CORE SAMPLE OF BOTTOM SEDIMENT AT THE NORTHERN PART OF NAKANOSE, TOKYO BAY

Yoshio Iwabuchi, Naoaki Aoki*, Kei Oshite**, Shoichi Hori†, and Takahiro Sato

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Abstract

The rate of sedimentation of Tokyo Bay is estimated by means of core analysis as 2.4 cm per 10 years. This rate was determined on the basis of the key bed of scoria layer derived from the Hoei eruption of Mt. Fuji.

And, chronological changes of sedimentary environment through the core have been found by the analyses of grain size, minerals, pollen, diatom, and foraminifera.

1. Introduction

The core sample of 3.4 m in length had been obtained from 33 m-depth of the northern part of Nakanose, Tokyo Bay (35° 19.′7 N., 139° 44.′2 E. Fig. 1), by the piston core sampler of the surveying ship *Takuyo* of the Hydrographic Office on October in 1958.

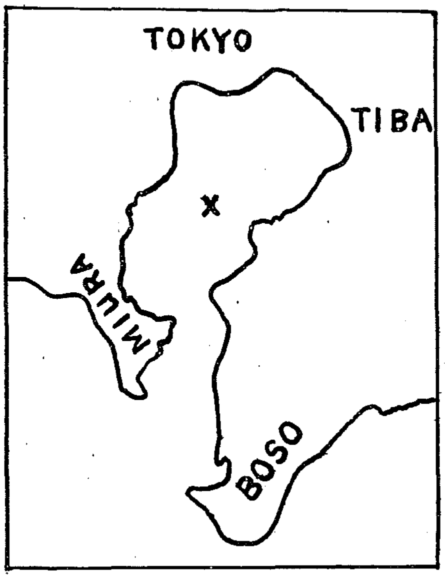


Fig. 1.

Recently, the rate of accumulation of the pelagic sediments is ascertained on the basis of radioactive isotopes and fossils. In the neritic or embayment sea, on the other hand, material for dating of sedimentation has not been adequatly informed.

It has been reported that the volcanic ashes coming from the Mt. Fuji eruption was interbeded in the sediment of Tokyo Bay (Hoshino 1958, Niino 1957).

The aims of this paper are, firstly to acertain the rate of accumlation of sediment of Tokyo Bay, which shows the typical bay environment, by means of these volcanic ashes and secondly to study grain sizes, minerals, pollens, diatoms and foraminiferas in order to know the chronological changes of sedimentary environ-

* Institute of Geology and Mineralogy, Tokyo University of Eduction.
** Institute of Earth Science, Hakodate Branch, Hokkaido Gakugei University.
† Biological Department, Faculty of Liberal Arts, Gumma University.

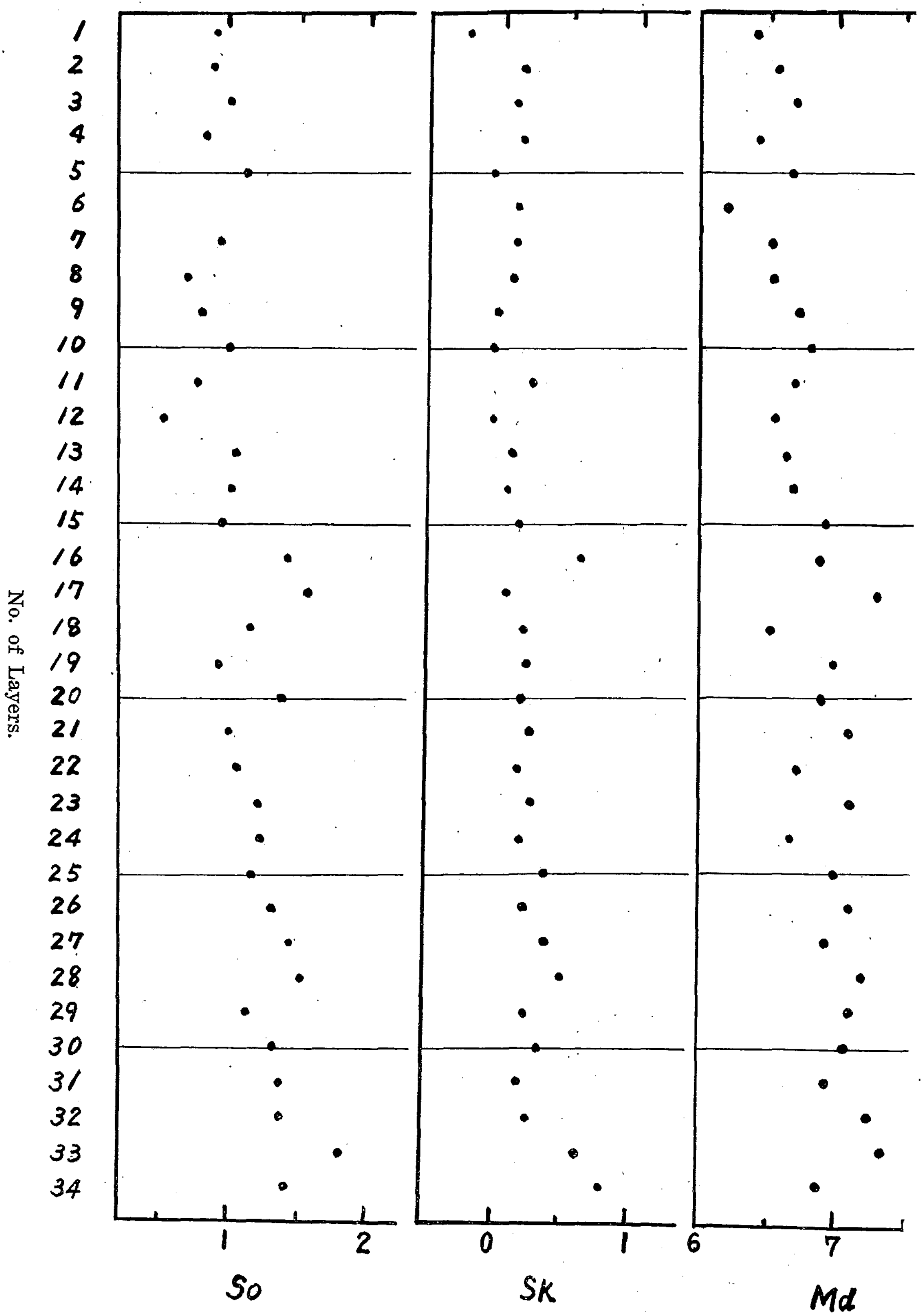


Fig. 2. Grain Size of the Samples.

ment.

Each section of this investigation was done by the following authors, and the whole text was arranged by the first author:

Grain size and minerals:	Iwabuchi and Sato
Pollen:	Hori
Diatom:	Oshite
Foraminifera:	Aoki

2. Grain size analysis

(1) Method of analysis.

The core sample of 3.4 m-length was divided by every ten centimeters equally, being denominated Nos. 1, 2, ..., 34 from the top. Grain size analysis was carried out for about 30 gr. in wet weight, by the pipette method (Sato and Nasu, 1956), since the samples were all muddy materials. Taking ϕ as an index of grain size in abscissa, the cumulative curve yields Q_1, Q_3, and Md, from which sorting coefficient So, and skewness Sk are evaluated by the following formulae, respectively:

$$So=(Q_3-Q_1)/2,$$

and

$$Sk=(Q_3+Q_1-2Md)/2.$$

These So and Sk are adopted as the representative values of each sample.

(2) Results of analysis.

Sediment samples show very little variance through out the core, and, in most cases, the finer fraction than 4 ϕ attains to 90~95%, except two scoria layers of 60 (No. 6) and 270 cm-layers (No. 27).

The values of Md obtained from the cumulative curve are adopted as the representatives showing the coarseness or fineness of sample, though they do not mean the most frequent diameters of grains directly. In general, each Md lies between 6~7.5 ϕ having little differences among samples. However, they may be divided into two parts, i. e. (i). Md=6~7 ϕ for samples upper than the layers Nos. 15 and 16, and (ii). Md=6.5~7.5 ϕ for samples lower than these layers (Table 1). The difference between these two parts can be recognized more clearly in the relations Md–Sk (Figs. 2 and 3). Sorting coefficients are various, but are, as a general tendency, becoming larger donwnwards. Skewnesses are, generally, positive or nearly equarl to zero, increasing downwards. Fig. 3 are diagrams of grain size, Md–So and Md–Sk. In this figure, we can classify the samples into three groups, which we call Types I, II and III, provisionally. Type I is coarse and has skewness of nearly equal to zero, showing well sorting. Type II is, on the contrary, fine and has positive skewness, showing well sorting (Fig. 3, Table 1). Type III is intermediate. For type I, samples concentrate to the upper parts of the core, i. e. Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, ..., and mean of Md=6.6 ϕ, So=0.55~

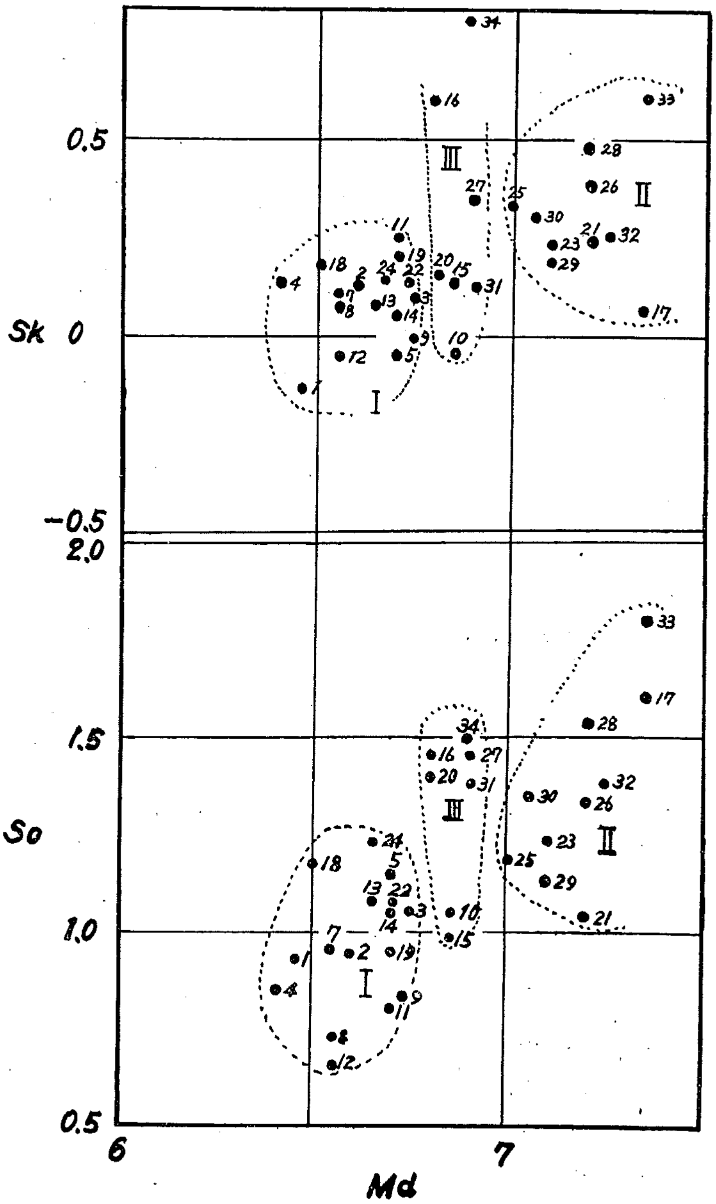


Fig. 3. Grain Size Diagram.

1.55, and Sk=−0.25∼+0.25. Type II contains Nos. 17, 21, 23, 25, 26, 28, 29, ..., and mean of Md=7.2 ϕ, So=1.05∼1.80, and Sk=0.05∼0.60. In Type III, some samples (Nos. 10 and 15) are similar to Type I, and show So=1.00± and Sk=−0.05∼+0.60, and some others (Nos. 16, 27 and 34) are similar to Type II, and show So=1.45 and Sk=0.35∼+0.60.

(3) Discussion.

We can see that, as a result of last sedimentation after repetitions of setting and disturbance, sea environment which had been favourable to accumulate fine deposits gradually changed to that favourable to accumulate coarse deposits. The cause of this change is a problem to be solved

TABLE 1. GRAIN SIZE DISTRIBUTION MEASURES

No.	Water Ratio %	Sand Ratio %	$4<\phi<8$ %	$\phi>8$ %	Q_1	Q_3	Md	SO	SK	Sediment Type
1	65.4	7.6	80.6	11.8	5.25	7.10	6.45	0.95	−0.25	I
2	64.5	5.3	65.8	28.9	5.80	7.70	6.60	0.95	+0.15	I
3	58.6	5.6	71.3	23.1	5.80	7.90	6.75	1.05	+0.10	I
4	58.2	6.3	75.8	17.9	5.70	7.40	6.40	0.85	+0.15	I
5	56.5	13.6	64.9	21.5	5.45	7.75	6.70	1.15	−0.10	I
6	54.5	29.5	52.5	18.0	—	7.30	6.20	—	—	
7	55.9	11.2	68.9	19.9	5.70	7.60	6.55	0.95	+0.10	I
8	57.0	6.3	77.0	16.7	5.90	7.35	6.55	0.75	+0.10	I
9	58.1	5.1	76.2	18.7	5.95	7.60	6.80	0.85	0.00	I
10	53.9	10.1	67.5	22.4	5.75	7.85	6·85	1.05	−0.05	III
11	54.7	3.0	74.3	22.7	6.15	7.75	6.70	0.80	+0.25	I
12	53.3	5.7	79.5	14.8	5.95	7.05	6.55	0.55	−0.05	I
13	55.3	10.6	67.4	22.0	5.65	7.80	6.65	1.10	+0.10	I
14	61.3	6.5	71.5	22.0	5.70	7.80	6.70	1.05	+0.05	I
15	61.3	2.1	73.7	24.2	6.00	7.95	6.85	1.00	+0.15	III
16	57.0	5.4	64.0	30.6	5.95	8.85	6.80	1.45	+0.60	III
17	—	1.6	59.2	39.2	5.80	9.00	7.35	1.60	+0.05	II
18	—	1.2	75.5	23.3	5.50	7.85	6.50	1.20	+0.20	I
19	56.9	3.5	70.0	26.5	6.25	8.15	7.00	0.95	+0.20	I
20	56.7	8.5	61.5	30.0	5.55	8.35	6.80	1.40	+0.15	III
21	54.7	1.0	67.9	31.1	6.40	8.45	7.20	1.05	+0.25	II
22	53.9	4.5	72.4	23.1	5.75	7.90	6.70	1.10	+0.15	I
23	53.2	2.9	63.5	33.6	6.10	8.55	7.10	1.25	+0.25	II
24	54.3	6.0	68.6	25.4	5.55	8.00	6.65	1.25	+0.15	I
25	56.4	3.6	64.6	31.8	6.15	8.50	7.00	1.20	+0.35	II
26	53.7	1.2	62.3	36.5	6.05	8.70	7.20	1.35	+0.20	II
27	53.5	8.6	56.7	34.7	5.80	8.70	6.90	1.45	+0.35	III
28	52.7	4.5	59.5	36.0	6.15	9.20	7.20	1.55	+0.50	II
29	52.5	4.7	66.6	28.7	6.05	8.30	7.10	1.15	+0.10	II
30	50.7	2.7	63.3	34.0	6.10	8.80	7.05	1.35	+0.40	II
31	51.0	4.5	65.8	29.7	5.65	8.40	6.90	1.40	+0.15	III
32	52.7	4.3	56.5	39.2	6.20	8.95	7.25	1.40	+0.35	II
33	50.7	3.4	54.4	42.2	6.15	9.75	7.35	1.80	+0.60	II
34	49.3	3.6	58.4	38.0	6.25	9.00	6.90	1.40	+0.75	III

in future.

3. Coarse grain analysis

For the coarse grains, we treated grains larger than 200-mesh. For grains of 200～48-mesh, analysis were carried out only on heavy minerals, and for the ones larger than 48-mesh, the ratio of composites were numbered under binocularmicroscope.

(1) Mineral composition.

Minerals are very rare, and more than half of contents are quartz and plagioclase. Though pyroxenes are found usually in heavy minerals, they are very rare. The numbers of pyroxene in 10 gr. of dry weight are shown in Fig. 4.

(2) Scoria.

The core sample is characterized by the coarse grained layers in Nos. 6 and 27 (Fig. 4), both of which are composed of black basaltic scoria. The scoria in No. 6 contains black scoria and rugged grey pumice, being the former more abundant. The boundary of layers between two pyroclastics is not recognized clearly, though rugged grey pumice seems to be more abundant in the lower part of No. 6. The elements of grain size of scoria are $Md=2.1\,\phi$, $So=0.6$ and $Sk=-0.2$, with 3 mm in maximum diameter. They are porous under microscope and some of them show phenocrysts of plagioclase and beautiful olivine. Microlites of plagioclase lath and augite are scattered in glassy groundmass. Scoria in the sample No. 27 has similar content as in No. 6, showing microlites of plagioclase and olivine, whose sizes are generally small, with maximum diameter of about 2 mm.

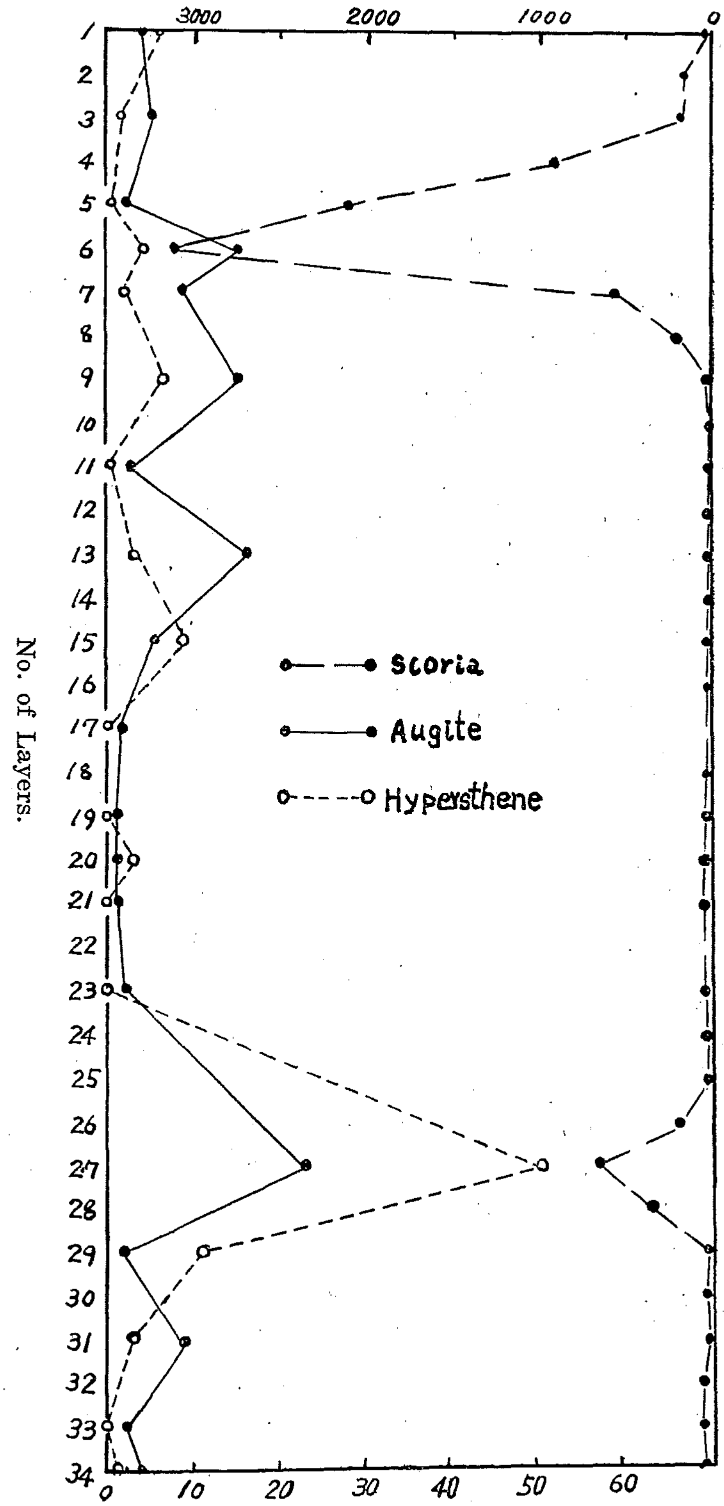
Number of heavy mineral specimens are scanty in No. 6-layer, neverthess, containing augite relatively much, and, on the contrary, No. 27-layer contains many specimens, and is abundant in hypersthene (Fig. 4).

(3) Discussion.

If the scoria layers of Nos. 6 and 27 had been conveyed from land indirectly, the samples would contain many other coarse materials of same sizes as scoria. Moreover,scoria layers occupy comparatively clear boundary in the upper and lower layers, respectively. Therefore, we may consider that these layers reflect volcanic eruptions at that times, respectively. On investigating the history of volcanic eruptions, we can refer the eruption of Mt. Fuji in the Hoei era (1707) for the source of scoria inferring from the condition that the eruption distributed abundant basaltic scorias for vast areas. (Kiuchi, 1959, and Omori, 1919). Incidentally, eruptions of Hoei found at Sibusawa-hill (Kanagawa-prefecture) are composed of regolith of 5 cm depth, black scoria of 10 cm, and grey pumice of 6 cm in descending order. Under microscope, this black scoria is composed of microlites of plagioclase and olivine which are perfectly identical with the basaltic scoria in the core. Further, the most distinctive feature of the Hoei eruption is existence of basaltic scoria under which acid andesite follows, and this phenomenon has never found in the eruptions of Mt. Fuji in other era (Tsuya, 1944). Since grey pumices are found under black basaltic scoria in No. 6-layer, it must be attributed to the Hoei eruption.

Though scoria represented by No. 6 scatters for 20 cm in depth, we adopt 60 cm-layer which situates in the lowest part of the scoria zone, and in which scoria distributes compactly, as the standard of chronological purpose. Then, we may assume that it has taken about 250 years to deposit mud layers of about 60 cm, that is, in the rate of 2.4 cm per ten years. Taking the effect of compression of core sample into account, we may assume the total length of the core to be about 3.8 m originally. Hence, the above rate of sedimentation yields 1600 years for the age of the core. Scoria layer of No. 27 cor-

Numbers of Scoria Specimens in 5 gr
of dry weight.



Numbers of Augite-and Hypersthene
Specimens in 10 gr of dry weight.

Fig. 4. Numbers of specimens of Scoria, Augite and Hypersthene.

responds to an eruption of about 1300 year ago. This scoria is basaltic, and we can not surmise whether it had been carried from Mt. Fuji or other volcano.

4. Pollen analysis

(1) Method of analysis.

Samples were taken at each 10 cm from the top of the core. 10% solution of potassium hydroxide was added twice the quantity of each sample of about 5 gr, respectively. They were heated in a water bath for for about 20 min, and were washed by water for several times. Then, the samples were examined under microscope (Fig. 5). Number of pollen specimens was counted for each layer, evaluating the percentage of each genus, though, except Nos. 1~7 layers, the analysis were impossible owing to their scarcity of pollens.

(2) Results of analysis.

The actual number of pollen specimens found in constant quantity of each sample is shown in Fig. 5. Pollens are fairly abundant in the layers Nos. 1~7, and are much rare in the layers under No. 9, except No. 31.

In samples, pollens of *Pinus, Picea, Abies, Tsuga, Quercus, Corylus, Alnus, Juglans, Zekova, Cryptomeria, Salix, Shiia,* and *Gramineae,* and spore of Pteridophyta are found (Table 2). In Nos. 1~7-layers, *Pinus* is most abundant, showing frequency over 85%, to which *Quercus,* 2~5.8%, and *Tsuga,* 0.7~3.5%, follows. Frequencies of the other pollens are very low. In No. 31-layer, *Quercus* is most abundant, 33.3%, to which *Pinus,* 21.9%, follows. *Picea, Abies* and *Cryptomeria* are much abundant than in the upper layers.

TABLE 2. OCCRRENCE PERCENTAGE OF POLLENS

Genus \ Depth	10 cm	20	30	40	50	60	70	310
Pinus	91.5	93.5	89.9	87.1	89.5	92.9	89.8	21.9
Picea	1.8	0.9	1.9	1.2		1.2	1.2	5.7
Abies	0.7					1.2	5.3	7.6
Tsuga	0.7	1.9		3.5	2.3		2.5	15.2
Quercus	3.9	1.9	4.3	5.8	5.8	4.7	1.2	33.3
Corylus	0.7		2.2					1.0
Alnus	0.7		1.2	1.2				1.0
Juglans				1.2	1.2			
Zelkova		0.9	1.2					2.9
Cryptomeria		0.9			1.2			11.4

(3) Discussion.

As stated above, the contents of pollens are much different between

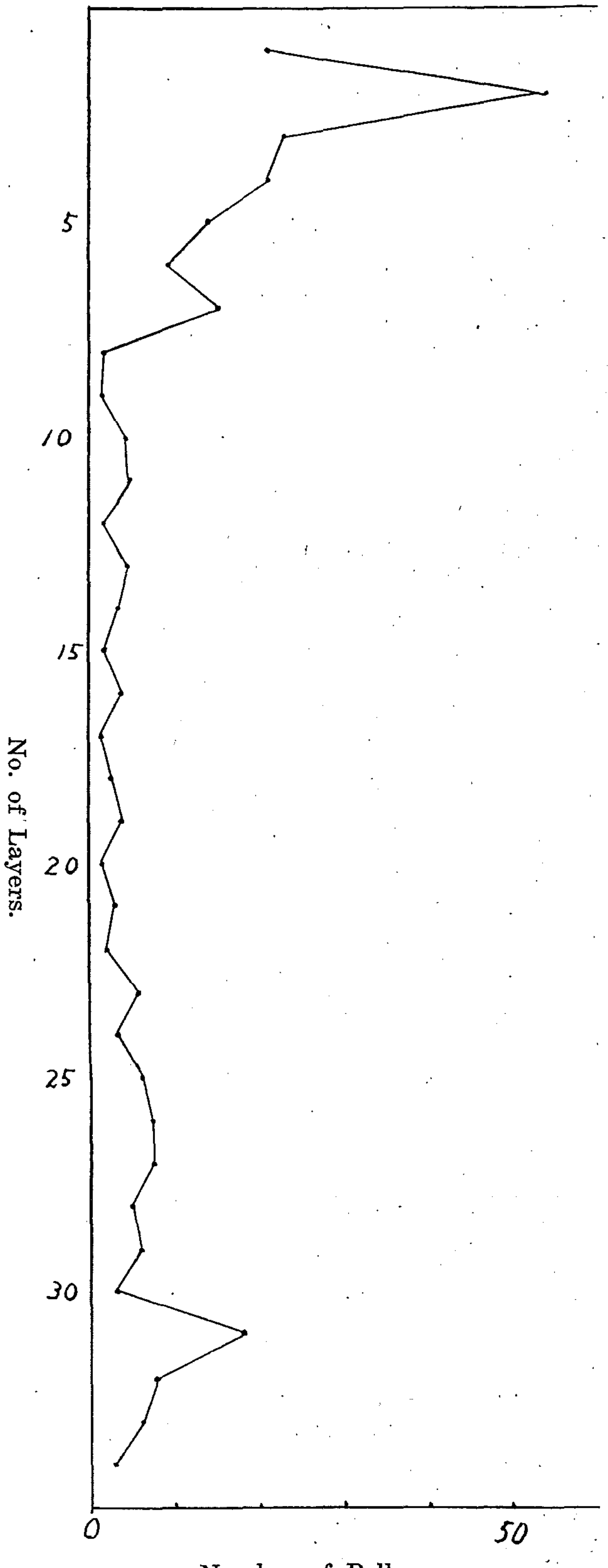


Fig. 5. Number of Pollen Specimens.

Nos. 1~7-layers and No. 31-layer, and we may attribute this to the difference of climates in the respective periods of sedimentation. The differences between upper and lower layers are also clear in grain size and diatoms. In considering the frequencies, it must be borne in mind that the more distant from the land the more frequent is the pollens of *Pinus* which can fly longer distance and the less the other pollens, and further, that *Pinus* has increased recently very much, climbing higher regions.

In any way, the analysis of pollens of bottom sediments has been carried out for the first time, and further analysis on the other samples are intended.

5. Diatom analysis

As shown in Table 3, the contents of diatoms are not so various through the core. The number of specimens shows gradual increase downwards, containing some ten thounsands in samples of 1 gr each. As for preservation. diatoms are less crashed in the lower parts, and some are remained in chain shape. Fresh water diatoms, such as *Epithemia zebra* and *Pinnularia* sp, are both in the upper and lower layers, being less than 1%.

TABLE 3. COMMON DIATOMS FROM CORE

Marine species
Actinoptychus senarius
As. splendens
Cocconeis scutellum
Coscinodiscus centralis
Co. excentricus
Co. curvatulus
Co. marginatus
Co. radiatus
Diploneis smithi
Melosira sulcata
Brackish species
Cyclotella striata
Fresh water species
Epithemia zebra
Pinnularia sp.

Fig. 6 shows the frequency of diatom fossils of three genera for every 50 cm-layer, i. e. plankton genus, *Coscinodiscus*, marine to brackish, *Cyclotella* and benthic *Actinoptychus*.

Frequency of brackish genus *Cyclotella* becomes larger, and on the contrary *Coscinodiscus* inhabitable in high salinity becomes smaller downwards.

Judging from the general trend, we can estimate the condition under the sedimentation that is, the lower parts of the core indicate the deposition

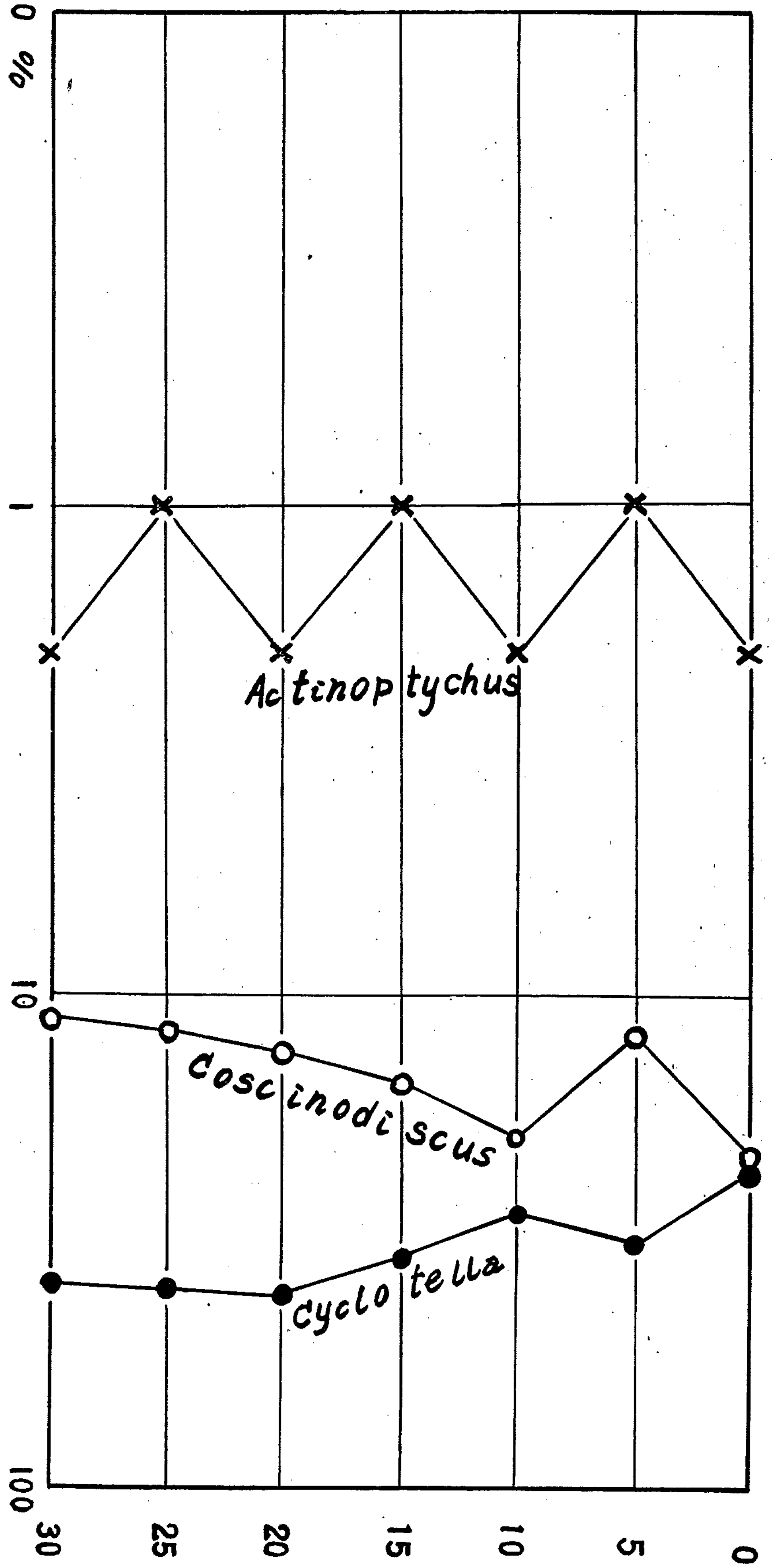


Fig. 6. Occurrence Percentage of Diatoms.

under the quiet sea or embayment, and at least the influence of fresh water was not so important as recent.

6. Foraminifera Analysis

Of the thirty-four samples in the core, seventeen ones in odd numbers with the lowest layer No. 34 were carefully examined for foraminiferal analysis, after washing in the 200-mesh standard seive. The results of this quantitative study are summarized in Table 4, showing the number of individual tests per 1 gr of sediment (dry weight).

The principal dominant species in every samples are as follows; *Nonionella pulchella*, *Rotalia beccarii japonica*, *Epistominella tamana*, *Quinqueloculina vulgaris*, *Nonion manpukujiense*, *Quinqueloculina seminulum*, *Fissurina* cf. *laevigata* and vars., *Bulimina ujiiei* n. sp., *Quinqueloculina lamarckiana*. The species belonging to the genera *Cassidulina*, *Elphidium*, *Bolvina*, *Fissurina* and *Lagena* are also abundantly occured, but the arenaceous and the pelagic forms are very rare.

The total foraminiferal numbers are low and fluctuate irregularly with an average of about 30~60, however, it is remarked that the layers Nos. 25~27 in the lower part of the core, have the highest value run up to 140~170 and the great numbers of species contained. The frequency of each species through the core shows to be generally related to the total foraminiferal number and the maximum count is usually in the layers Nos. 25~27, therefore, any significant vertical change in assemblage can not be detected from the base to the top in this core.

Reffering to the study of the surface sediments in Tokyo Bay (Morishima, 1955), the above-mentioned constituent species are all characteristic of and distribute in abundance in, the central part of the Bay and the composition of species is also similar to the modern one of the Nakanose, off Yokohama, from which this piston core sample had been collected.

Description of New Foraminifera

(by Naoaki Aoki)

Family Elphidiidae

Genus ELPHIDIUM Montfort, 1808

Elphidium subgranulosum Asano, subsp. *aureum* Aoki, n. subsp.

Plate 1, Nos. 7~10

Description.—Test medium in size, planispiral and involute, periphery broadly rounded and much lobulated; six to eight chambers in a final coil, increasing in size as added, strongly inflated, especially in later chambers; umbilical region depressed without a boss; sutures distinct, gently curved, much depressed, filled with whitish granular shell materials, provided with retral processes, about six in a suture; wall very distinctly perforated, colored in yellowish brown; last formed chamber usually projecting and much inflated, having transparent wall of more faint color; aperture several small round openings at the base of apertural face.
Length up to 0.36 mm.

Remarks.—This form is closely allied to *Elphidium subgranulosum* Asano, 1938, but it differs from the latter in having comparatively fewer number of the more inflated chambers. It is also distinguishable from *Elphidium etigoense* Husezima and Maruhasi, 1944, by more inflated chambers, more deep sutures with fewer retral processes and coarser perforation of this new subspecies.

Types.—Holotype, Reg. No. 52032, from the layer No. 11 (at 100—110 cm. deep), Paratype, Reg. No. 52033, from the layer No. 33 (at 320—330 cm. deep), both in the piston core sample from Nakanose, off Yokohama, Tokyo Bay; Holocene.

Genus ELPHIDIELLA Cushman, 1936

Elphidiella tokyoensis Aoki, n. sp.

Plate 1, Nos. 1~4

Description.—Test of small size, compressed, planispiral, nearly circular or

slightly longer than broad, margin very slightly lobulated and round in periphery, sides nearly parallel, umbilical portion slightly depressed; chamber seven to nine in last coil, not inflated; suture very slightly depressed, gently curved, about ten pores arranged along curved sutures, but occasionally two rows of pores clearly observable; wall smooth, transparent, finely perforated; surface of the one or two earliest chambers of the last whorl and the apertural face of the last formed chamber ornamented with numerous fine granules; aperture indistinct in all, a few number of small openings, about five, at the base of the septal face of the penultimate chamber.
Length up to 0.25 mm.

Remark.—This species differs from *Elphidiella hannai* (Cushman and Grant, 1927), by its minute size, less developed and indistinct sutural pores and delicate wall, and also differs from *Elphidium somaense* Takayanagi, 1955, by fewer number of chambers and the sutural characters of the new species.

Besides from the recent sediment in the Tokyo Bay, this species was found rather frequently from the Pleistocene Tokyo and Narita Formations developed around the Bay. The recent specimens are all smaller in size.

Types.—Holotype, Reg. No. 52034, and Paratypes, Reg. No. 52035, from the "Tokumaru Shell Bed" of the Tokyo Formation, exposed at Negishi, Asaka, west of Tokyo; Pleistocene. Figured Paratype, Reg. No. 52036, from the layers No. 3 (at 20—30 cm deep) in the piston core sample from Nakanose, off Yokohama, Tokyo Bay; Holocene.

Family Buliminidae

Genus BULIMINA d'Orbigny, 1826

Bulimina ujiiei Aoki, n. sp.

Plate 1, Nos. 5, 6

Description.—Test minute in size, subcircular in cross section, nearly twice as long as broad, fusiform in outline, consisting of about three whorls, overhanging previous ones, last formed whorl making up over two-thirds of the test; chambers distinct, inflated, triserially arranged, increasing rapidly in size, with the base undercut and a few short spines along the edge; sutures distinctly depressed; wall thin, transparent and very finely perforated; aperture, terminal, a broad, loop-shaped opening, placed above the preceeding chamber, with a distinct lip.
Length up to 0.23 mm.

Remarks.—This species is easily distinguished from *Bulimina marginata* (d'Orbigny, 1826), and *B. marginospinata* Cushman and Parker, 1938, and their related species by its much small-sized and slender test.

Virgulina schreibersiana var. *spinosa* Heron-Allen and Earland, 1932, from off Falkland Islands, may be the most allied species to the present one, but, the former has a more elongate test, less overlapped chambers and fewer number of conspicuous spines.

Types.—Holotype, Reg. No. 52037, from the layers No. 23 (at 220—230 cm. deep), Paratype, Reg. No. 52038, from the layers No. 25 (at 24—25 cm. deep), both in the piston core sample from Nakanose, off Yokohama, Tokyo Bay; Holocene.

Family Cassidulinidae

Genus CASSIDULINA d'Orbigny, 1826

Cassidulina kattoi Takayanagi, subsp. *obesa* Aoki, n. subsp.

Plate 1, Nos. 11～14

Description.—Test medium, somewhat compressed, breadth about two-thirds of the length, periphery rounded and slightly lobulated, ovale in lateral view, with thickness of test more than half its diameter; about four pairs of chambers forming the last coil, broad and inflated, last one about a half of test in size; sutures distinctly depressed, umbonal portion depressed; wall rather polished, opaque, finely perforated; aperture elongate narrow slit, nearly parallel to plane of coiling, curved, extending the full length of the last septal face, with a elongate, projecting, plate-like tooth.
Length up to 0.40 mm.

Remarks.—This recent subspecies differs from *Cassidulina kattoi* Takayanagi, 1953, from the Pliocene formations in Kochi Prefecture, in having a more inflated chambers, distinctly depressed sutures and a more elongate slit-like aperture with a large flap. It also resembles to *Cassidulina oblonga* Reuss, 1850, except its size and apertural character.

Types.—Holotype, Reg. No. 52039, from the layers No. 31 (at 300—310 cm deep), Paratype, Reg. No. 52040, from the layers No. 9 (at 80—90 cm deep), both in the piston core sample from Nakanose, off Yokohama, Tokyo Bay; Holocene.

Explanation of Plate.

Nos.

1—4 *Elphidiella tokyoensis* Aoki, n. sp.
X150. 1, 2, Holotype, from the Pleistocene Tokyo Formation at Asaka, Tokyo. 3, 4, Paratype, from Sample 3.

5, 6 *Bulimina ujiiei* Aoki, n. sp.
X120. 5, Holotype, from Sample 23. 6, Paratype, from Sample 25.

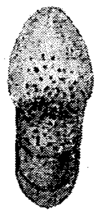
7—10 *Elphidium subgranulosum aureum* Aoki, n. subsp.
X120. 7, 8, Holotype, from Sample 11. 9, 10, Paratype, from Sample 33.

11—14 *Cassidulina kattoi obesa* Aoki, n. subsp.
X120. 11, 12, Holotype, from Sample 31. 13, 14, Paratype, from Sample 9.

All specimens listed in the Table 4 are preserved in the collections of the Institute of Geology and Mineralogy, Tokyo University of Eduction, under Registered Numbers from 51301 to 52040.

The author is much indebted to Prof. Kiyoshi Asano and Dr. Yokichi Takayanagi for their valuable suggestions on foraminifera.

PLATE I. Foraminifera (Aoki)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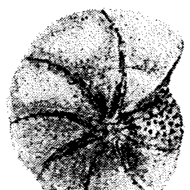
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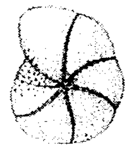
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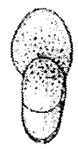
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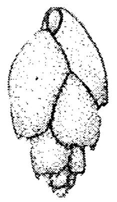
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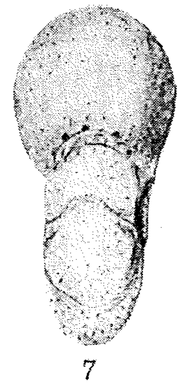
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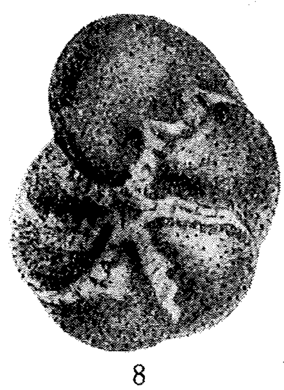
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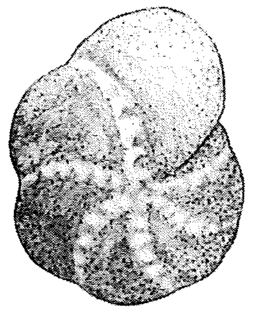
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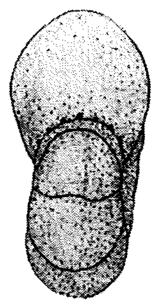
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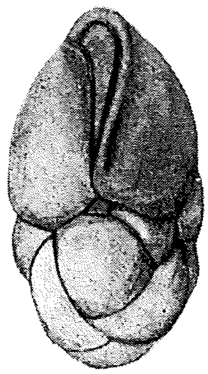
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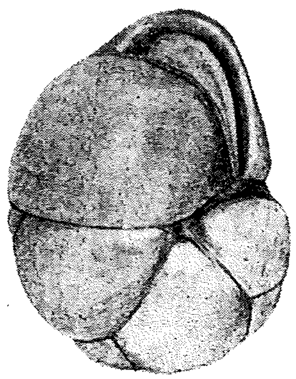
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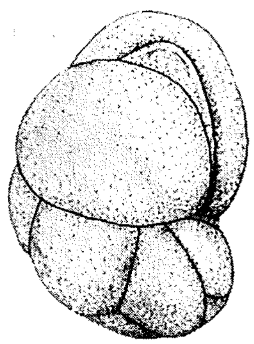
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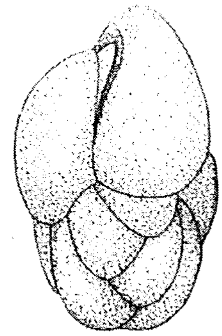
14

TABLE 4. FORAMINIFERA IN THE CORE SAMPLE
(Number of specimens in 1 gr of dry sediment).

Foraminifera \ Sample No.	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	34
Haplophragmoides 2 spp.	0.1	—	—	—	0.1	—	—	0.2	—	—	—	—	0.1	—	—	—	—	—
Quinqueloculina lamarckiana d' Orbigny	0.1	0.2	—	—	0.5	0.6	0.8	0.3	0.3	0.6	1.6	1.4	1.6	2.5	1.2	1.2	0.8	1.6
Q. seminulum (Linné)	1.3	0.4	0.4	1.6	1.5	0.7	2.2	1.3	—	2.4	2.0	1.4	5.0	5.2	4.6	6.0	5.2	2.4
Q. valgaris d' Orbigny, and var.	2.1	3.8	2.6	2.6	2.8	1.3	4.4	2.6	1.3	2.6	4.0	6.8	10.2	13.8	5.2	6.4	4.0	1.8
Q. sp. A.	—	—	—	—	0.3	0.1	—	0.1	—	—	0.2	—	0.2	1.3	—	0.8	0.4	0.2
Q. spp.	0.2	—	—	—	—	0.1	—	0.2	—	—	—	—	—	—	—	—	—	—
Triloculina tricarinata d' Orbigny, and var.	—	0.2	0.2	—	0.5	0.1	0.6	0.1	0.1	0.2	0.2	—	0.4	0.7	0.2	—	—	—
Biloculinella "subsphaerica" Wiesner	—	—	0.2	0.4	0.1	—	—	—	—	0.4	0.4	—	0.4	0.2	—	0.4	—	—
Pyrgoella sphaera (d' Orbigny)	—	—	—	—	0.2	—	—	—	—	—	0.4	0.2	0.4	0.1	0.2	0.4	—	0.2
Spiroloculina sp.	—	—	—	—	0.1	—	—	—	—	—	—	—	—	0.1	0.2	—	—	—
Massilina sp.	—	—	—	—	0.1	—	—	—	—	—	—	—	—	—	0.2	0.4	—	—
Cornuspira involvens (Reuss)	—	—	0.2	—	—	—	—	—	—	—	—	—	0.1	0.3	—	—	—	—
Cornuspirella diffusa (Heron-Allen and Earland)	—	—	—	—	0.2	—	—	—	—	—	—	—	—	0.2	—	—	—	—
Trochammina globigeriniformis (Parker and Jones)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.4	—
T. sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—	—	—	—
Robulus calcar (Linné)	0.4	—	0.4	—	0.3	0.3	0.2	0.1	—	0.2	0.2	—	0.4	0.5	0.2	0.4	—	0.2
R. cf. *lucidus* (Cushman)	—	—	—	—	0.1	—	—	—	—	—	—	—	0.1	0.2	—	—	—	—
R.? sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—	—	—	—
Lenticulina? cf. *kamakuraensis* Asano	—	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—
Saracenaria latifrons (Brady)	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—
S. cf. *minatoi* Shirai	—	—	—	—	—	—	—	—	—	—	—	0.2	—	0.2	—	—	—	—
Astacolus? sp.	—	—	—	—	0.1	—	—	—	—	—	—	0.2	0.1	—	—	—	—	—
Dentalina emaciata Reuss	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
D. 2 spp.	—	—	—	—	—	—	—	0.1	—	0.2	—	—	—	—	—	—	—	—
Nodosaria pyrula d' Orbigny	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—
Lagenonodosaria pauciloculata (Cushman)	0.1	—	—	—	—	—	—	—	—	—	—	—	0.1	0.2	—	0.4	—	—
L. scalaris sagamiensis Asano	—	—	0.2	0.2	—	—	0.2	—	—	—	—	—	—	0.1	0.2	—	—	0.2
Lagena distoma Parker and Jones	—	—	0.2	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—
L. meridionalis Wiesner	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—	—	—	—
L. parri Loeblich and Tappan	—	—	0.2	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—

TABLE 4. *(Continued)*

Foraminifera \ Sample No.	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	34
L. perlucida (Montagu)	—	—	0.2	—	0.1	—	—	—	—	—	0.2	—	0.1	0.2	—	—	—	—
L. striata (d' Orbigny)	0.1	—	—	—	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—
L. setigera (Millet)	—	0.2	—	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—
L. sulcata laevicostata Cushman and Gray	—	—	—	—	0.2	0.2	0.2	—	—	—	—	—	—	—	—	—	—	—
L. sulcata spicata Cushman and McCulloch	0.3	0.6	0.8	0.4	0.5	0.2	0.8	0.1	—	0.8	0.6	—	0.9	1.1	—	—	0.4	—
Oolina cf. *globosa* Montagu	0.1	—	—	0.2	—	—	—	0.1	—	—	—	—	—	—	—	—	0.4	—
O. hexagona Williamson	—	—	—	—	—	—	0.2	—	—	0.4	—	0.2	0.1	—	—	0.4	—	—
Fissurina cf. *diaphana* Buchner	—	—	—	0.2	—	0.1	—	—	—	0.4	0.2	—	1.0	0.7	0.4	—	0.4	0.2
F. cf. *laevigata* Reuss, and vars.	2.2	3.6	3.2	3.4	1.4	0.5	1.6	1.2	0.1	1.8	1.2	1.6	1.9	2.9	0.8	0.8	1.6	—
F. cf. *laevigata agassizi* Todd and Bronnimann	—	1.0	1.0	0.2	—	0.1	0.4	—	—	—	—	0.6	0.6	0.7	0.2	0.4	—	—
F. cf. *laevigata labiata* Buchner	0.3	1.6	0.4	1.4	0.3	—	0.6	0.2	—	1.0	1.2	—	0.8	1.2	—	—	0.4	—
F. lucida (Williamson)	—	—	0.2	—	0.1	—	—	—	—	—	—	—	0.1	—	—	0.4	—	—
F. cf. *orbignyana* Seguenza	—	—	—	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—
F. cf. *trigonolaevigata* (Balkwill and Millet)	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—
Nonion grateloupi (d' Orbigny)	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—	—	—	—
N. japonicum Asano	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.4	0.4	—
N. labradoricum (Dawson)	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—	—	—	—	—
N. manpukujiense Otuka	4.0	1.0	2.2	2.4	2.6	1.5	2.0	2.9	1.7	2.2	1.6	2.8	3.8	4.1	4.6	10.8	6.8	8.6
Nonionella pulchella Hada	7.7	12.8	8.2	10.8	6.9	1.5	5.2	4.9	0.5	12.6	19.6	7.8	44.1	61.5	10.6	12.8	10.8	2.6
N. trugida (Williamson)	—	0.6	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—
Pseudononion sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—	—	—	—
Astrononion umbilicatulum Uchio	—	—	0.4	—	—	—	—	—	—	—	0.2	—	—	0.2	0.2	0.4	—	—
Elphidium advenum depressulum Cushman	0.2	0.2	1.4	0.2	0.2	—	—	0.3	—	0.2	—	0.2	1.4	0.8	1.6	1.2	1.2	0.2
E. cf. *clavatum* Cushman	0.1	—	—	—	—	—	—	—	—	—	0.4	—	0.2	—	—	—	—	—
E. incertum (Williamson)	—	—	—	—	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—
E. cf. *subgranulosum* Asano	0.1	—	0.2	—	0.1	—	0.2	—	—	—	—	—	—	—	—	—	—	0.2
E. subgranulosum aureum Aoki, n. subsp.	1.0	—	—	0.2	0.3	0.1	0.6	—	—	0.8	0.6	—	0.5	0.5	—	0.4	0.8	0.4
E. sp. A.	0.1	0.4	0.4	0.2	0.2	0.2	0.2	0.1	—	0.2	1.0	—	1.1	0.7	0.4	—	—	0.4
E. spp.	—	—	—	—	—	—	—	—	—	—	—	—	0.3	0.1	—	—	—	—
Elphidiella tokyoensis Aoki, n. sp.	—	0.2	0.2	—	—	—	—	—	—	—	0.2	—	0.2	0.2	0.4	—	0.8	0.2

TABLE 4. *(Continued)*

Foraminifera \ Sample No.	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	34
Bulimina marginata d' Orbigny	0.3	0.2	0.2	0.4	—	0.1	—	—	—	—	0.4	—	0.6	1.4	0.2	1.2	0.4	—
B. cf. *honjoensis* Iwasa	—	—	—	—	—	—	—	0.1	—	—	—	—	0.4	0.6	—	—	0.4	—
B. cf. *kochiensis* Takayanagi	—	—	—	—	0.1	—	—	0.1	—	—	—	—	—	0.1	—	—	—	—
B. *ujiiei* Aoki n. sp.	0.3	1.0	1.6	2.8	0.7	0.1	0.4	0.1	0.2	0.8	1.8	0.6	1.3	2.7	—	—	1.6	0.2
Bolivina cf. *biserialis* (Millet)	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—	—	—	—
B. cf. *pseudoplicata* Heron-Allen and Earland	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. *robusta* Brady	—	—	—	—	—	—	0.2	—	—	—	0.2	—	0.2	0.5	0.4	0.4	0.4	—
B. *seminuda humilis* Cushman and McCulloch	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.1	—	—	0.4	0.4	0.7	0.2	—	—	—	—
B. cf. *spathulata* (Williamson)	—	—	—	—	—	—	—	—	—	—	—	—	0.3	0.6	—	—	—	—
B. *stiatula* Cushman	—	—	—	0.4	0.1	0.1	—	—	0.1	—	—	—	0.3	0.2	—	—	—	—
B. 2 spp.	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—	0.4	—	—
Loxostomum cf. *karrerianum* (Brady)	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Reussella pacifica Cushman and McCulloch	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—
Hopkinsina pacifica Cushman	0.3	1.2	0.2	—	—	—	0.2	0.1	—	—	1.0	0.2	0.6	1.5	0.2	0.8	—	—
Siphogenerina raphanus (Parker and Jones)	—	—	0.4	—	—	—	—	—	—	—	—	—	—	0.2	0.2	0.4	—	—
Virgulina complanata Egger	—	0.2	—	—	—	—	—	0.1	—	—	0.2	—	0.1	0.3	—	—	—	—
V. cf. *pauciloculata* Brady	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2
Rotalia beccarii japonica Hada	7.2	2.6	2.4	1.2	1.8	4.3	12.2	0.9	1.0	5.6	6.4	4.6	16.9	22.9	18.6	26.8	11.2	12.2
R. *papillosa* Brady	0.2	—	0.2	0.4	0.2	—	0.2	0.1	—	—	0.2	—	0.2	0.3	0.2	—	—	1.2
R. *ketienziensis angulata* Kuwano	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	—	—	—	—
R.? *minuta* Takayanagi	—	—	—	—	—	—	—	0.1	—	—	—	—	—	—	—	—	—	—
R.? sp.	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Buccella frigida (Cushman)	0.3	—	0.6	0.2	—	—	—	—	—	—	—	—	0.1	—	—	—	—	—
Eponides umbonatus (Reuss)	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Gyroidina io Resig	—	—	0.2	—	—	—	—	—	—	—	—	—	—	0.1	—	0.4	—	—
G. sp.	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Discorbis cf. *clara* Cushman	0.1	—	—	0.2	—	0.1	—	—	—	—	0.2	—	0.1	0.1	—	—	—	—
Valvulineria 2 spp.	0.1	—	—	0.2	—	—	—	—	—	—	—	—	0.1	0.1	—	—	—	—
Baggina? sp.	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—
Cassidulina carinata Silvestri	0.2	0.4	0.8	0.8	0.6	0.1	0.2	0.1	—	0.8	—	0.2	1.5	1.9	1.0	0.8	0.8	1.2

TABLE 4. *(Continued)*

Foraminifera \ Sample No.	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	34
C. cf. *islandica* Norvang, and var.	—	—	0.4	0.2	0.1	—	—	—	—	0.2	—	—	0.5	0.1	—	—	—	—
C. *kattoi obesa* Aoki, n. subsp.	0.1	0.2	—	0.2	0.6	—	—	0.1	—	0.4	0.4	—	0.1	0.5	0.2	0.4	0.8	0.2
C. cf. *sagamiensis* Asano	0.1	—	0.2	—	0.1	0.1	—	—	—	—	0.2	—	1.3	1.8	0.2	—	0.4	0.2
C. *subglobosa* Brady	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	0.2	—	0.8	—
C. sp. A.	0.2	—	—	—	0.2	—	—	0.2	—	—	0.2	—	0.9	0.4	—	—	0.4	—
Cassidulinoides cf. *tenuis* Phlager and Parker	0.1	—	0.2	0.2	—	0.1	—	—	—	—	—	0.2	—	0.3	0.2	—	0.4	—
Epistominella naraensis (Kuwano)	0.2	0.4	0.6	0.4	0.1	—	0.2	—	—	0.4	0.4	—	0.8	0.4	0.6	—	—	0.4
E. cf. *vitrea* Parker	3.2	3.4	4.2	8.6	2.9	0.9	1.2	2.0	0.2	4.6	5.2	1.2	34.0	32.7	7.4	2.4	7.6	2.4
E. *tamana* (Kuwano)	—	—	—	—	—	—	—	—	0.1	—	0.2	—	—	—	—	—	—	—
Anomalina cf. *globulosa* Chapman and Parr	—	—	—	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—
A. *balthica* (Schroeter)	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—
Hanzawaia nipponica Asano	—	—	—	—	—	—	—	—	—	—	—	—	—	0.1	0.2	—	—	—
Cibicides sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—
Globigerina bulloides d' Orbigny	0.1	1.2	—	0.6	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—
G. cf. *bulloides* d' Orbigny	—	—	—	—	—	—	—	—	—	—	—	—	0.4	0.4	0.2	—	—	—
G. cf. *eggeri* Rhumbler	0.5	0.6	0.2	0.8	0.2	—	—	0.2	—	0.4	0.4	—	1.2	1.0	—	—	—	—
G. sp.	—	—	—	—	0.1	—	—	—	—	—	—	—	—	—	—	—	—	—
Globigerinoides minuta Natland	—	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—
Total Foraminiferal Number	34.4	38.6	36.2	42.8	28.0	14.0	36.0	19.1	5.6	40.2	55.0	31.0	139.3	173.2	61.8	78.4	60.0	37.6
Number of species (Total 118)	39	28	39	35	43	28	29	31	11	25	42	20	55	67	35	29	28	24
Weight of dry sediment examined (gram)	10	5	5	5	10	10	5	10	10	5	5	5	10	10	5	2.5	2.5	5

7. Conclusion

Core samples of 3.4 m in length which had been obtained from the bottom of 33 m depth of Tokyo Bay were analyzed for every ten centimeters.

Changes of sedimentation environments are recognized from the upper to lower parts of the core.

(1) Grain sizes. Whole length of the core is filled with muddy deposits, being occupied over 90% by silt and clay. Values of Md, So and Sk decrease downwards. There are distinct scoria layers in the 60–and 270 cm-layers mainly composed of basalt. The 60–layer can be attributed to the Hoei eruption (1707) of Mt. Fuji.

(2) Pollen. In the upper layers, *Pinus* exceeds 85% and *Quercus* is 2~5.8%, and in the lower layers, on the contrary, *Quercus* is 33%.

Pinus is 22%, and *Abies* and *Tsuga* increase.

(3) Diatom. The frequency of marine to brackish genus, *Cyclotella*, becomes larger, *Coscinodiscus* being smaller downwards. The lower parts of the core was deposited under the considerable influence of bay environment.

(4) Foraminifera. Dominant genera throughout the core are *Nonionella*, *Nonion*, *Rotalia*, *Epistominella*, *Quinqueloculinna* and so on.

Vertical changes in fossil assemblage are not clearly detected, but the larger values of total foraminiferal number are found in the lower parts of the core.

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