meters depth. There are some shallow water genera in this fauna. They are represented by the genera *Quinqueloculina* and *Triloculina*. They are so few that they do not suggest the depth preferable to them.

The foraminiferal fauna from locality no. 5 consists of a few species and individuals. Generally speaking this fauna seems to be indicative of shallower than those from localities no. 1, no. 2, no. 3 and no. 4. As stated in the previous paragraph *Nummulites amakusensis* Yabe and Hanzawa and other larger Foraminifera have been known from several localities belonging to nearly same horizon of locality no. 5. Thus, the lowest part of the Kyōragi beds seems to have been deposited in warm waters connecting with the Tethyan sea. Judging from occurrences of *Cyclammina formosensis* Yabe and Hanzawa and *Cyclammina tani* Ishigaki in a richly foraminiferous zone about 50 meters below the top of the Kyōragi beds, the connection with Tethyan sea through Formosa seems to have been persisted in the later stage of deposition of the Kyōragi beds.

VII. Age Considerations

On the whole, the benthonic fauna found in a richly foraminiferous zone about 50 meters below the top of the Kyōragi beds is closely related to those of about 700 feet of strata at the base of the Willapa Valley section in southwest Washington. According to W. W. Rau (1951), the basal 700 feet of strata of the Willapa Valley section is equivalent to at least part of the type Cowlitz formation of Lewis County, Washington. *Quinqueloculina goodspeedi* Hanna and Hanna, *Robulus becki* Rau, *Robulus holcombensis* Rau and *Hemicristellaria saundersi* (Hanna and Hannaoccur) with varying frequency in the present fauna and the fauna from the basal part of the Willapa Valley section. These species are not necessarily restricted to the sediments of the Cowlitz age, but their occurrence seems to be significant, as they are usually found together in the upper Eocene sediments and are restricted, for a most part, to the Cowlitz or its approximate equivalents. Among these species, *Quinqueloculina goodspeedi* Hanna and Hanna is most significant as it has been recorded previously only from the type Cowlitz or its probable equivalents. This species is generally recognized in the Pacific Northwest of the United States as one of the index fossils of the Cowlitz (W. W. Rau, 1951).

As stated by R. S. Beck (1943), W. W. Rau (1951) and V. S. Mallory (1959), it is coincident that the Cowlitz formation and its equivalents correlate with the upper part of the Tejon formation of California and their horizons belong to the upper Eocene. Thus, it is all right in a sense that the age of the uppermost part of the Kyōragi formation is later Eocene. However, this age consideration leaves some questions.

" During the past 10 to 20 years there has been an enormous increase in the recognition of the value of the planktonic Foraminifera as stratigraphic index fossils. They form an excellent basis for precise regional and world-wide correlation. Their dispersal is world-wide, affected only by such environmental factors as temperature and salinity. After death their shells sink to the sea floor, regardless of whether the bottom facies is abyssal, neritic, lagoonal, or reefal. Furthermore, the advent and extinction of species and even genera, from the Cretaceous to the Recent, is so spaced that an excellent and exact zonation can be based on their stratigraphic distribution."——H. M. Bolli, A. R. Loeblich, Jr. and H. Tappan (1957).

The planktonic foraminifers are fairly common in a richly foraminiferous zone belonging to the uppermost part of the Kyōragi beds. Unfortunately, their considerably deformed tests make accurate identification practically impossible. As shown in table 2, excepting a few highly deformed specimens, they are referable to following 7 species:

Globigerina linaperta Finlay
Globigerina parva Bolli
Globigerina senni (Beckman)
Globigerina venezuelana Hedberg
Globigerina yeguaensis Weinzierl and Applin
Globorotalia perclara Loeblich and Tappan

Globorotalia wilcoxensis Cushman and Ponton

According to H. M. Bolli (1957 c), above five species of *Globigerina* have been found together in the middle Eocene deposits of Trinidad, British West Indies. The *Globorotalia wilcoxensis* zone has been widely known in the Wilcox stage of the Gulf Coast area of United States (K. Asano, 1958). On the other hand, according to T. F. Grimsdale (1951), this zone ranges from Ypresian to Lutetian in the Middle East of Asia. *Globorotalia perclara* Loeblich and Tappan has been originally described from the upper Paleocene Aquia formation of Aquia Creek, Virginia (A. R. Loeblich and H. Tappan, 1957 a). Accoring to A. R. Loeblich and H. Tappan (1957 b), this species has been known in Paleocene and lower Eocene deposits of Gulf and Atlantic Coastal Plains of United states.

As stated in the previous paragraph, *Nummulites amakusensis* Yabe and Hanzawa and other larger Foraminifera have been known from several localities belonging to nearly same horizon of locality no. 5. However, *Nummulites amakusensis* Yabe and Hanzawa and other larger Foraminifera are mostly characteristic in the Fukuregi formation of H. Matsushita (1949). According to the authors (1925), *Nummulites amakusensis* Yabe and Hanzawa shows an affinity to Cuisian species *Nummulites planulatus* Lamarck in every respect and is a less-advanced form compared with Lutetian species of *Nummulites.*

Trochammina amakusaensis n. sp. has a near half in the foraminiferal population of locality no. 5. This species is also irregularly distributed in the foraminiferal populations of localities no. 1, no. 2, no. 3, and no. 4. The Californian specimen figured by V. S. Mallory (1959) under the name of *Trochammina* cf. *T. globigeriniformis* (Parker and Jones) is apparently similar to the present species. According to V. S. Mallory (1959), his *Trochammina* cf. *T. globigeriniformis* (Parker and Jones) is distributed in Ynezian, Baltian, Penutian and Narizian deposits of California.

Plectofrondicularia packardi Cushman and Schenck and its allied species are characteristic in the upper Eocene and lower Oligocene deposits of west coastal regions of United States, that is, Cowlitz, Keasey and Lincoln formations and their equivalents of Washington (W. W. Rau, 1951), and Narizian and Refugian deposits of California (V. S. Mallory, 1959). They are also characteristic in the Sakasegawa shale, but they are not found in the Kyōragi beds.

Thus, in conclusion, it can be said that the Kyōragi beds is upper Ypresian (Cuisian) to Lutetian in age, while the underlying Fukuregi formation of H. Matsushita (1949) is lower Ypresian. Some elements of the foraminiferal faunas of Cowlitz formation and its equivalents seem to have occurred earlier in Japan than in Washington.

VIII. Systematic Catalogue

It is not the purpose of the writer to provide a complete synonomy for the species listed in the systematic discussion which follows. Rather, the synonomy is complete for described species of Japanese Paleogene and is fairly representative of most of the Japanese Paleogene foraminiferal literatures. For convenience, the systematic arrangement of the family grouping largely follows that of J. A. Cushman (1948).

Family Astrorhizidae

Genus *Bathysiphon* M. Sars, 1872

Bathysiphon eocenica Cushman and G. D. Hanna

(Plate I, figure 1)

Bathysiphon eocenica Cushman and G. D. Hanna, 1927, California Acad. Sci. Proc., 4th Ser., vol. 16, no. 8, p. 210, pl. 13, figs. 2, 3.

Bathysiphon eocenica Asano, 1952, Short Papers, IGPS*, no. 4, pp. 31–32, pl. 3, figs. 3–4.

Bathysiphon eocenica Asano, 1952, Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera, Supplement no. 1, p. 1, figs. 1–2.

Bathysiphon eocenicus Ujiié and Watanabe, 1960, Sci. Rep. Tokyo Kyoiku Daigaku, Sec. C, vol. 7, no. 63, p. 127, pl. 1, figs. 1 and 2 ?.

Although the present specimens are smaller than the typical forms, their compressed sylindrical test and thick wall which is made of fine white amorphous material are the characteristic features of this species.

The species has been recorded from the Paleogene formations of Oregon and California and from the Poronai shale and its equivalents of Hokkaido.

Family AMMODISCIDAE

Genus *Ammodiscus* Reuss, 1861

Ammodiscus sp.

The specimens referred to the genus *Ammodiscus* are usually immature and fragmental. It seems that they belong to one species, but their specific determination is impossible.

Family LITUOLIDAE

Genus *Haplophragmoides* Cushman, 1910

Haplophragmoides amakusaensis Asano and Murata

(Plate I, figures 2～4)

Haplophragmoides amakusaensis Asano and Murata, 1858, Sci. Rep, Tohoku Univ., 2nd Ser. (Geol), vol. 29, p. 61, pl. 11, figs. 8 a, b.

"Test compressed, planispiral, not completely involute, umbilical area usually depressed, periphery rounded, lobulate; chambers numerous, 8–9 in last whorl, inflated; sutures fairly distinct, curved, depressed; wall rather coarsely arenaceous; aperture at base of apertural face, usually indistinct. Diameter up to 1mm."——Original description of authors.

The types of this species are from the upper part of the Sakasegawa shale at Oshima, Oniike, Itsuwa-machi, Shimo-shima. The species has been found not only in the Sakasegawa shale but also in the Kyōragi beds.

The present specimens are generally deformed and variable in size and outline, but the well preserved specimens certainly identical to those figured by original authors.

Haplophragmoides cf. *emaciatum* Brady

(Plate I, figure 5)

Haplophragmium emaciatum Brady, 1884, Rep. Challenger Expedition, Zoology, vol. 9, pt. 22, p. 305, pl. 33, figs. 26–28.

Haplophragmoides cf. *emaciatum* Asano, 1950, Contr. Cushman Found. Foram. Res., vol. 1, pp. 76–77, pl. 12, fig. 5.

* IGPS, abbreviation for Institute of Geology and Paleontology, Tohoku University, Sendai.

Haplophragmoides cf. *emaciatum* Asano, 1951, Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera, pt. 10, p. 3, fig. 3.
Haplophragmoides cf. *emaciata* Ujiié and Watanabe, 1960, Sci. Rep. Tokyo Kyoiku Daigaku, Sec. C, vol. 7, no. 63, p. 127, pl. 1, fig. 6.

The present specimens are more or less distorted or fragmentary, and are not strictly identified with H. B. Brady's species They are compared closely with those described and figured from the Miocene Shiiya formation of Niigata prefecture (K. Asano, 1950) and upper Eocene "Poronai shale" of Ashibetsu District, Ishikari Coal-field (H, Ujiié and H. Watanabe, 1960), but they are considerably smaller than the latters.

This form has been found in Miocene, Oligocene and Eocene formations of Japan. *Haplophragmoides emaciatum* (Brady) has been known in Recent deposits of adjacent seas of Japan.

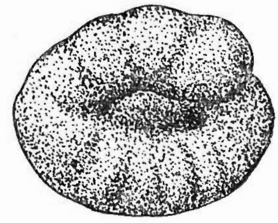
Haplophragmoides subamakusaensis Fukuta, n. sp.
(Text-figure 2; Plate I, figures 6~10)

Cribrostomoides cf. *cretacea* Ujiié and Watanabe(not Cushman and Goudkoff), 1960, Sci. Rep. Tokyo Kyoiku Daigaku, Sec. C, vol. 7, no. 63, pp. 127–128, pl. 1, figs. 3?, 4 and 5.

Test wide, close-coiled planispirally, generally umbilical area on each side somewhat opened, periphery broadly rounded, somewhat lobulated; chambers numerous, 10–12 in last whorl, slightly inflated; sutures fairly distinct, slightly curved and depressed; wall finely arenaceous, smoothly finished; aperture at base of apertural face, usually indistinct. Diameter up to 0. 8 mm.

Holotype: CF 58007 from loc. no. 2.

This species appears to be very similar to *Haplophragmoides desertorum* LeRoy described from the Eocene Esna shale of Egypt, but differs from the latter in its larger test. The writer found this species from the Poronai, Akabira and Wakkanabe formations of the Ishikari Coal-field, Hokkaido.



Text-figure 2 *Haplophragmoides subamakusaensis* n. sp. Side view of holotype x 50

Haplophragmoides sp.
(Plate I, figure 11)

Test not compressed, much longer than broad, umbilical area slightly depressed, periphery rounded, somewhat lobulated; chambers not numerous, 6–7 in last whorl, somewhat inflated, rather rapidly increasing in size as added; sutures not so distinct, slightly curved and depressed; wall rather coarsely arenaceous; aperture at base of apertural face, usually indistinct. Length up to 0. 9 mm.

The present specimens are possibly new species, but the further materials are needed for specific evaluation.

Genus *Ammobaculites* Cushman, 1910
Ammobaculites sp.
(Plate I, figure 12)

Test moderate size, not so compressed; sutures indistinct; wall rather coarsely arenaceous; sutures indistinct. The later chambers in a linear series are lost for the most part. Diameter of the coiled part up to 0.6 mm.

Genus *Cyclammina* Brady, 1876

Cyclammina formosensis Yabe and Hanzawa

(Plate I, figures 13~17; Plate II, figures 1, 2)

Cyclammina complanata Yabe and Hanzawa (not Chapman), 1930, Sci. Rep. Tohoku Univ., 2nd Ser. (Geol), vol. 14, no. 1, p. 46, figs. a, b.

Cyclammina formosensis Yabe and Hanzawa, 1935, ibid., vol. 18, p. 13.

Cyclammina formosensis Asano, 1951, Short Papers, IGPS, no. 3, pp. 22–23, pl. 4, figs. 9 a, b.

The present specimens are somewhat smaller in size and fewer in chambers than the typical forms.

This species is very similar to *Cyclammina compressa* Cushman, and may be synonymous with latter. According to Li-Sho Chang (1953), the species is the exceedingly compressed form of *C. compressa* Cushman. However, in the typical forms of the latter, the test is not completely involute and the umbilical region is much excavated. The specimens showing these features are very rare in the present ones.

This species has been recorded from Eocene and Oligocene formations of Formosa.

A few well preserved large tests of this species have been found by the writer in some rock samples collected by A. Mizuno (1957) from the Kinan group of the southern coastal part of the Kii peninsula. The Kinan group is assigned to the Eocene age from this evidence.

Cyclammina incisa (Stache)

(Plate II, figures 3~6)

Haplophragmium incisum Stache, 1864, Novara-Exp., Geol. Theil., Bd. 1, p. 165, pl. 21, figs. 1, 2.

Cyclammina incisa Cushman and Laiming, 1931, Jour. Paleont., vol. 5, no. 2, p. 93, pl. 9, figs. 6 a, b.

Cyclammina sp. (cf. *incisa* Stache) Asano, 1949, Jour. Paleont., vol. 23, no. 5, p. 474, figs. 1–5, 6.

Cyclammina incisa Asano, 1950, Contr. Cushman Found. Foram. Res., vol. 1, pp. 77–78, pl. 12, figs. 8 a, b; 9 a, b.

Cyclammina incisa Asano, 1951, Short Papers, IGPS, no. 3, p. 20, pl. 4, figs. 1 a, b.

Cyclammina incisa Asano, 1951, Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera, pt. 10, p. 6, figs. 18, 19.

Cyclammina incisa Murata, 1952, Bull. Kyushu Inst. Tech., no. 2, p. 67, pl. 1, figs. 6 a, b; 7 a, b.

Cyclammina incisa Asano, 1952, Short Papers, IGPS, no. 4, p. 32, pl. 3, figs. 6 a, b; 7 a, b.

Cyclammina pacifica Beck var. *kushiroensis* Yoshida, 1957, Trans. Proc. Paleont. Soc. Japan., N. S. no. 26, p. 65, text-figs. 18, 19.

Cyclammina incisa Asano, 1958, Sci. Rep. Tohoku Univ., 2nd Ser. (Geol), vol. 29, pl. 13, figs. 20 a, b.

Cyclammina incisa Murata, 1959, Bull, Kyushu Inst. Tech., no. 5, p. 35, pl. 1, figs. 4 a, b.

The present specimens have somewhat fewer chambers than the typical forms of this species, but they are very similar to the latter in all other characters.

This is a common Oligo-Miocene species of the Circum-Pacific region and occurs abundantly in the same geological horizon of Japan and Formosa, but this is not so common in the Eocene formations.

Cyclammina cf. *obesa* Cushman and Laiming
(Plate II, figures 7~12)

Cyclammina cancellata Brady, var. *obesa* Cushman and Laiming, 1931, Jour. Paleont., vol. 5, no. 2, p. 94, pl. 9, figs. 10a, b.
Cyclammina cancellata obesa Asano, 1951, Short Papers, IGPS, no. 3, p. 22, pl. 4, figs. 10a, b.

The present specimens differ from the typical forms in its not so inflated test and a little more chambers.

This species is commonly found in Oligocene and Miocene formations of California, together with *Cyclammina incisa* (Stache).

Cyclammina cf. *pacifica* Beck
(Plate II, figures 13~15; Plate III, figures 1~3)

Cyclammina pacifica Beck, 1943, Jour, Paleont., vol. 17, no. 6, p. 591, pl. 98, figs. 2, 3.
Cyclammina cf. *pacifica* Asano, 1951, Short Papers, IGPS, no. 3, pp. 20–21, pl. 3, figs. 5a, b.
Cyclammina cf. *pacifica* Asano, 1951, Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera, pt. 10, p. 7, figs. 24, 25.
Cyclammina cf. *pacifica* Murata, 1952, Bull. Kyūshū Inst. Tech., no. 2, p. 67, pl. 1, figs. 2a, b.
Cyclammina pacifica Asano, 1952, Short Papers, IGPS, no. 4, p. 33, pl. 3, figs. 1a, b; 2; pl. 5, figs. 11 a, b.
Cyclammina cf. *pacifica* Yoshida, 1955, Jour. Hokkaido Gakugei Univ., vol. 6, no. 2, p. 6, pl. 2, figs. 33, 34, 39, 40.
Cyclammina pacifica Asano, 1958, Sci. Rep. Tohoku Univ., 2nd Ser.(Geol.), vol. 29, pl. 13, fig. 3.

The present specimens are generally distorted, and are somewhat variable in their size and outline, but are characterized by wide and low apertural face and curved sutures.

This species occurs commonly in the Eocene and Oligocene formations of Oregon and Washington. The species has been also recorded from the Eocene and Oligocene formations of Japan and Formosa.

Cyclammina pusilla Brady
(Plate III, figure 7)

Cyclammina pusilla Brady, 1884, Challenger Rep., Zool., vol. 9, p. 353, pl. 37, figs. 20–23.
Cyclammina pusilla Asano, 1950, Contr. Cushman Found. Foram. Res., vol. 1, p. 78, pl. 12, figs. 6 a, b.
Cyclammina pusilla Asano, 1951, Short Papers, IGPS, no. 3, p. 15, pl. 4, figs. 2 a, b.
Cyclammina pusilla Asano, 1951, Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera, pt. 10, p. 7, figs. 26, 27.
Cyclammina pusilla Murata, 1952, Bull. Kyushu Inst. Tech., no. 2, p, 67, pl. 1, figs. 5 a, b.

The single present specimen is very similar to the typical forms of this species.

" There are two Challenger records for this species, one from the east of Japan, the other from the middle of the North Pacific; Cushman gives off the south coast of Japan. As a rule, this species seems to live in cold and rather deep water, like other species of the genus. It also occurs in the Miocene formations of Japan.

There is a possibility of *C. pusilla* being the young of *C. compressa*, but Cushman says that they are not as a rule found together in the Pacific."——K. Asano (1951, p. 15).

In addition, this species has been known from the Oligocene formations of northern Kyushu.

Cyclammina tani Ishizaki
(Plate III, figures 4~6)

Cyclammina tani Ishizaki, 1941, Taiwan Chigaku Kizi, vol. 12, nos. 2–3, p. 25, pl. 14, figs. 1–5.
Cyclammina tani Asano, 1951, Short Papers, IGPS, no. 3, p. 21, pl. 3, figs. 4 a, b.
Cyclammina tani Asano, 1951, Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera, pt. 10, p. 7, figs. 28, 29.
Cyclammina tani Murata, 1952, Bull. Kyushu Inst, Tech., no. 2, p. 66, pl. 1, figs. 1 a, b.
Cyclammina tani Asano, 1958, Sci. Rep. Tohoku Univ., 2nd Ser. (Geol.), vol. 29, pl. 11, figs. 1 a, b,

According to Li-Sho Chang (1953), though the types of this species are from the Miocene rocks of the Chutouchi Oil-field, Formosa, the species occurs rather rarely in the materials collected from the Nanko formations and its equivalents. The species is most common and widely distributed in the Oligocene Suityoryu formation of the Urai group and its equivalents in the Suo group.

The present specimens are somewhat variable in size, but they are indistinguishable from the named species in their peculiar elongate tests and sigmoidal sutures.

According to K. Asano (1951), this species seems to be related to *Cyclammina simiensis* Cushman and Mc Masters, but differs from the latter in its more elongated test and more depressed and sigmoidal sutures.

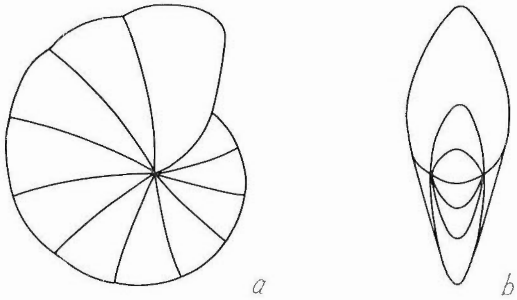
Cyclammina amakusaensis Fukuta, n. sp.
(Text-figure 3; Plate III, figures 8~10)

Test small, lenticular. periphery subacute, not lobulated, umbilical region generally closed, but sometimes slightly opened; chambers numerous, 11–13 in last coil; sutures distinct, nearly radial, depressed; aperture at base of apertural face, usually indistinct. Diameter up to 1. 0 mm.

Holotype: CF 58041 from loc. no. 4.

This species somewhat similar to *Cyclammina incisa* (Stache), but differs from the latter in its not compressed test, not lobulated periphery and greater number of chambers. The species seems to be related to *Cyclammina pacifica* Beck, but it is easily distinguishable from the latter by its higher apertural face, subacute periphery and nearly radial sutures.

Cyclammina sp. 1
(Plate III, figure 11)



a. Side view; b. apertural view
Text-figures 3a, b *Cyclammina amakueaensis* n. sp.
Outlines of holotype x 35

Test elongated, periphery rounded and not lobulated, deeply umbilicated; number of chambers unknown, but probably up to 8 in last coil; sutures indistinct; aperture at base of apertural face, usually indistinct. Diameter up to 1.0 mm.

This form is possibly a new species, but the further material is needed for the specific evaluation.

Cyclammina sp. 2
(Plate III, figures 12, 13)

Test distinctly deformed, small, thickly lenticular, completely involute, periphery subacute; chambers numerous, probably 10 or more in last coil; sutures slightly depressed, nearly radial; aperture at base of apertural face, usually indistinct. Diameter up to 0.7 mm.

There is a possibility of this form being a deformed *Cyclammina amakusaensis* Fukuta, n. sp., but the further material is needed for the specific identification.

Cyclammina spp.

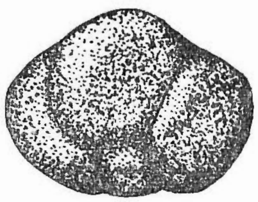
Various fragmentary or highly deformed specimens are grouped here for checklisting purpose.

Family TROCHAMMINIDAE
Genus *Trochammina* Parker and Jones, 1859
Trochammina amakusaensis Fukuta, n. sp.
(Text-figure 4; Plate 4, figures 1a∼4)

Ammoglobigerina sp. aff. *A. globigeriniformis* Israelsky (not Parker and Jones), 1951, Foraminifera of the Lodo Formation, Central California, General Introduction and Part 1, Geol. Surv. Prof. Pap. 240-A, p. 15, pl. 5, figs. 4-6.

Trochammina cf. *T. globigeriniformis* Mallory (not Parker and Jones), 1959, Lower Tertiary Biostratigraphy of the California Coast Ranges, p. 133, pl. 5, fig. 16.

Test subglobose, low spired trochospiral, only the last volution of 3 or 4 chambers clearly seen; chambers subglobular, increasing rather rapidly in size as added; sutures



Text-figure 4 *Trochammina amakusaensis* n. sp.
Dorsal view of holotype x 30

well marked; aperture usually indistinct, probably central, at inner face of last chamber; wall finely arenaceous, roughly finished. Diameter up to 0.7 mm.

Holotype: CF 58046 from loc. no. 2.

This new species is closely related to *Trochammina globigeriniformis* (Parker and Jones), except that the chambers of the latter are more distinct in the early whorls.

The Californian specimens described and figured by M. C. Israelsky (1951) and V. S. Mallory (1959) under the names of *Ammoglobigerina* sp. aff. *A. globigeriniformis* (Parker and Jones) and *Trochammina* cf. *T. globigeriniformis* (Parker and Jones) respectively must be referred to this new species. It is very interesting that these Californian specimens have been collected from many localities belonging to Ynezian, Bultian, Penutian and Narizian stages.

Trochammina sp. 1
(Plate IV, figure 5)

This form is very similar to above mentioned new species in its outline, but differs from the latter in its coarsely arenaceous wall. Diameter 0.9 mm.

The single present specimen is possibly a new species, but the further material is needed for the specific evaluation.

Trochammina sp. 2
(Plate IV, figure 6)

Test small, low spired trochospiral, both sides nearly parallel; chambers somewhat inflated, 6 in last coil, rather slowly increasing in size as added; sutures well marked; wall finely arenaceous, smoothly finished; aperture not seen. Diameter 0.3 mm.

The single present specimen is considerably deformed in its ventral side. This specimen is possibly a new species, but the further material is needed for the specific evaluation.

Trochammina sp. 3
(Plate IV, figure 7)

Test much compressed; chambers few, 3 in last coil, last chamber very large as compared with other chambers; sutrures distinct, slightly depressed, nearly straight in both sides; wall finely arenaceous, roughly finished; aperture not seen, but apertural depression appears at inner margin of final chamber. Diameter 0.6 mm.

The single present specimen is possibly a new species, but the further material is needed for the specific evaluation.

Trochammina sp. 4
(Plate IV, figure 8)

Test low spired trochospiral, dorsal side somewhat flattened, ventral side convex;

sutures obscure; chambers flush, probably 3 in last coil; aperture not seen, but apertural depression appears medially at inner magin of final chamber; wall finely arenaceous, roughly finished. Diameter 0. 6 mm.

The single present specimen is fairly well preserved, and it is possibly a new species, but the further material is needed for the specific evaluation. The specimen is apparently similar to some figures of *Trochammina* sp. A detected from the Lodo formation of central California by M. C. Israelsky (1951).

Trochammina sp. 5
(Plate IV, figures 9, 10)

Test highly deformed, much compressed, low spired trochospiral; chambers somewhat inflated, 3 or 4 in last coil, last chamber very large as compared with other chambers; wall finely arenaceous, roughly finished; aperture not seen, but apertural depression appears at inner margin of final chamber. Diameter up to 0. 6 mm.

The present specimens are much deformed and variable in size and outline. Some specimens listed under this name may be referred to other species.

Trochammina spp.

Various highly deformed or fragmentary specimens are grouped here for checklisting purpose.

Genus *Conotrochammina* Finlay, 1940
Conotrochammina? sp.
(Plate IV, figure 11)

Test globular, low spired trochospiral; chambers indicernible on dorsal face, several somewhat inflated chambers visible ventrally; aperture not seen; wall finely arenaceous, roughly finished. Diameter 0. 5 mm.

In the typical forms of the genus *Conotrochammina*, their walls are coarsely arenaceous,but the other features excepting aperture are recognized in the single present specimen. The present specimen is possibly a new species, but the further material is needed for the specific evaluation.

The genus *Conotrochamina* has been only recorded from the Cretaceous and Paleocene of New Zealand and the Lodo formation (Paleocene to middle Eocene) of California (M. C. Israelsky, 1951).

Family VERNEUILINIDAE
Genus *Eggerella* Cushman, 1933
Eggerella amakusaensis n. sp.
(Plate IV, figures 2, 3; Plate V, figure 1)

Test usually somewhat distorted, triserial in adult, originally rounded in section, increasing rapidly in diameter toward the apertural end; chambers distinct, somewhat inflated, early whorl with more than 3 chambers; sutures well marked, wall finely arenaceous, roughly finished; aperture a low opening at inner margin of last chamber. Length up to 0.9 mm; diameter up to 0. 7 mm.

Holotype: CF 59057 from loc. no. 4.

This species is similar to *Eggerella cushmani* (Wienzierl and Applin), which is a characteristic species in the Eocene Claiborne group of the Gulf Coastal Plain of the United States, but differs from the latter by its test increasing more rapidly in diameter toward the apertural end.

Eggerella? sp.
(Plate V, figure 2)

Test highly deformed by compression, conical, triserial in the adult, originally rounded in section, increasing rapidly in diameter toward the apertural end; chambers indistinct, somewhat inflated in the adult; sutures obscure; wall finely arenaceous, rather smoothly finished; aperture obscure. Length 1. 1 mm; diameter 0. 9 mm.

The single present specimen is possibly a new species, but the further material is needed for the specific evaluation.

Genus *Plectina* Marsson, 1875
Plectina eocenica Cushman
(Plate V, figure 3)

Plectina eocenica Cushman, 1936, Special Publ. no. 6, Cushman Lab. Foram. Res., p. 32, pl. 5, figs. 5 a, b.

Plectina eocenica Cushman, 1937, Special Publ. no. 8, Cushman Lab. Foram. Res., p. 108, pl. 12, figs. 5–7.

The single present specimen is not well preserved, but it is indistinguishable from the named species in its coarsely arenaceous test, inflated and somewhat nodose later chambers.

The types of this species are from the Eocene of Biarritz, France. The species also occurs in the Eocene of Val di Lonte, Italy, and from the Eocene of Hammer, Bavaria. The species seems to be characteristic in the Eocene of southern Europe. The typical forms of this species have been also known from the Eocene of Hindustan and Trinidad.

Plectina poronaiensis Asano
(Plate V, figures 4, 5)

Plectina poronaiensis Asano, 1952, Short Papers, IGPS, no. 4, pp. 33–34, pl. 4, figs. 12, 13.

Plectina poronaiensis Asano, 1958, Sci. Rep. Tohoku Univ., 2nd Ser. (Geol.), vol. 29, pl. 11, fig. 10; pl. 13, figs. 5–7.

"Test comparatively short and broad, initial end slightly tapering, greatest breadth toward apertural end; chambers of early portion somewhat obscure, later inflated, biserial; sutures rather indistinct, somewhat depressed in last portion; wall rather coarsely arenaceous, roughly finished; aperture in adult circular, somewhat above inner margin of last formed chamber. Length up to 1. 2 mm; breadth 0. 7 mm."——K. Asano, 1952.

The types of this species are from the Poronai shale of the Hobetsu section in the southern part of the Ishikari Coal-field. The species has been also recorded from the Sakasegawa shale and the Kyoragi shale (K. Asano, 1958).

Recently, H. Ujiié and H. Watanabe (1960) identified some specimens of arenaceous Foraminifera from the "Poronai shale" of the Ashibetsu section in the northeastern part of the Ishikari Coal-field with the species. Being based on these specimens, they established a new genus *Poronaia*. The original description of the genus *Poronaia* is as follows:

"Test agglutinated; in initial stage, depressed trochospiral like *Trochammina*, composed of relatively few chambers; later, biserial with rather flattened chambers attaching beneath the ventral side of the trochospire, and then apart but beneath the preceding chamber throughout, in a constant direction; thus adult form with an elongate outline constructed by imbricated accumulation of chambers; aperture, early, ventral and basal pore nearly at proximity to the trochospiral axis, and in later stage, basal broad slit on the preceding chamber."

In addition, the following remarks have been given by the authors:

"At a glance, the features mentioned above may be recognized as a crushed one of *Valvulina*, *Eggerella*, or *Dorothia*. Notwithstanding such an aspect, they permit us to establish the new genus because of the position of initial part, which is constantly detached from the proximal end of the elongate test, and the regularity of chamber-arrangement not affected by such a crushing."

Although the above statement of H. Ujiié and H. Watanabe is probably true as for the specimens figured by them, the statement may be not applicable to the types of *Plectina poronaiensis* Asano. The figures given by H. Ujiié and H. Watanabe are not always similar to the type figures of this species.

The present specimens are generally somewhat deformed and variable in outline, but the well preserved specimens are certainly identified with those originally figured by K. Asano (1952).

Plectina sp.
(Plate V, figure 6)

The single present specimen is lacking in initial part, and it is impossible to identify it accurately.

Family MILIOLIDAE
Genus *Quinqueloculina* d'Orbigny, 1826
Quinqueloculina goodspeedi Hanna and Hanna
(Plate V, figures 7, 8)

Quinqueloculina goodspeedi Hanna and Hanna, 1924, Washington Univ. (Seatle) Pub. Geol. vol. 1, no. 4, p. 58, pl. 13, figs. 3, 4.

A few present specimens, in which the tests are partly broken, agree in all details with description and illustration of this species. They are typically long and rounded, but ovate in cross section, with a circular, somewhat protruding aperture. The tooth is not seen.

This species has been recorded from the Cowlitz formation and its equivalents of Washington. The species has been also recorded from the Sakasegawa shale and the Kyōragi shale (K. Asano, 1958).

Genus *Triloculina* d'Orbigny, 1826
Triloculina cf. *trigonula* (Lamarck)
(Plate VI, figure 1)

Miliolites trigonula Lamarck, 1804, Paris Mus. Nat. Hist. Nat., Ann. vol. 5, p. 351.

Miliolites trigonula Lamarck, 1807, Ibid., vol. 9, pl. 7, fig. 4.
Miliolina trigonula Williamson, 1858, Rec. Foram. Great Britain, p. 84, pl. 7, figs. 180–182.
Triloculina trigonula Cushman, 1917, Bull. 71, U. S. Nat. Mus., pt. 6, p. 65, pl. 25, fig. 3.
Triloculina trigonula Asano, 1951, Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera, Part 6, p. 17, figs. 116, 117.

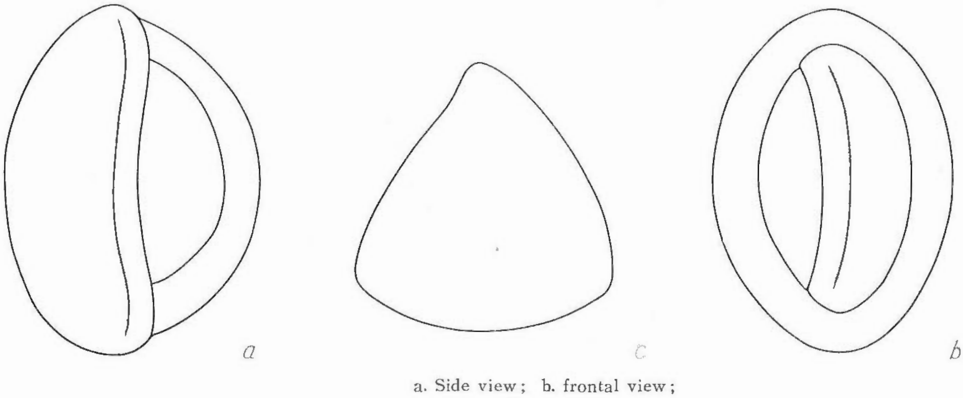
The penultimate chamber of the single present specimen is mostly broken out. The specimen is similar to the typical forms of this species, but the further material is needed for the precise determination.

S. Murata (1959) reported *Triloculina* sp. cf. *T. trigonula* (Lamarck) from the Oligocene Nishisonogi group in the Sakito-Matsushima Coal-field. Judging from the figures of S. Murata (pl. 1, figs. 12 a, b), the specimens from the Nishisonogi group must not be compared with this species, because they are not roundly triangular in end view.

This widely distributed species has been found commonly in the Neogene and Recent deposits of Japan.

Triloculina amakusaensis Fukuta n. sp.
(Text-figures 5 a–c; Plate V, figures 9 a–c)

Test somewhat longer than broad, somewhat roundly triangular in end view; periphery subacute; chambers somewhat inflated; sutures distinct, depressed; surface smooth; aperture not seen. Length up to 1.1 mm; breadth up to 0.7 mm.



a. Side view; b. frontal view; c. rcoss section
Text-figures 5a–c *Triloculina amakusaensis* n. sp. Outlines of holotype x 42

Holotype: CF 58067 from loc. no. 2.

This new species is somewhat similar to *Triloculina trigonula* (Lamarck), but differs from the latter in it subacute periphery and not greatly inflated chambers.

Strictly speaking, it is impracticable to determinate whether the present specimens belong to the genera *Triloculina* or *Cruciloculina*. However, the present specimens probably belong to the genus *Triloculina*, because the genus *Cruciloculina* has been not known from the Miocene and older formations.

Family LAGENIDAE
Genus *Robulus* Montfort, 1808
Robulus becki Rau
(Plate VI, figures 2～4)

Robulus becki Rau, 1951, Jour. Paleont., vol. 25, no. 4, p. 431, pl. 65, figs. 19, 20.
Robulus becki Asano, 1958, Sci, Rep. Tohoku Univ., 2nd Ser. (Geol.), vol. 29, pl. 12, fig. 11.

The present specimens are somewhat smaller than the typical forms, but they agree in all other features with original description and illustration of this species.

The types of this species are from the lower part of the Willapa Valley section (Cowlitz, Keasey and Lincoln equivalents) of southwest Washington. According to W. W. Rau (1951), a single specimen described and illustrated by R. S. Beck (1943) as "*Robulus* sp. a" from the Cowlitz formation seems essentially identical with the species. In Japan, the species has been recorded by K. Asano (1958) from the Kyōragi beds.

This species is rather variable in size, but it is usually characterized by strongly curved sutures, especially near and in the umbonal region.

Robulus holcombensis Rau
(Plate VI, figures 5～9)

Robulus holcombensis Rau, 1951, Jour. Paleont., vol. 25, no, 4, pp. 431–432, pl. 63, figs. 14–17.
Robulus cf. *holcombensis* Asano, 1954, Jour. Geol. Soc. Japan, vol. 60, no. 701, p. 48, figs. 3 a, b.
Robulus cf. *holcombensis* Asano, 1958, Sci, Rep. Tohoku Univ., 2nd Ser (Geol.), vol. 29, pl. 12, figs. 14 a, b.
Robulus sp. cf. *R. holcombensis* Murata, 1959, Bull. Kyushu Inst. Tech., no. 5, p. 38, pl. 1, figs. 14 a, b.

The present specimens are rather variable in their size and number of chambers, but some of them agree in all details with original description and illustration of this species.

This species was originally described from the lower part of the Willapa Valley section (Cowlitz and Keasey equivalents) of southwest Washington. The seemingly conspecific forms have been known from the Cowlitz formation of Washington, and Coaledo, Helmick and Bastendorf formation of Oregon. In Japan, a few forms, which are compared with this species, have been recorded from the Wakkanabe formation of the Ishikari Coal-field, the Nishisonogi group of the Sakito-Matsushima Coal-field, the Okinoshima and Iojima formations of Takashima Coal-field, and the Kyōragi beds of Amakusa Coal-field.

Robulus cf. *weaveri* Beck
(Plate VI, figure 10)

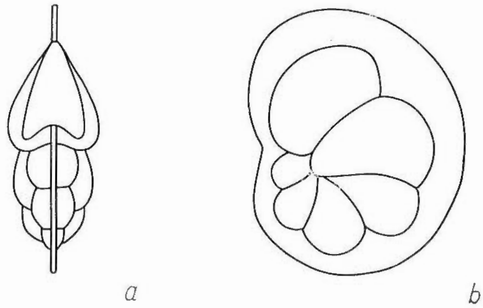
Robulus weaveri Beck, 1943, Jour. Paleont., vol. 17, p, 433, pl. 63, figs. 21, 22.
Robulus cf. *weaveri* Asano, 1958, Sci. Rep. Tohoku Univ., 2nd Ser (Geol.), vol. 29, pl. 10, figs. 9, 10.

The present specimens compare closely with those referred to *Robulus* cf. *weaveri* Beck from the middle part of the Willapa Valley section (Lincoln equivalent) (W. W. Rau, 1951) and from the Sakasegawa shale (K. Asano, 1958). The further material is needed for precise identification.

This species was originally described from the type Cowlitz of northwest Washington It is also recorded from the Porter shale of Washington.

Robulus nagaoi Fukuta, n. sp.
(Text-figures 6 a, b; Plate VI, figures 11, 12)

Test small, somewhat longer than broad, not compressed, involute; periphery with



a. Apertural view; b. side view
Text-figures 6a, b *Robulus nagaoi* Fukuta, n. sp.
Outlines of holotype x 70

a thin broad keel; chambers inflated, about 6 in last coil; sutures well marked, strongly curved; details of aperture unknown. Diameter up to 0.7 mm.

Holotype: CF 58078 from loc. no. 3.

This new species is somewhat similar to *Robulus miyagiensis* Asano which has been known from the Miocene formations of northern Japan, but differs from the latter in its completely involute test and thin broad keel.

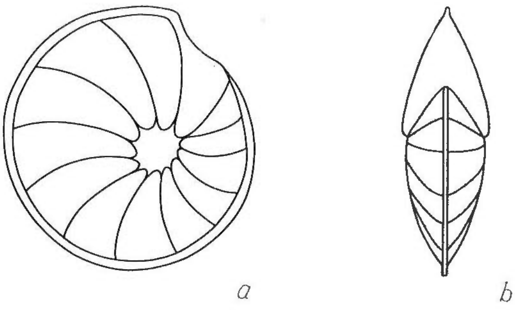
The name of this species is dedicated to late Dr. T. Nagao, a excellent pioneer of the Paleogene stratigraphy of Japan.

Robulus amakusaensis Fukuta, n. sp.
(Text-figures 7 a, b; Plate VI, figure 13)

Test moderate size, circular in outline, thickly lenticular in side view, nearly flat in umbonal region, tapering rapidly to narrow keel; chambers distinct, numerous, about 2 in last coil, last chamber somewhat raised; sutures distinct, gently curved, meeting periphery at about 60 degrees, nearly rectangular to umbo, flush to surface; umbonal region filled by clear shell material, but not raised; apertural parts generally broken, and details of aperture unknown. Diameter up to 1.1 mm.

Holotype: CF 58080 from loc. no. 4.

This new species is similar to *Robulus texanus* (Cushman and Applin) which is widely distributed in the Eocene formations of Washington, Oregon, California and Gulf Coastal Plain, but differs from the latter in its larger number of chambers. This species is also closely related to *Robulus chehalisensis* Rau, which is originally described from the Porter shale of Washington and also known from the lower part of Willapa Valley section, but



a. Side view ; b. apertural view
Text-figures 7a, b *Robulus amakusaensis* n. sp.
Outlines of holotype x 40

the latter is easily recognized by its extremely large size and compressed form.

Robulus spp.

Various illy preserved specimens are grouped here for checklisting purpose. Some of the specimens grouped here may belong to the genus *Lenticulina*.

Genus *Planularia* Defrance, 1824
Planularia sp.
(Plate VI, figure 14)

Test small, ovoid in outline, somewhat longer than broad, planispiral, bilaterally symmetrical, much compressed, both sides nearly parallel, peripheral margin with a broken keel; chambers distinct, probably 6 in last coil, somewhat inflated, increasing rapidly in size as added; sutures distinct, gently curved, considerably raised in later ones; details of aperture unknown, apertural face rather concave. Length 0.4 mm.

The single present specimen is similar to *Planularia markleyana* Church, which is rarely known from the Kreyenhagen formation and its equivalents of California (V. S. Mallory, 1959), but differs from the latter in its smaller number of chambers. The specimen is possibly a new species, but the further material is needed for specific evaluation.

Genus *Hemicristellaria* Stache, 1864
Hemicristellaria saundersi (Hanna and Hanna)
(Plate VII, figures 1, 2)

Cristellaria saundersi Hanna and Hanna, 1924, Washington Univ. (Seatle) Pub. Geology, vol. 1, no. 4, p. 61, pl. 13, figs. 5, 6 and 15.

Vaginulinopsis saundersi Beck, 1943, Jour. Paleont., vol. 17, p. 598, pl. 105, figs. 1, 2, 4, 5 and 10.

Hemicristellaria saundersi Asano, 1958, Sci. Rep. Tohoku Univ., 2nd Ser. (Geol.), vol. 29, pl. 10, figs. 3, 4.

The present specimens are very similar to the typical forms of this species.

The types of this species are from the Cowlitz formation of Washington. The species is widely distributed in the Paleogene formations of Washington, California, Mexico and Cuba. In Japan, the species has been recorded from the Sakasegawa shale and the Kyōragi beds of Amakusa Islands (K. Asano, 1958).

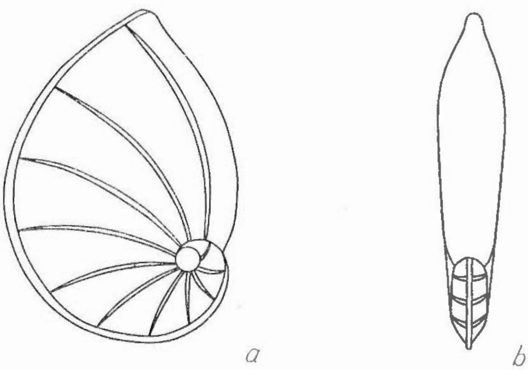
Some authors applied the genus *Vaginulinopsis* Silvestri, 1904 to this species. However, conforming to the usage of K. Asano (1958, description not given), the writer wishes to apply the genus *Hemicristellaria* to this species.

Hemicristellaria amakusaensis Fukuta, n. sp.
(Text-figures 8 a, b; Plate VI, figures 1, 2)

Test ovate, somewhat longer than broad, somewhat compressed, becoming loosely coiled in later portion, periphery somewhat keeled; chambers distinct, about 10 in last coil, slightly inflated in later portion, rapidly increasing in size as added; sutures distinct, gently curved, generally somewhat raised; wall smooth; aperture radiate, somewhat projecting, apertural face truncated. Length up to 1.2 mm; breadth up to 0.8 mm.

Holotype: CF 58084 from loc. no. 2.

This new species is somewhat similar to *Hemicristellaria gotoensis* Asano described from south of Gotō Islands in 152 m depth, but differs from the latter in its more number of chambers and sutures being not strongly raised.



a. Side view; b. apertural view
Text-figure 8a. b *Hemicristellaria amakusaensis* n. sp.
Outlines of holotype x 45

Genus *Dentalina* d'Orbigny, 1839
Dentalina cf. *hexacostata* Howe
(Plate VII, figures 5, 6)

Dentalina hexacostata Howe, 1939, Louisiana Geol. Surv. Bull., 14, p. 44, pl. 5, fig. 13.

The single fragmentary present specimen is similar to the typical forms of this species in cross section, but the further material is needed for precise identification.

This species was originally described from the Eocene of Louisiana, and it has been also known from the middle and upper Eocene formations of California.

Genus *Nodosaria* Lamarck, 1812
Nodosaria paupercula Reuss
(Plate VII, figure 7)

Nodosaria paupercula Reuss, 1845, Verstein. böhm. Kreideformation, pt. 1, p. 26, pl. 12, fig. 12.

The single fragmentary present specimen is characterized by slightly longer than wide bulbous chamber, strongly constricted sutures, and about 10 well developed costae extending across sutural areas. Diameter 1.0 mm.

This species is characteristic of the Upper Cretaceous of Europe and America. The species has been also recorded from the Eocene Esna shale of Egypt.

Genus *Lagena* Walker and Jacob, 1798
Lagena costata (Williamson)
(Plate VII, figure 8)

Entosolenia costata Williamson, 1858, Recent Foraminifera of Great Britain, p. 9, pl. 1, fig. 18.

Lagena costata Reuss, 1862, Akad. Wiss. Wien, Math-naturwiss. Kl. Sitzungsber., vol. 46, pt. 1, p. 329, pl. 4, fig. 54.

The single present specimen is very similar to the typical forms of this species in all aspects.

Many forms have been assigned to this species and no synonymy can be given with any degree of accuracy. The species is very widely distributed not only geographically but also stratigraphically.

Family POLYMORPHINIDAE
Genus *Guttutlina* d'Orbigny, 1839
Guttulina cf. *pacifica* Cushman and Ozawa
(Plate VII, figures 9, 10)

Guttulina (*Sigmoidina*) *pacifica* Cushman and Ozawa, 1928, Contr. Cushman Lab. Foram. Res., vol. 4. p. 19, pl. 2, fig. 13.

Guttulina (*Sigmoidina*) *pacifica* Asano, 1951, Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera, Part 8, p. 5, figs. 24-26.

Two present specimens, both partly broken, are similar to the typical forms of this species, but the further material is needed for precise identification.

This species is commonly found as a Recent form in the Indo-Pacific region. The species has been also found in the Neogene of Japan.

Family NONIONIDAE
Genus *Nonion* Montfort, 1808
Nonion amakusaense n. sp.
(Plate VII, figures 11~15)

Test circular in outline, close-coiled planispirally, symmetrical; involute in young stage, but evolute in adult stage to a certain extent; periphery broadly rounded, slightly lobulated;

chambers distinct, numerous, about 8 to 10 in last whorl,of nearly uniform shape, slightly inflated; sutures distinct, strongly limbate, nearly radial, but sometimes slightly curved; umbilical area depressed; wall smooth, finely perforate; aperture a curved slit at base of apertural face. Diameter up to 0.7 mm.

Holotype: CF 58093 from loc. no. 2.

This new species is similar to *Nonion chapapotense* Cole, which has been originally described from the Eocene Chapapote formation of Mexico and widely known from the Eocene of the Coastal Plain of United States, but in the latter the test is generally smaller and the umbilical region is filled by a central boss.

The present specimens are generally somewhat distorted.

Family HETEROHELICIDAE

Genus *Amphimorphina* Neugeboren, 1850

Amphimorphina californica Cushman and Mc Masters

(Plate VII, figure 16)

? *Amphimorphina californica* Cushman and Mc Masters, 1936, Jour. Paleont., vol. 10, no. 6, p. 513, pl. 75, figs. 21–25.

Amphimorphina californica Asano, 1958, Sci. Rep. Tohoku Univ.,2nd Ser. (Geol.), vol. 29, pl. 11, figs. 16 a–17.

Although the single present specimen is fragmental, it is very similar to the earlier flattened portion of the typical forms of this species.

This species was originally described from the middle Eocene Llajas formation of Simi Valley, Ventura County, California. The species is characteristic in the middle Eocene of California. In Japan, the species has been only reported by K. Asano (1958) from the Kyōragi beds of Amakusa Islands.

Family Buliminidae

Genus *Bulimina* d'Orbigny, 1826

Bulimina tarda Parker and Bermúdez

(Plate VIII, figure 1)

Bulimina tarda Parker and Bermúdez, 1937, Jour. Paleont., vol. 11, p. 514, pl. 58, figs. 6 a–c.

The single present specimen is rather regular in outline, but agrees with this species in all other features. The specimen is also similar to *Bulimina tuxpamensis* Cole, but differs from the latter in its smaller size and very slighly depressed sutures.

The types of this species are from the Eocene of Loma Principe, Havana, Cuba. The species has been also recorded from the Eocene material in some Atlantic cores taken off the east coast of the United States, and from the Eocene of Santa Susana, Poison Oak Canyon, north of Simi Valley, Ventura County, California.

Genus *Siphogenerina* Schlumberger, 1883

Siphogenerina? sp.

(Plate VIII, figure 2)

The single fragmentary present specimen is similar to the earliest uniserial part of some species of the genus *Siphogenerina*. The further material is needed for precise identification.

Family CHILOSTOMELLIDAE

Genus *Pullenia* Parker and Jones, 1862

Pullenia quinqueloba (Reuss)

(Plate VIII, figure 5)

Nonionina quinqueloba Reuss, 1851, Zeitschr. Deutsch. Geol. Ges., vol. 3, p. 71, pl. 5, fig. 31.

Pullenia quinqueloba Asano, 1951, Illustrated Catalogue of Japanese Tertiary Smaller Foraminifera, Part 12, p. 11, figs. 9, 10.

Pullenia quinqueloba Asano, 1958, Sci, Rep. Tohoku Univ., 2nd Ser.(Geol.), vol. 29, pl. 11, figs. 14 a, b.

The single present specimen is identical with the typical forms of this species excepting its elongated test by distortion.

There are many records for this widely-ranging species, but in Japan it has been only known from the Pliocene Hamada formation of Aomori prefecture and the Eocene Sakasegawa shale of Shimo-shima.

Pullenia cf. *quinqueloba angusta* Cushman and Todd

(Plate VIII, figures 4 a, b)

Pullenia quinqueloba Reuss var. *angusta* Cushman and Todd, 1943, Contr. Cushman Lab. Foram. Res., vol. 19, p. 10, pl. 2, figs. 3, 4.

Although two present specimens are somewhat distorted, their subglobular tests consisting of 5 chambers in adult coil show that they are referable to this sub-species.

The types of this subspecies are from the Eocene Midway group of Texas. This form has been also known from the Eocene formations of California, Mexico and Egypt.

Family ANOMALINIDAE

Genus *Cibicides* Montfort, 1808

Cibicides elmaensis Rau

(Plate VIII, figures 3 a, b; 7 a, b)

Cibicides elmaensis Rau, 1948, Jour. Paleont., vol. 22, p. 173, pl. 31, figs. 18–26.

A few present specimens are rather much variable in their size, but they are furnished with all features of this species.

This species was originally described from the Oligocene Lincoln formation of Washington. The species has been also recorded from lower and middle parts of the Willapa Valley section (Keasey, Lincoln and Blakeley? equivalents).

Cibicides cf. *hodgei* Cushman and Schenck

(Plate VIII, figure 8)

Cibicides hodgei Cushman and Schenck, 1928, California Univ., Dep. Geol. Sci. Bull., vol. 17, no. 9, p. 315, pl. 45, figs. 3, 5.

The single present specimen is partly broken and somewhat distorted, but it is somewhat similar to the illustrations of this species from the lower part of the Willapa Valley section (Cowlitz and Keasey equivalents) in its somewhat flattened dorsal surface, considerably enlarged last few chambers and distinctly limbate sutures (W. W. Rau, 1951, p. 451, pl. 67, figs. 28–30). The further material is needed for precise identification.

This species has been also recorded from the Bastendorf formation and the Keasey shale of Oregon, the Tumey formation of California and the type Cowlitz of Washington.

Cibicides sp.
(Plate VIII, figure 6)

Test small, somewhat longer than broad, distinctly planoconvex, dorsal side flattened, ventral side strongly convex; periphery subacute, bordered by a distinct flange of clear shell material; wall conspicuously perforate; dorsally all whorls visible, but last whorl distinctly overlapping on early ones, ventrally last whorl visible only; sutures distinct, limbate and raised, strongly curved; ventral sutures meet at umbilical area in a large plug of clear shell material; chambers distinct, numerous, 11 or 12 in last coil, gradualy increasing in size as added; last 2 or 3 chambers broken and apertural part lost. Length 0. 34 mm; breadth 0. 24 mm.

This form is somewhat similar to *Cibicides falconensis* Renz, but differs from the latter in its sutures which are strongly curved and raised in both sides, and a larger central plug of clear shell material on ventral side.

The form is provably a new species, but the further material is needed for specific evaluation.

Family GLOBIGERINIDAE
Genus *Globigerina* d'Orbigny, 1826
Globigerina cf. *linaperta* Finlay
(Plate VIII, figures 9, 10)

Globigerina linaperta Finlay, 1939, Trans. Proc. Roy. Soc. New Zealand, vol. 69, p. 125, pl. 13, figs. 54–57.

Globigerina triloculinoides Asano (not Plummer), 1958, Sci. Rep. Tohoku Univ., 2nd Ser. (Geol.), vol. 29, pl. 12, figs. 3 a, b.

The present specimens are usually somewhat distorted and rather variable in size and outline, but they are similar to those figured by H. M. Bolli (1957 a, c) from the lower Lizard Spring and Navet formations of Trinidad. The further material is needed for precise identification.

According to H. M. Bolli (1957 a), this species is provably a descendant of *Globigerina triloculinoides* Plummer from which it is distinguished by its larger size and less distinct flaring lip projecting the aperture.

This species ranges from the middle Paleocene to upper (not uppermost) Eocene in Trinidad (H. M. Bolli, 1957 a, c). In Japan, H. Ujiié and H. Watanabe (1960) reported *Globigerina* cf. *linaperta* Finlay from the Poronai formation in the Ashibetsu district, Ishikari Coal-field, but his identification left some questions owing to lack of figures. K. Asano (1958) reported *Globigerina triloculinoides* Plummer from the Kyōragi beds of Shimo-shima. Judging from his figures, this form is better to be placed in *Globigerina linaperta* Finlay.

Globigerinia cf. *parva* Bolli
(Plate VIII, figure 11)

Globigerina parva Bolli, 1957, U. S. Nat. Mus. Bull. 215, p. 108, pl. 22, figs. 14 a–c.

Although the present specimens are usually compressed, they are characterized by small, lobate and fairly high spired test with 4 chambers in last coil. The above mentioned features are recognized in the typical forms of this species, but the further material is needed for precise identification.

According to H. M. Bolli (1957 b, c), this species ranges from the upper Eocene to lower Oligocene in Trinidad, and a form comparable to this species has been also known from the uppermost middle Eocene in the same region.

Globigerina cf. *senni* (Beckmann)
(Plate VIII, figure 13)

Sphaeroidinella senni Beckman, 1953, Ecolog. Geol. Helvetinae, vol. 46, no. 2, pp. 394–395, pl. 26, figs. 2–4, text-fig. 20.

Globigerina senni Bolli, 1957, U. S. Nat. Mus. Bull. 215, p. 163, pl. 35, figs. 10 a–12.

Although the present specimens are usually considerably deformed, they are similar to the typical forms of this species in their arrangement of chambers. The further material is needed for precise identification.

According to H. M. Bolli (1957 c), this species is found in all Navet zones except the highest in Trinidad.

Globigerina cf. *venezuelana* Hedberg
(Plate VIII, figure 14)

Globigerina venezuelana Hedberg, 1937, Jour. Paleont., vol. 11, no. 8, p. 681, pl. 92, figs. 7 a, b.

The single present specimen is somewhat compressed, and the further material is needed for precise identification.

According to H. M. Bolli (1957 b, c), this species ranges from *Porticulasphaera mexicana* zone, Navet formation to *Globorotalia menardii* zone, Lengua formation in Trinidad.

Globigerina yeguaensis Weinzierl and Applin
(Plate VIII, figure 15)

Globigerina yeguaensis Weinzierl and Applin, 1929, Jour. Paleont., vol. 3, no. 4, p. 408, pl. 43, figs. 1a, b.

The single present specimen is somewhat compressed, and the further material is needed for precise identification.

According to H. M. Bolli (1957 c) this species ranges from *Hantkenia aragonensis* zone, Navet formation to *Globorotalia cocoaensis* zone, San Fernando formation in Trinidad.

Globigerina spp.

Various illy preserved specimens are grouped here for checklisting purpose.

Family GLOBOROTALIIDAE
Genus *Globorotalia* Cushman, 1927
Globorotalia cf. *perclara* Loeblich and Tappan
(Plate VIII, figure 12)

Globorotalia perclara Loeblich and Tappan, 1957, U. S. Nat. Mus. Bull. 215, pp. 191–192, pl. 40, figs. 7 a–c; pl. 41, figs. 8 a–c; pl. 42, figs. 4 a–c; pl. 45, figs. 11 a–c; pl. 46, figs. 3 a-c; pl. 47, figs. 6 a–c; pl. 50, figs. 1 a–c; pl. 54, figs. 6 a–7 c; pl. 57, figs. 3 a–4 c; pl. 60, figs. 5 a–c.

The single present specimen is poorly preserved, and the further material is needed for precise identification.

According to A. R. Loeblich and H. Tappan (1957), this species has been known from the Paleocene and lower Eocene formations in the Gulf and Atlantic Coastal Plains of United states.

Globorotalia cf. *wilcoxensis* Cushman and Ponton
(Plate VIII, figure 16)

Globorotalia wilcoxensis Cushman and Ponton, 1932, Contr. Cushman Lab. Foram. Res., vol. 8, pt. 3, p. 71, pl. 9, figs. 10 a–c.

The present specimens are poorly preserved, and the further material is needed for precise identification.

" The *Globorotalia wilcoxensis* zone has been widely known in the Wilcox stage of the Gulf Coast of America; and in the Middle East of Asia, the zone ranges from the Ypressian to Lutetian, according to Grimsdale, 1951"——K. Asano (1958). According to H. M. Bolli (1957 a), this species has been found in the *Globorotalia rex* zone, Upper Lizard Springs formation of Trinidad.

Globorotalia sp.

The single present specimen is highly distorted, and it is impossible to specifically identify this specimen.

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天草下島教良木層産始新世有孔虫類

福田　　理

要　　旨

教良木層は天草下島に広く分布し，主として頁岩からなり，900m 以上の層厚を有する。本研究の基礎となつた試料は5地点から採集されたが，その中の4地点は本層の上限から約 50m 下位にある有孔虫に富んだ層準に属し，残りの1地点は本層の基底から約 50m 上位に位置している。これらの試料から26属・15科に属し，9新種を含む約60種類の有孔虫が検出された。

上位の有孔虫に富んだ層準に属する4地点の有孔虫群相互の間には本質的な相違はなく，いずれも温帯の数100m の深度の変化が少ない環境を暗示している。残りの1地点の有孔虫群は上述の4地点より浅い環境を示すものであろう。この地点と大体同じ層準から *Nummulites amakusensis* Yabe and Hanzawa その他の高等有孔虫が知られていることから判断すると，教良木層の最下部は台湾を通じて Tethys 海と連絡していた暖流の影響下に堆積したものと考えられる。*Cyclammina formosensis* Yabe and Hanzawa および *Cyclammina tani* Ishizaki が上位の有孔虫に富んだ層準に産することから見て，Tethys 海との連絡は本層の堆積の後期に至るまで続いていたと思われる。

上位の有孔虫に富んだ層準の底棲有孔虫群は上部始新統とされている Cowlitz 層およびその相当層のものに近縁であるが，筆者は本層を Ypressian の後半から Lutetian にわたる時代のものと考えたい。何となれば，上位の有孔虫に富んだ層準の浮游性有孔虫群は中部始新世の特徴を有するからである。坂瀬川層に特徴的な *Plectofrondicularia packardi* Cushman and Schenck およびその近縁種が本層に見られないことも以上の時代論の裏づけとなるものであろう。Cowlitz 層およびその相当層の底棲有孔虫群の要素の一部は Washington より日本において早期に出現したものと思われる。

地質調査所報告は１報文につき報告１冊を原則とし，その分類の便宜のために次のようにアルファベットによる略号を附ける。

A．地質およびその基礎科学に関するもの
- a．地　質
- b．岩石・鉱物
- c．古生物
- d．火山・温泉
- e．地球物理
- f．地球化学

B．応用地質に関するもの
- a．鉱　床
- b．石　炭
- c．石油・天然ガス
- d．地下水
- e．農林地質・土木地質
- f．物理探鉱・化学探鉱および試錐

C．そ　の　他

D．事業報告

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- c. Paleontology
- d. Volcanology and Hot spring
- e. Geophysics
- f. Geochemistry

B. Applied geology
- a. Ore deposits
- b. Coal
- c. Petroleum and Natural gas
- d. Underground water
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REPORT, GEOLOGICAL SURVEY OF JAPAN

No. 189

Takahashi, K., Sunagawa, I. & Otsu, H.: Minor constituents in sulphide minerals from the Oppu mine, Aomori prefecture, 1961 (in Japanese with English abstract)

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PLATES

AND

EXPLANATIONS

(with 8 Plates)

Explanation of Plate I

Figure 1 *Bathysiphon eocenica* Cushman and G. D. Hanna
Side view of hypotype CF 58001 from loc. no. 3. ×20.

Figures 2～4 *Haplophragmoides amakusaensis* Asano and Murata
2, Side view of hypotype CF 58002 from loc. no. 1. 3, Side view of hypotype CF 58003 from loc. no. 1. 4, Side view of hypotype CF 58004 from loc. no. 1. All figures ×20.

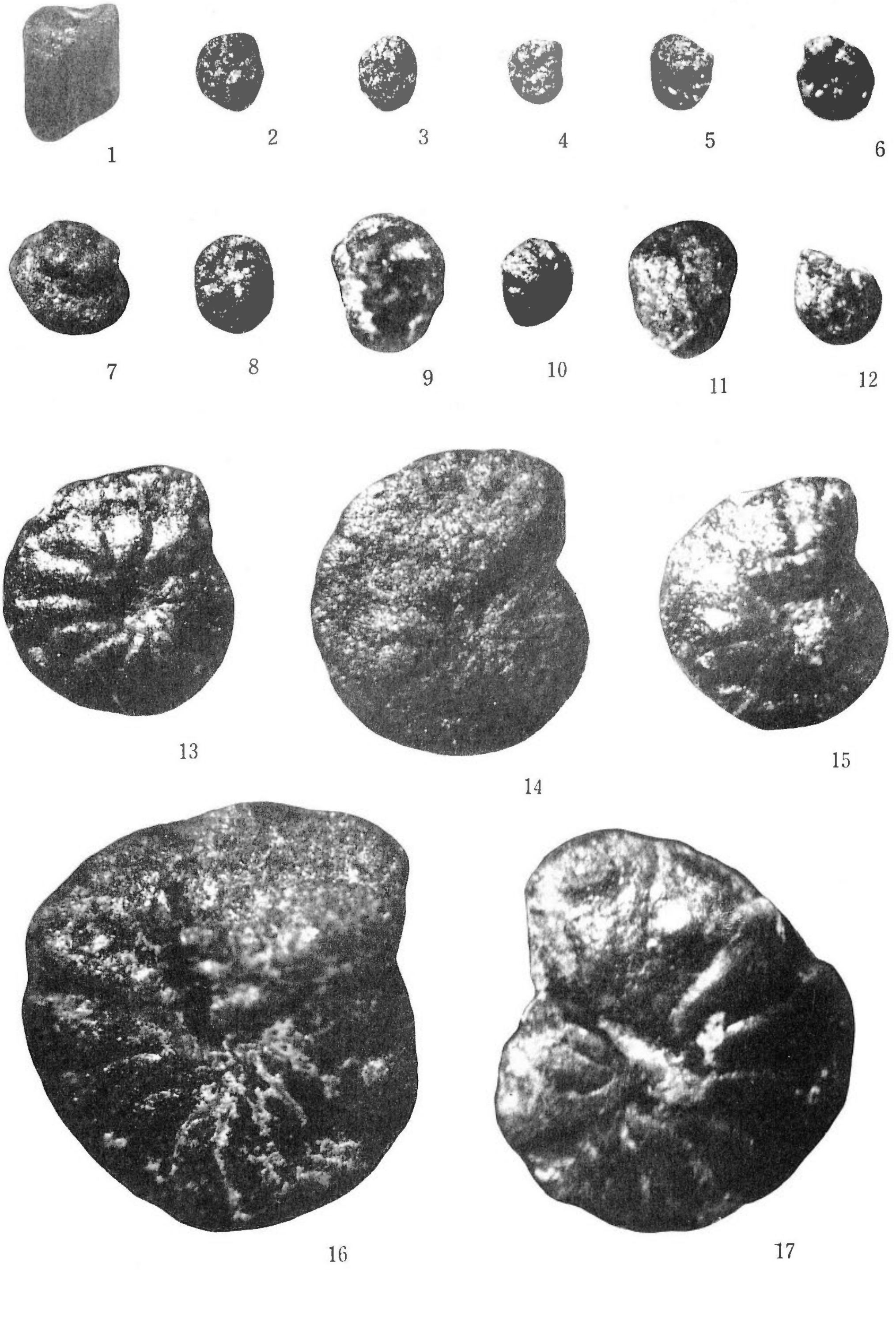
Figure 5 *Haplophragmoides* cf. *emaciatum* (Brady)
Side view of hypotype CF 58005 from loc. no. 2. ×20.

Figures 6～10 *Haplophragmoides subamakusaensis* Fukuta, n. sp.
6, Side view of paratype CF 58006 from loc. no. 1. 7, Side view of holotype CF 58007 from loc. no. 2. 8, Oblibuely side view of distorted paratype CF 58008 from loc. no. 1. 9, Back view of highly distorted paratype CF 58009 from loc. no. 13. 10, Side view of paratype CF 58010 from loc. no. 2. All figures ×20.

Figure 11 *Haplophragmoides* sp.
Side view of hypotype CF 58011 from loc. no. 2. ×20.

Figure 12 *Ammobaculites* sp.
Side view of hypotype CF 58012 from loc. no. 4. ×20.

Figures 13～17 *Cyclammina formosensis* Yabe and Hanzawa
13, Side view of hypotype CF 58013 from loc. no. 1. 14, Side view of hypotype CF 58014 from loc. no. 3. 15, Side view of hypotype CF 58015 from loc. no. 4. 16, Side view of hypotype CF 58016 from loc. no. 4. 17, Side view of hypotype CF 58017 from loc. no. 4. Fig. 13 ×21; fig. 14 ×25; fig. 15 ×28; fig. 16 ×23; fig. 17 ×19.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Explanation of Plate II

Figures 1, 2 *Cyclammina formosensis* Yabe and Hanzawa

1, Side view of hypotype CF 58018 from loc. no. 4. 2, Side view of hypotype CF 58019 from loc. no. 4. Fig. 1 ×23 ; fig. 2 ×21.

Figures 3～6 *Cyclammina incisa* (Stache)

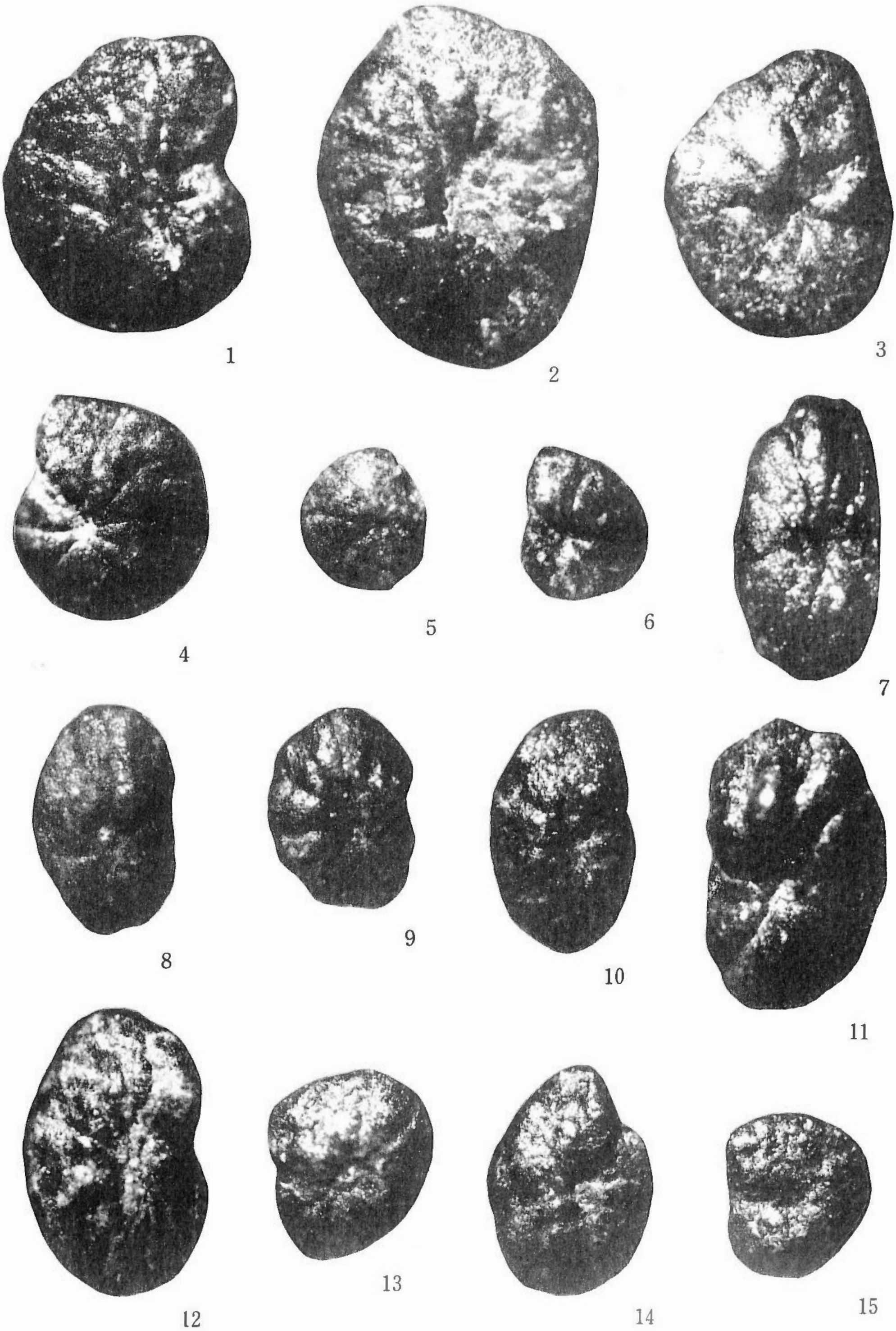
3, Side view of hypotype CF 58020 from loc. no. 4. 4, Side view of hypotype CF 58021 from loc. no. 4. 5, Side view of hypotype CF 58022 from loc. no. 4. 6, Side view of hypotype CF 58023 from loc. no. 4. Fig. 3 ×22 ; figs. 4 ×30 ; figs. 5, 6 ×22.

Figures 7～12 *Cyclammina* cf. *obesa* Cushman and Laiming

7, Side view of hypotype CF 58024 from loc. no. 2. 8, Side view of hypotype CF 58025 from loc. no. 1. 9, Side view of hypotype CF 58026 from loc. no. 1. 10, Side view of hypotype CF 58027 from loc. no. 1. 11, Side view of hypotype CF 58028 from loc. no. 4. 12, Side view of hypotype CF 58029 from loc. no. 4. Fig. 7 ×23; figs. 8～10 ×22; fig. 11 ×24 ; fig. 12 ×22.

Figures 13～15 *Cyclammina* cf. *pacifica* Beck

13, Side view of hypotype CF 58030 from loc. no. 1. 14, Side view of hypotype CF 58031 from loc. no. 1. 15, Side view of hypotype CF 58032 from loc. no. 2. Fig. 13 ×22 ; figs. 14, 15 ×24.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Explanation of Plate III

Figures 1~3 *Cyclammina* cf. *pacifica* Beck
1, Side view of hypotype CF 58033 from loc. no. 2. 2, Side view of hypotype CF 58034 from loc. no. 4. 3, Side view of hypotype CF 58035 from loc. no. 4. All figures ×22.

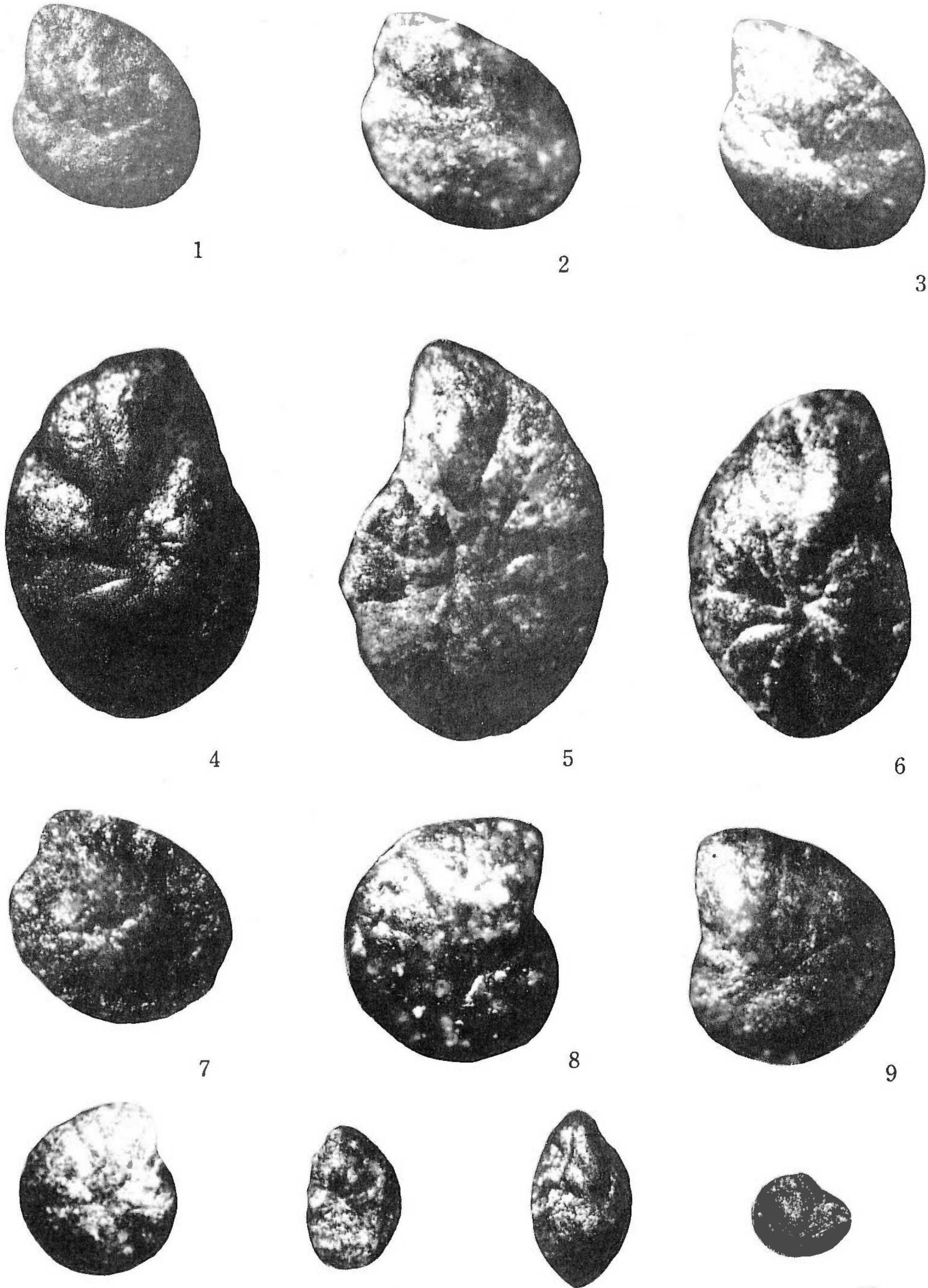
Figures 4~6 *Cyclammina tani* Ishizaki
4, Side view of hypotype CF 58036 from loc. no. 3. 5, Side view of hypotype CF 58037 from loc. no. 4. 6, Side view of hypotype CF 58038 from loc. no. 4. All figures ×22.

Figure 7 *Cyclammina pusilla* Brady
Side view of hypotype CF 58039 from loc. no. 3. ×40.

Figures 8~10 *Cyclammina amakusaensis* Fukuta, n. sp.
8, Side view of paratype CF 58040 from loc. no. 2. 9, Side view of holotype CF 58041 from loc. no. 4. 10, Side view of paratype CF 58042 from loc. no. 4. Figs. 8, 9 ×40 ; fig. 10 ×22.

Figure 11 *Cyclmamina* sp. 1
Side view of hypotype CF 58043 from loc. no. 4. ×22.

Figures 12, 13 *Cyclammina* sp. 2
12, Side view of hypotype CF 58044 from loc. no. 3. 13, Side view of CF 58045 hypotype from loc. no. 3. Both figures ×22.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Explanation of Plate IV

Figures 1 a~4 *Trochammina amakusaensis* Fukuta, n. sp.

1 a, Ventral view of holotype CF 58046 from loc. no. 2; 1 b, dorsal view of same specimen. 2 a, Dorsal view of paratype CF 58047 from loc. no. 3; 2 b, ventral view of same specimen. 3 a, Dorsal view of paratype CF 58048 from loc. no. 4; 3 b, ventral view of same specimen. 4, Dorsal view of distorted paratype CF 58049 from loc. no. 2. Figs. 1 a, b ×22 ; figs. 2 a~4 ×45.

Figure 5 *Trochammina* sp. 1

Dorsal view of hypotype CF 58050 from loc. no. 1. ×22.

Figure 6 *Trochammina* sp. 2

Dorsal view of hypotype CF 58051 from loc. no. 1. ×45.

Figure 7 *Trochammina* sp. 3

Dorsal view of hypotype CF 58052 from loc. no. 4. ×45.

Figure 8 *Trochammina* sp. 4

Dorsal view of hypotype CF 58053 from loc. no. 2. ×45.

Figures 9, 10 *Trochammina* sp. 5

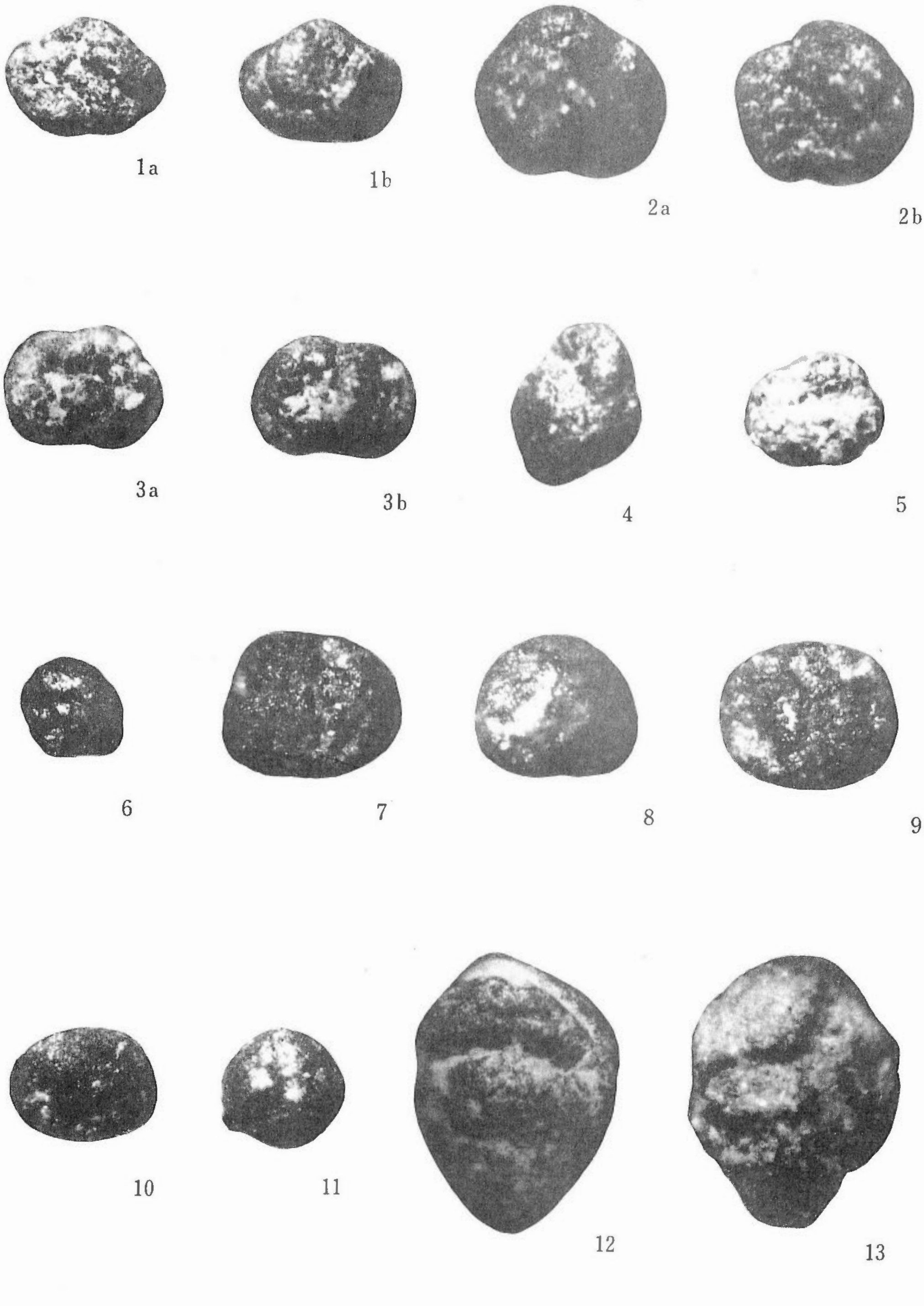
9, Dorsal view of hypotype CF 58054 from loc. no. 4. 10, Dorsal view of CF 58055 from loc. no. 4. Both figures ×45.

Figure 11 *Conotrochammina* ? sp.

Dorsal view of hypotype CF 58056 from loc. no. 2. ×45.

Figures 12, 13 *Eggerella amakusaensis* Fukuta, n. sp.

12, Side view of holotype CF 58057 from loc. no. 4. 13, Side view of paratype CF 58058 from loc. no. 4. Both figures ×50.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Explanation of Plate V

Figure 1 — *Eggerella amakusaensis* Fukuta, n. sp.
Side (somewhat apical) view of paratype CF 58059 from loc. no. 3. ×45.

Figure 2 — *Eggerella* ? sp.
Side view of hypotype CF 58060 from loc. no. 4. ×45.

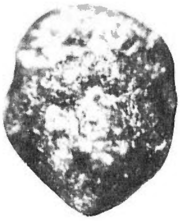
Figure 3 — *Plectina eocenica* Cushman
Side view of hypotype CF 58061 from loc. no. 4. ×45.

Figures 4, 5 — *Plectina poronaiensis* Asano
4, Side view of hypotype CF 58062 from loc. no. 3. 5, Side view of hypotype CF 58063 from loc. no. 3. Both figures ×45.

Figure 6 — *Plectina* sp.
Side view of hypotype CF 58064 from loc. no. 2. ×45.

Figures 7, 8 — *Quinqueloculina goodspeedi* Hanna and Hanna
7, Frontal view of hypotype CF 58065 from loc. no. 4. 8a, Frontal view of hypotype CF 58066 from loc. no. 4; 8b, back view of same specimen. All figures ×45.

Figures 9a～c — *Triloculina amakusaensis* Fukuta, n. sp.
9a, Side view of holotype CF 58067 from loc. no. 2; 9b, frontal view of same specimen; 9c, apertural view of same specimen. All figures ×45.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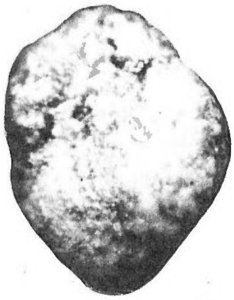
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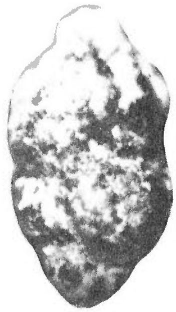
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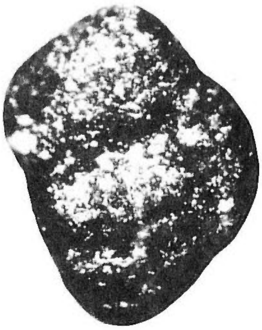
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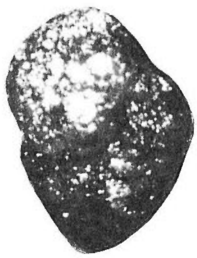
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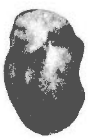
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9a


9c


9b

Explanation of Plate VI

Figure 1 *Triloculina* cf. *trigonula* (Lamarck)
Frontal view of hypotype CF 58068 from loc. no. 2. ×45.

Figures 2～4 *Robulus becki* Rau
2, Side view of hypotype CF 58069 from loc. no. 4. 3, Side view of hypotype CF 58070 from loc. no. 4. 4, Side view of hypotype CF 58071 from loc. no. 4. All figures ×45.

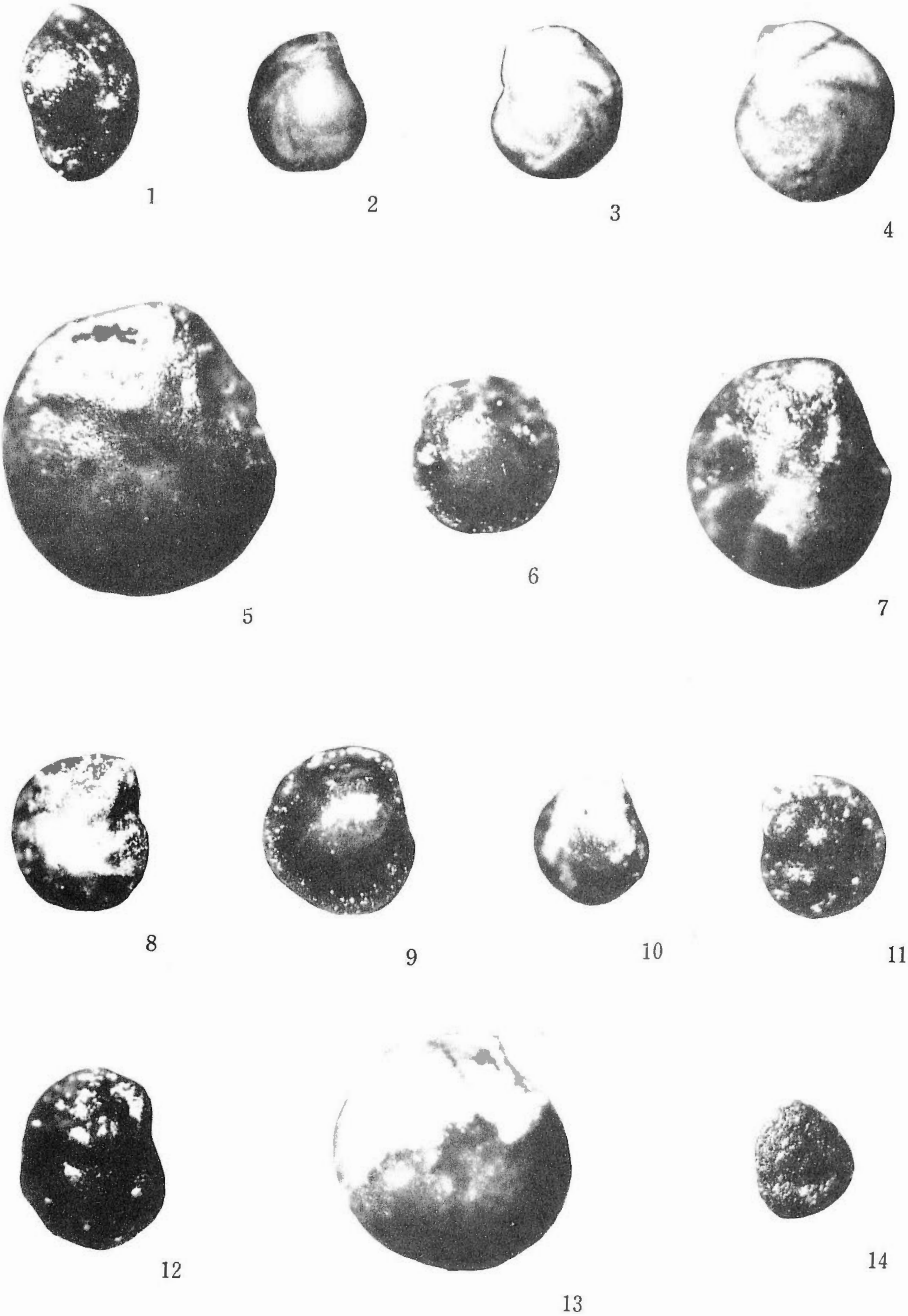
Figures 5, 7, 8 *Robulus holcombensis* Rau
5, Side view of hypotype CF 58072 from loc. no. 2. 7, Side view of hypotype CF 58074 from loc. no. 2. 8, Side view of hypotype CF 58075 from loc. no. 2. Figs. 5, 7 ×45; fig. 8 ×40.

Figures 6,9,10 *Robulus* cf. *weaveri* Beck
6, Side view of hypotype CF 58073 from loc. no. 2. 9, Side view of hypotype CF 58076 from loc. no. 3. 10, Side view of hypotype CF 58077 from loc. no. 3. All figures ×45.

Figures 11, 12 *Robulus nagaoi* Fukuta, n. sp.
11, Side view of holotype CF 58078 from loc. no. 3. 12, Side view of paratype CF 58079 from loc. no. 3. Both figures ×45.

Figure 13 *Robulus amakusaensis* Fukuta, n. sp.
Side view of holotype CF 58080 from loc. no. 4. ×45.

Figure 14 *Planularia* sp.
Side view of hypotype CF 58081 from loc. no. 2. ×45.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Explanation of Plate VII

Figures 1, 2 *Hemicristellaria saundersi* (Hanna and Hanna)
1, Side view of hypotype CF 58082 from loc. no. 2. 2, Side view of hypotype CF 58083 from loc. no. 2. Both figures ×45.

Figures 3, 4 *Hemicristellaria amakusaensis* Fukuta, n. sp.
3, Side view of holotype CF 58084 from loc. no. 2. 4, Side view of paratype CF 58085 from loc. no. 2. Both figures ×22.

Figures 5, 6 *Dentalina* cf. *hexacostata* Howe
5, Side view of hypotype CF 58086 from loc. no. 5. 6. Obliquely side view of hypotype CF 58087 from loc. no. 5. Both figures ×45.

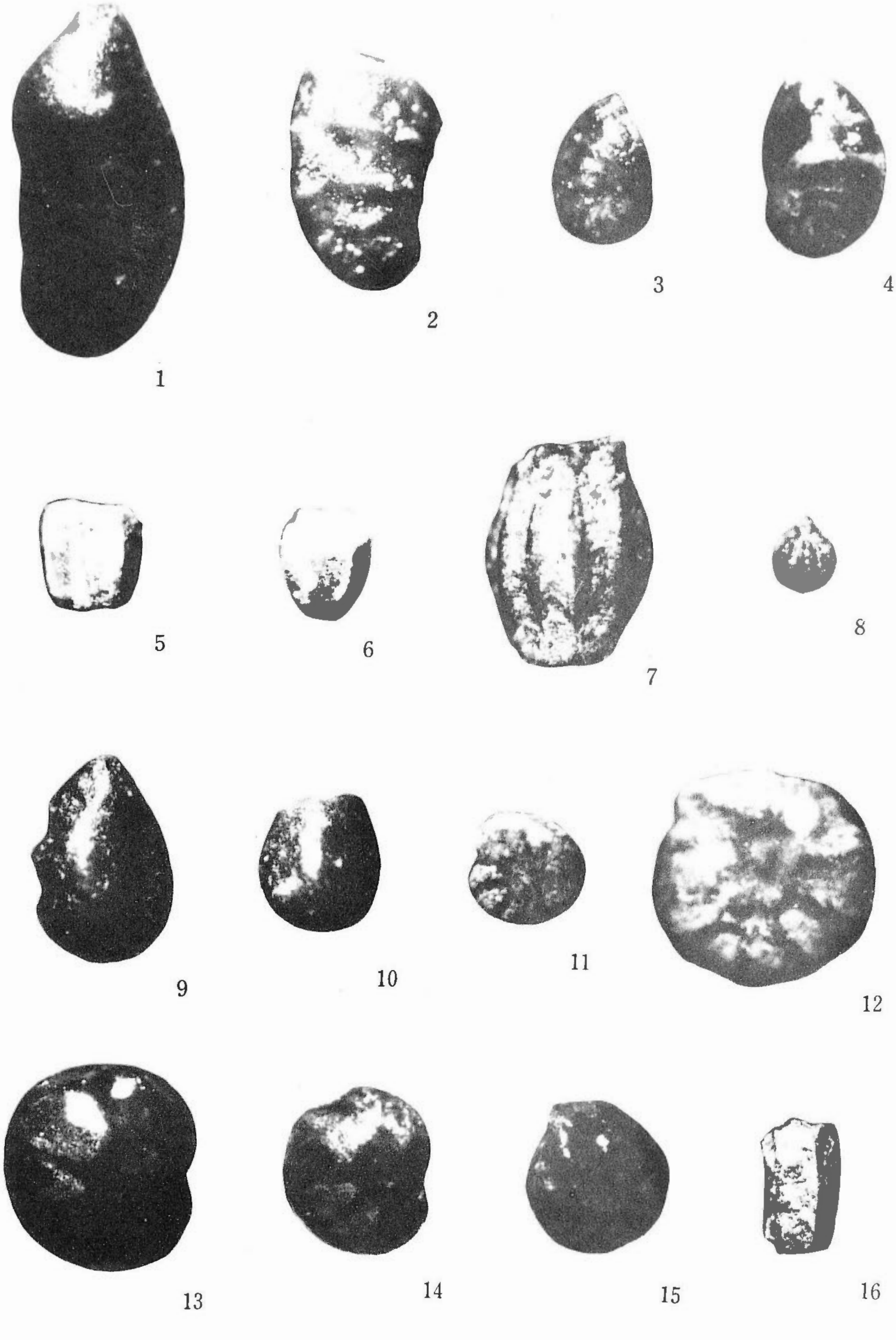
Figure 7 *Nodosaria paupercula* Reuss
Side view of hypotype CF 58088 from loc. no. 4. ×22.

Figure 8 *Lagena costata* (Williamson)
Side view of hypotype CF 58089 from loc. no. 2. ×45.

Figures 9, 10 *Guttulina* cf. *pacifica* Cushman and Ozawa
9, Side view of hypotype CF 58090 from loc. no. 2. 10, Side view of hypotype CF 58091 from loc. no. 2. Both figures ×45.

Figures 11～15 *Nonion amakusaense* Fukuta, n. sp.
11, Side view of paratype CF 58092 from loc. no. 2. 12, Side view of holotype CF 58093 from loc. no. 2. 13, Side view of paratype CF 58094 from loc. no. 2. 14, Side view of paratype CF 58095 from loc. no. 2. 15, Side view of paratype CF 58096 from loc. no. 2. All figures ×40.

Figure 16 *Amphimorphina californica* Cushman and McMasters
Side view of hypotype CF 58097 from loc. no. 4. ×45.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Explanation of Plate Ⅷ

Figure 1 *Bulimina tarda* Parker and Bermúdez
Side view of hypotype CF 58098 from loc. no. 3. ×45.

Figure 2 *Siphogenerina* ? sp.
Side view of hypotype CF 58099 from loc. no. 5. ×45.

Figures 3 a, b ; 7 a, b. *Cibicides elmaensis* Rau
3 a, Dorsal view of hypotype CF 58100 from loc. no. 2; 3 b, ventral view of same specimen. 7 a, Dorsal view of hypotype CF 58104 from loc. no. 2; 7 b, ventral view of same specimen. All figures ×45.

Figures 4 a, b *Pullenia* cf. *quinqueloba angusta* Cushman and Todd
4 a, Obliquely side view of distorted hypotype CF 58101 from loc. no. 4; 4 b, apertural view of same specimen. Both figures ×45.

Figure 5 *Pullenia quinqueloba* (Reuss)
Side view of hypotype CF 58102 from loc. no. 4. ×45.

Figure 6 *Cibicides* sp.
Side view of hypotype CF 58103 from loc. no. 2. ×45.

Figure 8 *Cibicides* cf. *hodgei* Cushman and Schenck
Side view of hypotype CF 58105 from loc. no. 4. ×45.

Figures 9, 10 *Globigerina* cf. *linaperta* Finlay
9, Obliquely umbilical view of distorted hypotype CF 58106 from loc. no. 2.10, Dorsal view of distorted hypotype CF 58107 from loc. no. 4. Both figures ×40.

Figure 11 *Globigerina* cf. *parva* Bolli
Dorsal view of compressed hypotype CF 58108 from loc. no. 4. ×40.

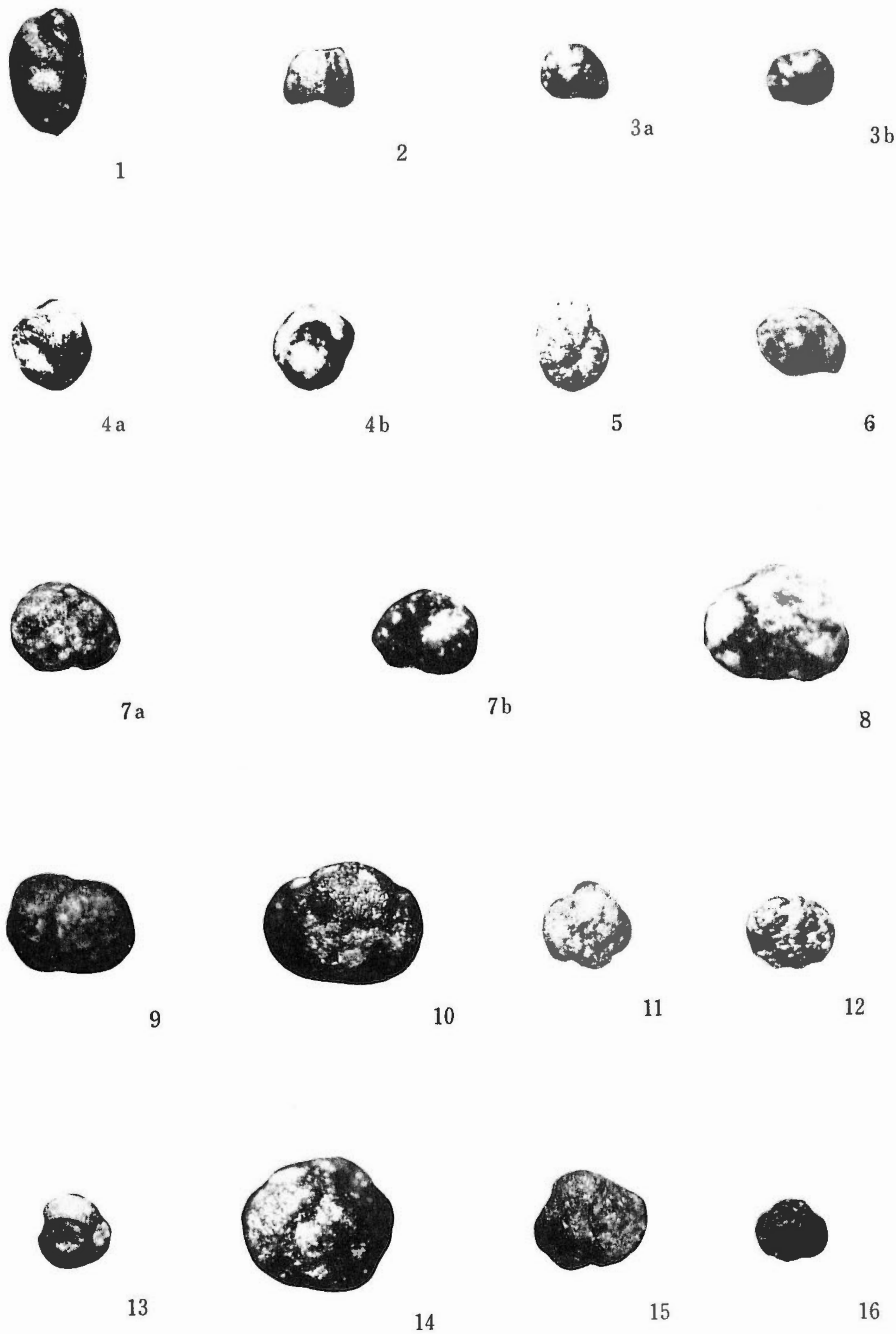
Figure 12 *Globorotalia* cf. *perclara* Loeblich and Tappan
Dorsal view of poorly preserved hypotype CF 58109 from loc. no. 2. ×40.

Figure 13 *Globigerina* cf. *senni* (Beckmann)
Umbilical view of distorted hypotype CF 58110 from loc. no. 4. ×40.

Figure 14 *Globigerina* cf. *venezuelana* Hedberg
Dorsal view of somewhat compressed hypotype CF 58111 from loc. no. 3. ×40.

Figure 15 *Glabigerina* cf. *yeguaensis* Weinzierl and Applin
Dorsal view of distorted hypotype CF 58112 from loc. no. 4. ×40.

Figure 16 *Globorotalia* cf. *wilcoxensis* Cushman and Ponton
Umbilical view of poorly preserved hypotype CF 58113 from loc. no. 2. ×40.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Fukuta, O.

Eocene Foraminifera from the Kyōragi Beds in Shimo-shima, Amakusa Islands, Kumamoto Prefecture, Kyushu, Japan

Osamu Fukuta
地質調査所報告, No, 194, p. 1～31, 1962
8 illus., 8 pl., 2tab.

The Kyōragi beds is widely distributed in Shimo-shima, Amakusa Islands, and mainly consists of shale more than 900 meters thick. The beds carries numerous Foraminifera of which about 60 forms belonging in 26 genera of 15 families are discussed and illustrated. Foraminiferal evidence appears to indicate that the Kyōragi beds is upper Ypressian to Lutetian in age. Environmental conditions are also discussed in accordance with foraminiferal evidence.

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