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PALYNOLOGICAL STUDY OF THE SURFACE SEDIMENTS OF SAGAMI BAY, WITH SPECIAL REFERENCE TO THE DISPERSAL PATTERN OF POLLEN AND SPORES AND THEIR TRANSPORTATION MECHANISM.

Tomio KURODA,* Masafumi ARITA** and Hiroyasu FURUKAWA*

*Department of Geology, Division of General Education, University of Ryukyus.

**Department of Marine Geology, Geological Survey of Japan.

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Abstract

In order to clarify the dispersal pattern of Pollen and spores and their transportation mechanism, the surface sediments of Sagami Bay was studied palynologically. In regard to the dispersal and transportation, the following four groups are recognized:

Group A: Pollen and spores of this group such as *Pinus* and *Gleichenia* have a large buoyancy and are consequently transported by the winds and water currents for a relatively long period. The dispersal pattern of this group is much influenced by hydraulic conditions.

Group B: *Quercus*, *Cyclobalanopsis*, *Alnus* and *Cryptomeria* belong to this group. Although they are same anemophilous flowers as pine, they do not have the same bladders with pine pollen. Pollen grains of this group are carried to Sagami Bay by the winds and rivers and deposited within a short period because of a relatively small buoyancy.

Group C: *Tsuga*, *Ulmus-Zelkova*, NAP (Non Arboreal Pollen) and FS (Fern Spores) of Monolete type belong to this group. Pollen and spores of this group are transported to the bay mainly by the rivers and deposited immediately after the water poured out into the sea.

Group D: *Keteleeria*, *Carya* and *Liquidambar* etc. belong to this group. Pollen of this group are reworked fossils from the Pre-Pleistocene sediments. So they are little influenced by the winds in the secondary dispersal process.

I. Introduction

In the palynological study of marine deposits, considerable attentions have recently been paid to the sedimentary mechanism of the surface sediments and sedimentary environments in order to clarify the history of the coastal plain and terrace deposits.

Generally speaking, pollen and spores have the same size of 20–50μm as silt grains (4–63μm). As sedimentary particles, therefore, pollen and spores show a similar behaviour to silt grains in the process of sedimentation. The following facts have been pointed out concerning with pollen sedimentation. 90% of pollen and spores are transported by the wind to the water within 50–100km (ERDTMAN, 1943; FAEGRI and IVERSEN, 1964). Larger and smaller type pollen go offshore with both regularly decreasing amounts of pollen per a gram of sample and ratio of larger pollen to smaller ones (HOFFMEISTER, 1954). Pollen and spores suspending and floating in the water are sorted by hydraulic movements, and show deviated sedimentary pattern (MULLER, 1959; ROSSIGNOL, 1961; CROSS and SHAFFER, 1965; GROOT, 1966; MATSUSHITA, 1981, 1982).

Much quantity of pollen and spores is found in the sediments of terrigenous clay and silt, but not so much in the sediments of amorphous silica (MULLER, 1959). Reflecting the fact that *Pinus* and FS (Fern Spore), especially Trilete type spores, have larger buoyancy and higher productivity, marine sediments have greater quantity of *Pinus* and fern spores than terrestrial sediments (KORENEVA, 1966; ZAGWIJIN and VEENSTRA, 1966). For example, SHIMAKURA (1968, 1970) reported high concentration of *Pinus* in the marine sediments of Japan Sea, Matsushima Bay and Shirahama near the Kii Peninsula. NAKAMURA (1973) made a comparative study of marine sediments from Tosa Bay and Susaki Bay and river sediments flowing into those bays from the viewpoint of composition of pollen and spores. His study made clear that the percentage of FS is increased in inverse proportion to the drastic decrease of NAP (Non Arboreal Pollen) in the marine sediments. Applying above mentioned results to a palyno-stratigraphic study of the sediments of the Nohbi Coastal Plain, he also discussed the sedimentary environments and paleogeographic succession of the district.

NAKAMURA et al. (1974) indicated that AP (Arboreal Pollen) except *Pinus* type and NAP had the tendency of taking the same behaviour in sedimentary process. Generally speaking, the vegetation of the land area is not always directly reflected in the composition of fossil pollen and spores in the nearby marine sediments. The composition of pollen and spores in the marine sediments must be interpreted on the basis of the assessment of the sedimentary environment, vegetation and inherent characters of palynomorphs, such as, their shapes, grain sizes and structures.

The aim of this study is to clarify the dispersal pattern of pollen and spores in the sediment of Sagami Bay in relation to the sedimentary environments.

II. Environments of the surveyed area

Topography and geology

A detailed description of the area of Sagami Bay as to its topography, geology and their environments has been given by HORIKOSHI (1957) and KIMURA (1976).

Sagami Bay is located on the Pacific Coast of the central part of the Japanese Main Island. The bay except for its southern part is surrounded by the land on three sides; the Izu Peninsula on the west, the coast of Shonan on the north, the peninsulas of Miura and Boso on the east. On the southern part, the volcanic islands of Oshima and Izu Islands are scattered. Tokyo Bay pours itself through the Uraga Channel between the Miura and Boso Peninsula. On the eastern half of the bay, coasts are fringed with shelves of 5–8km width, while on the western, there is no such prominent shelf except for the neighbourhood of Ito and Shimoda (see Figs. 1 and 2).

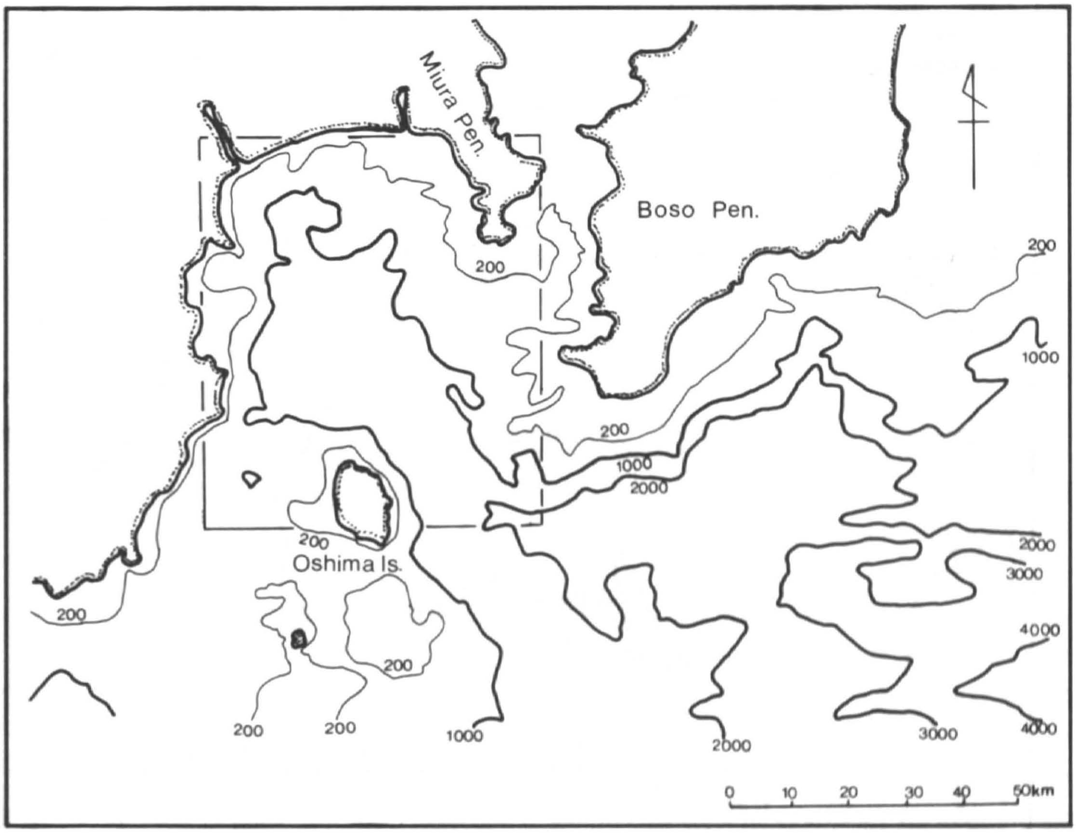


Fig.1 Location, topography and bathymetry around Sagami Bay.

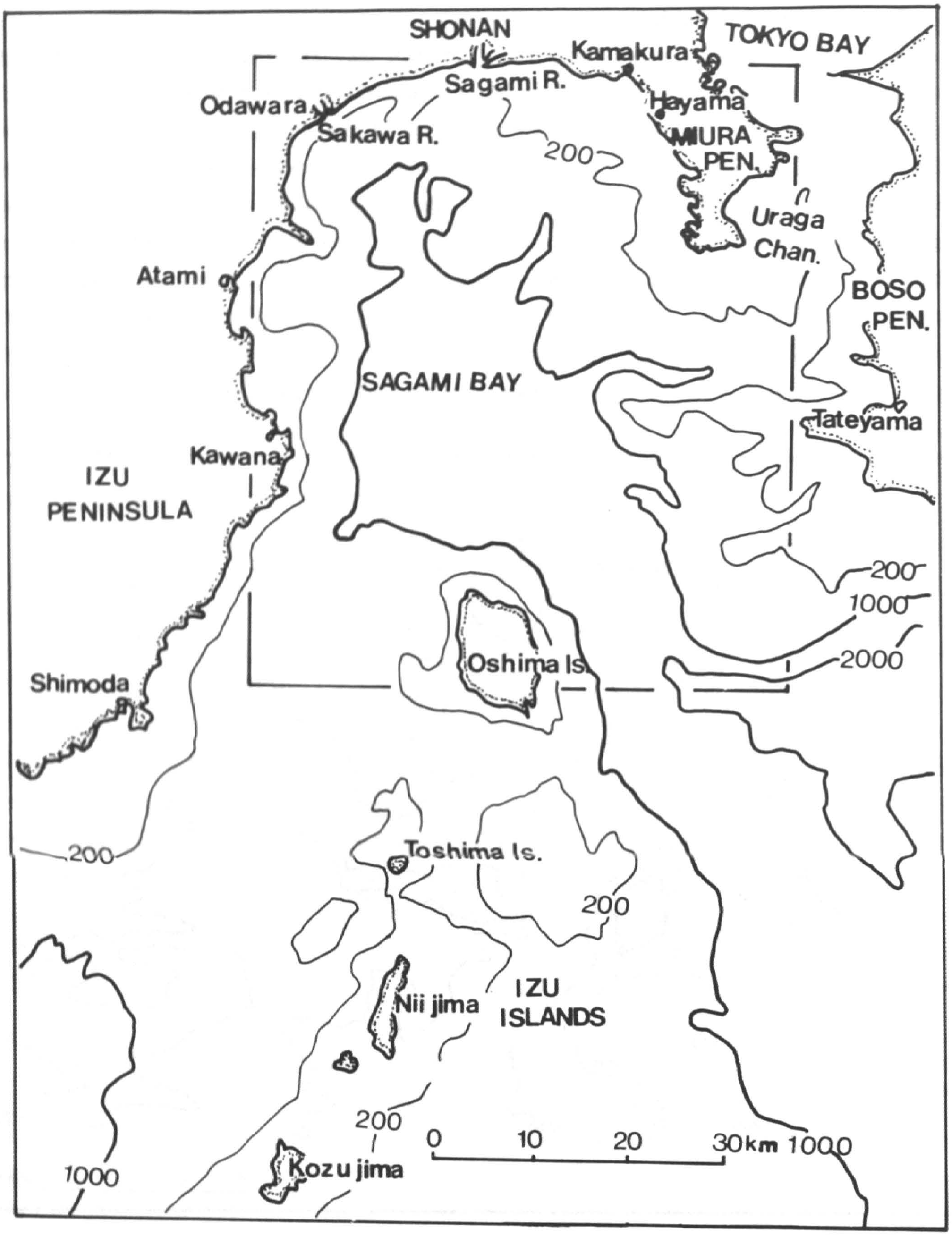


Fig.2 Detailed topographical map of Sagami Bay and its adjacent waters (from HORIKOSHI, 1957).

The shelves near Ito and Shimoda have the steep slope ranging from 100–200m to 700m depth. The main basin of the bay has a depth of approximately 1,600m at the center, and opens into the ocean floor along the eastern side of Oshima Island. Oshima Island is connected with the Izu Peninsula by 500m deep submarine terrace.

According to KIMURA (1976), the topography and geology of the surveyed area of Sagami Bay are a kind of variable zone. The area has a narrow continental shelf and steep slope, many canyons and banks, and a large trough called the Sagami Trough exists on the continental slopes. The trend of the trough shows NW–SE direction across the center of the bay and changes its trend to E–W direction east of Oshima Island. And the area is one of the most active ones of Japanese Islands, and many earthquakes have occurred in Sagami Bay and its adjacent area. Geologically the Izu Peninsula is mainly composed of Neogene andesitic and basaltic lavas and accompanied pyroclastic and sedimentary rocks of the so–called "Green–Tuff" area. In contrast, the Miura and Bos Peninsulas are mainly composed of sedimentary rocks of the Oligocene to Pleistcene age (KIMURA, 1976).

Current and wind

After falling upon the surface of the water, pollen and spores are floated and suspended for some period and then slowly deposited on the bottom. It is impossible to calculate the actual speed of this settling process, because it is influenced by many factors which are not analyzable at the present. That is to say, the floating period depends on the specific gravity of a particular grain and its structure etc.. Settling of grains in the water is related with moving water mass. In addition, the slight difference of the density between fresh and salt waters will influence upon the deposition of palynomorph. Finally, the strength of the local tidal currents is an important but hardly measurable factor. Therefore, only the general water movements will be described here, which are considered to have a fundamental influence on the overall dispersal of pollen and spores.

The warm oceanic current, Kuroshio runs along the Pacific Coast of Japan. According to HORIKOSHI (1957), a branch of Kuroshio flows north–northeasterly into the bay, usually from between Oshima Island and the Izu Peninsula, bending then to the northeast and the east, and runs off into the open ocean, sweeping through the southern half of the bay (see Fig.3). On its way, the main branch sends three sets of offshoots toward the innermost part, the northeast and southeast corners of the bay. There are two kinds of current groups in Sagami Bay; the one is the above mentioned Kuroshio, whose velocity usually exceeds 1 kt. (1–3.5 kt.) on the south side of the bay, and the others are clockwise counter currents which are induced by the branch of the Kuroshio on the northern side and current velocity is usually below 0.5 kt. (0.3–1.0 kt.).

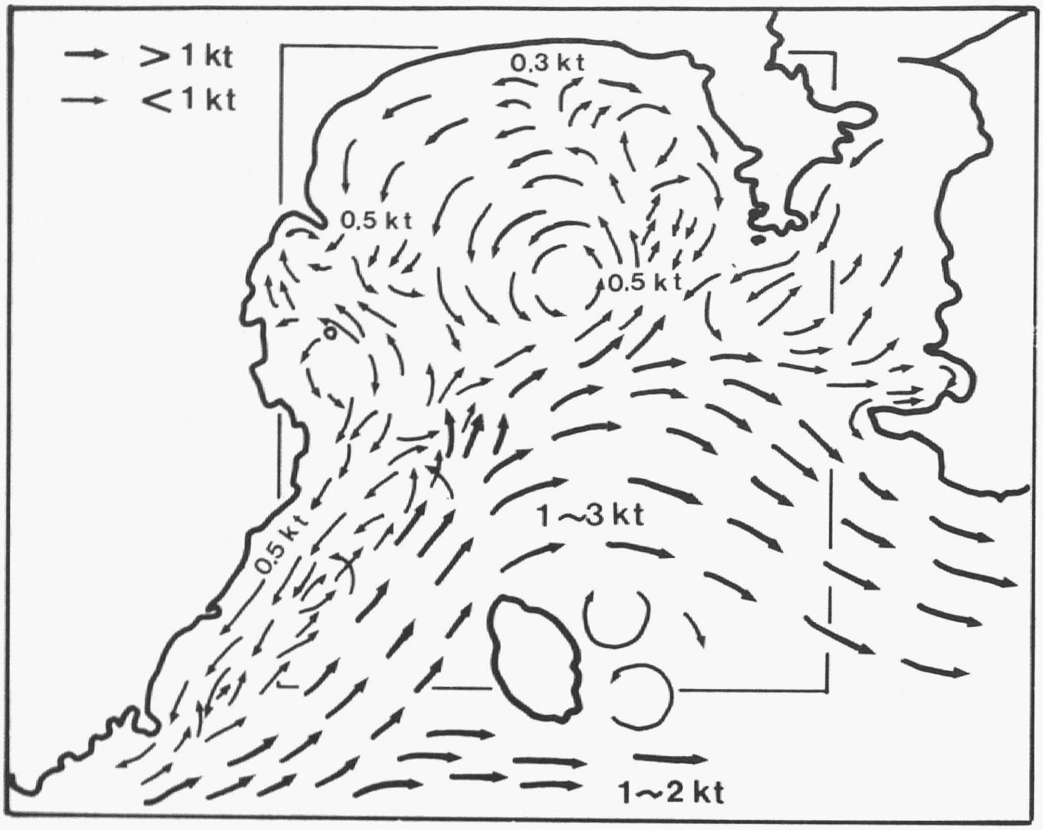


Fig.3 Condition of water current in Sagami Bay during the winter (from HORIKOSHI, 1957).

At times, the branch of the Kuroshio flows into the bay along the east side of Oshima Island, and it induces a clockwise circulation in the northern half of the bay. Regardless of the fluctuation above noted a southward current is fairly persistent along the coast of the Izu Peninsula, from the cape of Kawana to southward. The outflow from Tokyo Bay is observed along the east coast of the Miura Peninsula (the western side of the Uraga Channel). Although the main body of the outflow from Tokyo Bay extends southwestward into Sagami Bay, a part of the flow goes very frequently off the west coast of the Miura Peninsula as far north as the interior of the bay. A coastal water is predominant in the region along the Miura Peninsula and the Shonan district, and also in the vicinity of Ito and Shimoda on the northeast side of Oshima Island (see Figs.2 and 3).

Most of pollen and spores liberated from flowers or sporangia are transported for some distance by air before settling on the land or water surface. Therefore air condition or wind direction will be important factors. Major pollen species represented in the palynomorphs of Sagami Bay liberate their flowers in the period from March to August. General wind directions through flower season from March to August are shown in Fig. 4 by the wind rose diagram. The direction of the prevailing wind in this season is east–west at Nagatsuro and northeast–southwest at Ajiro, Oshima and Tomisaki.

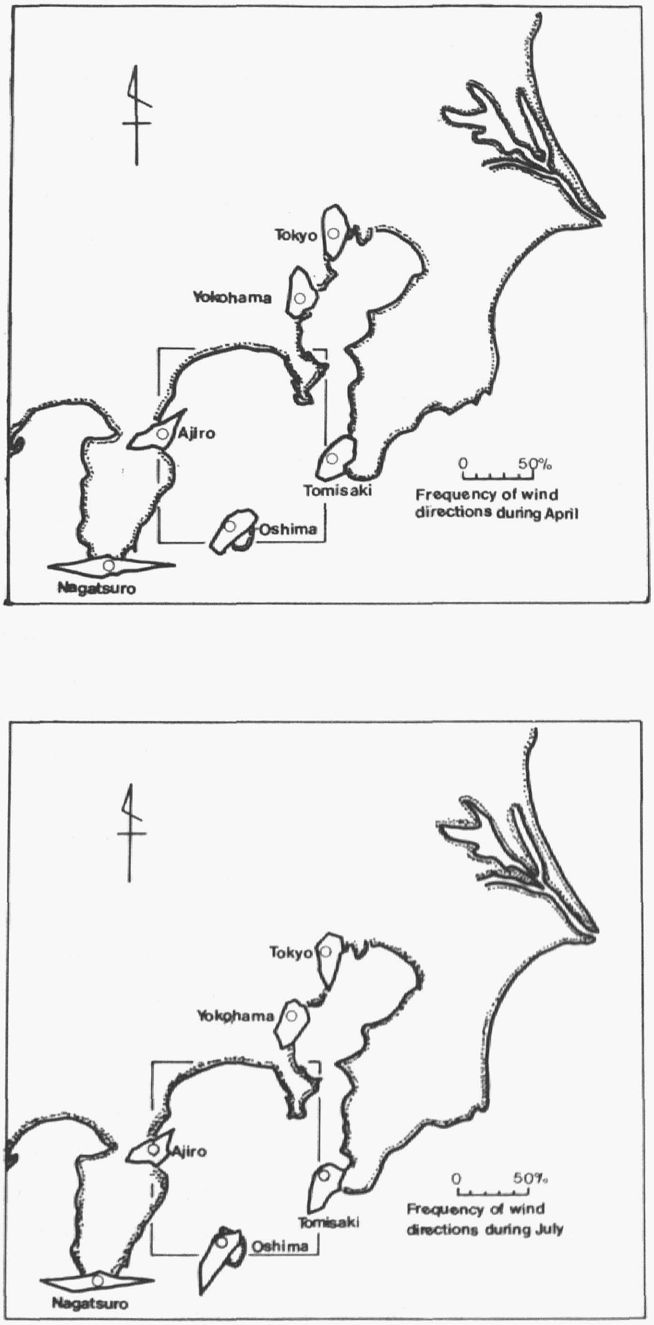


Fig.4 General wind directions through flower season from March to August may be estimated by the wind rose diagrams of April and July (from WADACHI, 1958).

Vegetation

From the stand point of the vegetation (UENO, 1971; MIYAWAKI, 1972 and OKUTANI, 1974), the land surrounding Sagami Bay can be divided into two parts; the eastern part of the Sagami River including the Miura Peninsula and western part of the river including the Izu Peninsula.

1) The eastern part: This area is almost all deforested owing to the drastic expansion of urbanization and poor vegetation. But some small scale secondary forests such as *Quercus serrata-Cyclobalanopsis myrsinaefolia* coppice and *Pinus densiflora* or *Cryptomeria japonica* plantation are found sporadically. On the other hand, rude weed comunities of Gramineae, Cyperaceae, Compositae, Polygonaceae and so on are widely seen.

2) The western part: In this area the low lands near the rivers of Sakawa and Sagami are occupied by the cultivated areas of rice and field crops. In the areas of low mountains, highly lands and diluvial terraces, which extensively cover the western part, *Quercus serrata-Q. acutissima* coppices and *Cryptomeria japonica-Chamaecyparis obtusa* plantation are dominant. In the southern part of the Izu Peninsula, *Shiia sieboldii* coppices are conspicuous. Seminatural stands of *Alnus* along the stream and plantation of the same genus for erosion control on hill sides are also seen. In the mountain zone up to 800m in altitude, *Abies firma-Tsuga sieboldii* forests which are occasionally accompanied by *Cryptomeria japonica, Pinus densiflora, Quercus serrata, Castanea crenata, Cyclobalanopsis myrsinaefolia* and *C. glauca* are distributed. *Zelkova serrata-Acer palmatum* forests are seen along streams or on alluvial fans. High places more than 800m in altitude such as Mt. Amagi in the Izu Peninsula, Mts. Hakone and Tanzawa in the northwestern area of the Kanagawa Prefecture are covered by *Fagus crenata and Quercus mongolica var. crispula* forest.

The sea side vegetation surrounding Sagami Bay is represented by coastal sand vegetation and maritime rock and scree one. Among them, the former is distributed mainly along the northern parts of the bay, and its components are herbs and grasses such as *Wedelia prostrata*, *Lathyrus maritimus*, *Carex pumila* and *Zoysia japonica* etc.. Oshima Island in the southern part of the bay is occupied by poor vegetation developing on lava flows and small stands of *Cryptomeria* plantation and *Pinus Thunbergii* forest are also found in places. In addition, *Gleichenia linearis*, a high spore producer, is found commonly on the floor of the *Pinus* forest at the Izu Peninsula. From these facts, it is considered that the western part of the Sagami River plays a important part as the source area of pollen and spores.

Ⅲ. Material and method

Sampling

Sampling materials from about 60 locations were collected by the Smith-McIntyre sampler from the surface layer sediments. The samples were punched out with vinyl pipe whose diameter measures about 7cm. The soft-x ray photographs of the punched samples were taken in order to reveal their sedimentary features. For farther palynological analysis, the samples composed of the sediments of the very surface layer, were selected with the aid of this photographical procedure.

The sampling materials were collected by the ship of Hakurei Maru from the localities shown in Fig. 5 which range in depth from 63m to 2,520 m on Sagami Bay and its vicinity (see Fig.1). And most of the material of this study were collected along the systematic sampling grid points by one of the present authors M. ARITA and his associates on Sagami Bay (ARITA, 1976). Several other samples of the surface sediments from nearby localities on the southern and western parts of the Boso Peninsula, and on the southern part of Oshima Island were also studies.

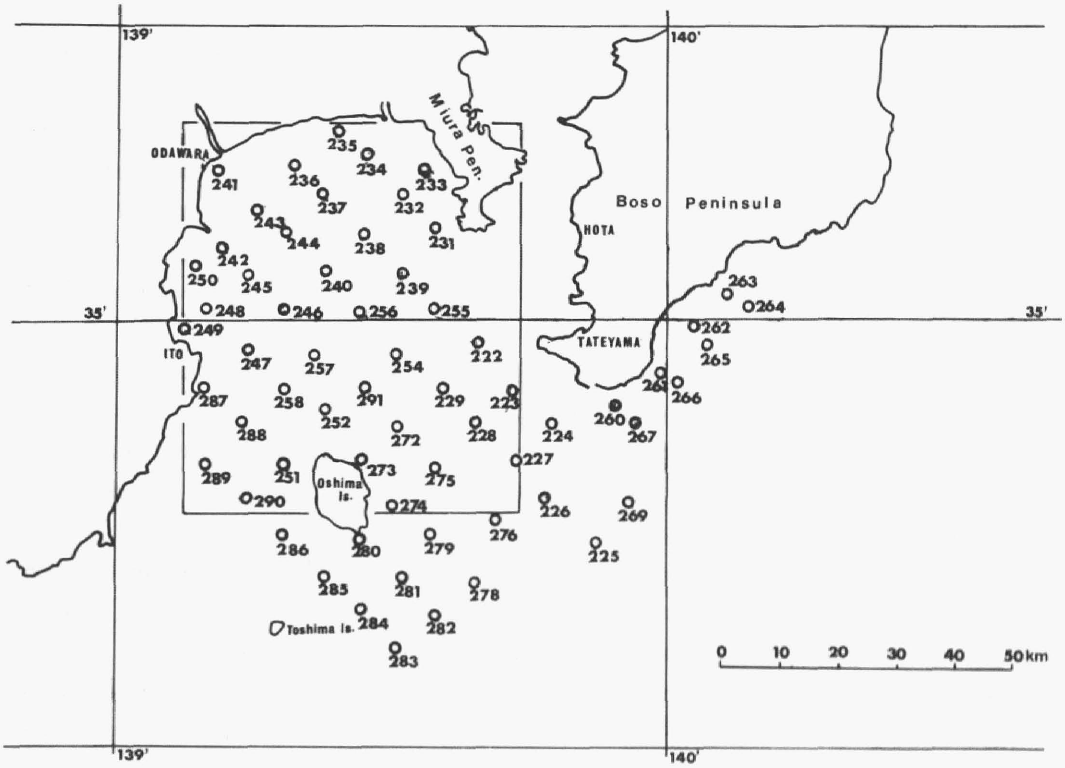


Fig.5 Numerical figures and circle signs (O) show sample numbers and sampling stations respectively.

The samples for palynological study are mostly clay and silts, though some of them are sandy gravel. The result of grain size analysis is shown in Table 1. Nearly all the samples contain foraminiferal and shell fragments and other skeletal remains and calcareous material in varying amounts, and a large number of the samples contain more or less degraded plant remains. In order to compare palynological aspects of the data, the distribution patterns various sediments are represented by the three types of sediments, such as, sand, silt and clay.

Maceration

Each sample was macerated by the standard procedure (NAKAMURA et al., 1972) for calcium-bearing sediments. This procedure consists of solution of the calcium carbonate in hydrochloric acid, followed by defumication in dilute alkali (KOH 10%) and acetylation with an acetic anhydride sulfuric acid mixture ($(CH_3CO)_2O : H_2SO_4 = 9:1$). The procedure is shown in the following notes.

1) Put about 5g of sample in a 50cc centrifuge-tube and dissolve calcium carbonate ($CaCO_3$) with hydrochloric acid (HCl 10%) until the reaction has ceased. More than three times wash it with water and centrifugalize it.
2) Add 10% KOH (25cc) to it and stir it with a glass rod thoroughly.
3) Treat with 10% KOH for 15 min. at 80℃ in the water bath and then wash and centrifugalize it. Repeat washings until wash water comes clear. The KOH treatment breaks up extraneous plant material and dissolves humic matter, if any is present.
4) Completely get rid of water and then add $ZnCl_2$ ($1.7 < \rho < 1.8$) to it 5-6 times as much as the sample. The sample in a 50cc centrifuge tube is stired with an agitator thoroughly and then transferred to the other two or three 15cc centrifuge tubes.
5) Clean the surface of pollen and spores exines with supersonic cleaner (29kHz) for 5-7 min..
6) Operate centrifuge (2,500-3,000 r.p.m.) for 30 min. and draw off the suspended matter from the admixture of $ZnCl_2$.
7) After the suspended matter is removed with a pipette and transferred to the other 15cc centrifuge tube, dilute with distilled water, add a few drops of 10% HCl and shake it.
8) Wash residue with distilled water after centrifugalized. Repeat washing and centrifugalizing until wash water comes clear.
9) Remove water from the residue with acetic acid and centrifugalize.
10) Add mixture (2cc) of acetic anhydridesulphuric acid ($(CH_3CO)_2O : H_2SO_4 = 9:1$) to dehydrated residue and treat with its mixture for 15 min. at 80℃ in a water bath and centrifugalize.
11) Wash the residue with acetic acid in order to prevent outburst and centrifugalize it.
12) After washing the residue with distilled water and centrifugalize more than three times, to add 10% KOH and keep it in the water bath for 2 min. at 80℃.
13) Wash it with distilled water and centrifugalize more than three times.

Slide preparation and counting method

Draw off a small drop of the residue from the sample vial, place it on a slide and add molten glycerin jelly (about 70℃), mix very completely and cover the mixture with cover-glass. And then, the slide is examined and counted on a microscope with a mechanical stage. Olympus standard microscope, with 10x and 40x objectives and 15x oculars were used in this study. The slide is completely counted from one corner of the cover glass to the other, until the total number of pollen grains and spores exceeds 500.

Grid method

The writers adopted Grid method in cooperation with the computer to clarify the distribution pattern of pollen and spores. In delineation of contour map, the first step is usually to produce a regular mesh or grid points. Many workers have discussed this method and details are refered to I.B.M. (1965), PALMER (1969), WALTER (1969) and DAVIS, J.C.(1973). In this paper, the writers used the program of KURODA (1976). He owes much to DAVIS, J.C. (1973) to draw up the program of Grid method. The steps in computation of grid values for contouring are shown in Fig.6. In this figure, the mark (●) represents an observation point on a map; each point is characterized by X coordinate (east-west), Y coordinate (north-south), and Z coordinate (elevation). X and Y show the position of sampling point on a map, and Z shows the values, that is, the results of analysis. For example, observation points O_1, O_2, O_3, and so on are represented by O_1 (X_1, Y_1, Z_1), O_2 (X_2, Y_2, Z_2), O_3 (X_3, Y_3, Z_3) and so on. In general way, an observation point O_i is shown by

$$O_i\ (X_i,\ Y_i,\ Z_i)$$

and has coordinate X_i in the east-west direction, Y_i in the north-south direction, and elevation (analytical value) Z_i. In figure 6, we have superimposed regular gride of control points (○) on the map. These control points are also numbered sequentially from G_1 to G_n. Grid point G_k has coordinates X_k and Y_k, and has an estimated value Z_k and is represented by G_k (X_k, Y_k, Z_k) generally.

Z_k is estimated on the basis of the nearest n data points; that is to say, firstly, nearest observation points to each grid intersection are searched out, and secondly, the distances from these points to the intersections are calculated. Suppose D_{ik} $\overline{(O_iG_k)}$ is the distance from observation point O_i to grid point G_k,

$$D_{ik}=\sqrt{(X_k-X_i)^2+(Y_k-Y_i)^2}$$

then the estimation of Z_k is

$$Z_k=\frac{\Sigma_{i=1}^{n}(Z_i/D_{ik})}{\Sigma_{i=1}^{n}(1/D_{ik})}$$

In this study, 6 nearest observation points (n=6) are used to calculate Z_k of each grid point.

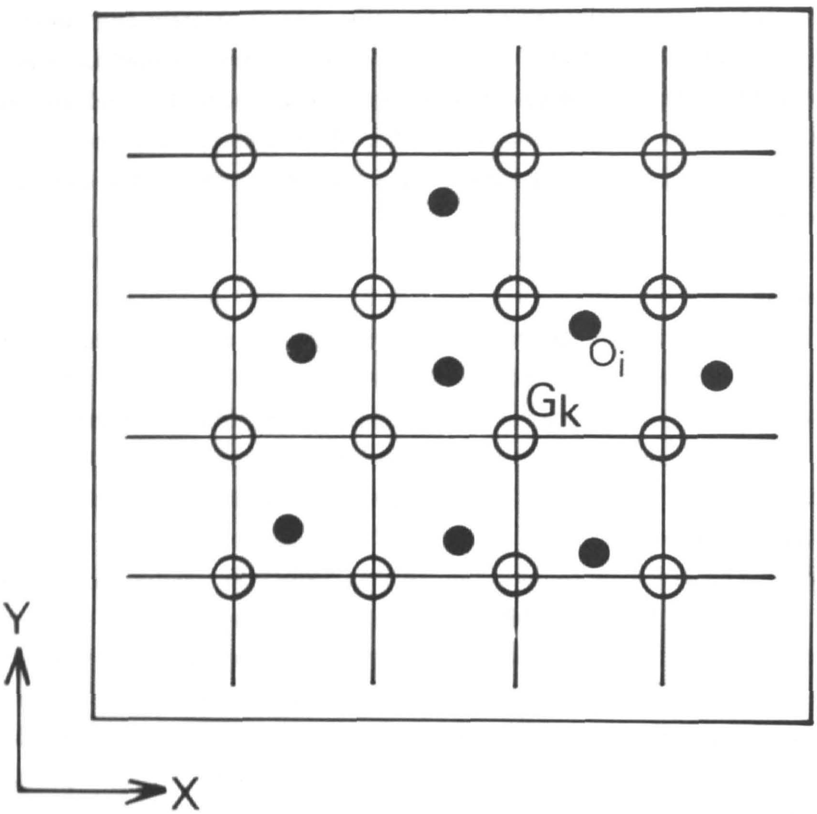


Fig.6 Steps in computation of grid values for contouring.
●Original set of irregularly spaced observation points on a map
○Regulaly spaced grid net-work

Ⅳ. Results of analysis

In this section, the data of pollen and grain size analysis are presented. The analytical data on which the distirbution chart are based, are found in Tables 1 and 2. Grain size analysis for the sediments from Sagami Bay was processed by ARITA.

Results of grain size analysis

The results of grain size analysis are show in Tables 1. The distribution charts which are drown by grid method using a computer, are show in Figs. 7, 8, 9 and 10.

Md ϕ

The most important feature of the grain size composition of bottom sediments is expressed by the mean diameter of grain size Md ϕ. In the distribution chart, Fig. 7, grain size is indicated by phi(ϕ) scal, so that sediments of the region of the symbol "D" denotes the most fine grains and sign "A" shows the most coarse ones (for example in Fig. 7, the following signs represent the approximate grain size of phi scal A≒-1ϕ, B≒1ϕ, ¥≒3ϕ, C≒5ϕ and D≒7ϕ respectively).

Table 1. Results of grain size analysis of the surface sediments from Sagami Bay.

Station No.	Depth (m)	Md phi Scale	Mud (%) contents	Sand (%) contents	Silt (%) contents	Clay (%) contents
222	595	5.13	60.04	32.68	55.19	12.13
225 *	2250	5.50	56.94	35.80	27.20	37.00
226	1800	4.42	52.43	39.11	57.59	3.30
227	960	4.56	54.32	35.51	63.62	0.87
228	432	1.50	1.59	97.81	2.18	0.01
231	85	1.13	6.10	93.07	5.15	1.78
232	360	3.50	40.04	55.79	36.54	7.67
233	75	3.69	26.87	62.56	32.64	4.80
234	163	1.63	23.20	70.51	24.39	5.10
235	85	5.63	67.16	23.86	58.14	18.00
236	865	6.25	93.71	2.97	90.43	6.60
237	980	5.00	56.63	36.86	55.61	7.53
238	1070	6.00	86.78	8.81	84.49	6.70
239	845	5.44	67.12	25.47	63.34	11.19
240 *	1340	6.88	94.51	3.26	75.64	21.10
241	390	4.88	64.19	27.34	71.65	1.01
242	337	2.28	42.31	47.24	19.46	33.30
243 *	1130	4.75	59.19	33.07	64.23	2.70
244	666	1.31	28.56	59.46	22.36	18.18
245	1200	3.07	32.25	64.52	32.16	3.32
246	1410	7.13	95.82	2.32	67.28	30.40
247	1265	6.69	88.36	7.70	67.40	24.90
248	130	3.13	16.75	79.88	7.24	12.88
249	93	3.63	28.91	65.29	32.71	2.00
250 *	470	4.63	53.31	40.13	59.03	0.84
251	645	3.00	8.99	87.63	12.10	0.27
252	840	4.00	44.76	49.92	47.88	2.20
254	1225	3.69	26.63	65.46	28.33	6.21
255	1095	6.07	86.86	8.08	83.12	8.80
256	1190	4.63	51.68	42.27	31.87	25.86
257 *	1560	2.63	10.26	86.67	12.70	0.63
258	1347	4.63	57.00	33.20	66.45	0.35
260 *	63	2.06	91.11	99.74	0.26	----
261	95	3.13	20.28	75.20	20.35	4.45
262	73	3.38	14.65	80.30	14.20	5.50
263	73	2.63	11.05	85.49	6.19	8.33
264	225	25.00	26.92	63.38	33.03	3.59
265	203	2.38	10.95	86.82	11.98	1.20
266	190	3.07	11.57	85.17	13.43	1.40
267 *	190	-2 >	0.87	95.42	4.58	----
269 *	2520	6.13	76.33	17.11	56.09	26.80
272 *	1750	3.06	4.85	90.30	9.69	0.01
273 *	665	3.13	29.88	59.27	38.47	2.26
274	850	2.69	15.81	74.43	25.35	0.22
275 *	1855	2.81	28.98	66.05	29.57	4.38
276 *	2230	6.31	87.00	8.68	75.32	16.00
278	1520	4.75	56.88	34.41	65.13	0.46
279	1560	3.00	13.59	81.55	18.38	0.07
283 *	95	1.50	0.12	99.78	0.22	----
284 *	87		0.39	98.78	1.20	0.02
285 *	335	2.13	0.64	98.87	1.08	0.05
286 *	303	-2 >	0.05	99.34	0.31	0.35
287	155		0.00	85.50	11.85	2.65
288 *	965	-2 >	8.00	94.55	5.33	0.12
289 *	350		0.38	97.14	2.86	----
290	475	1.43	5.63	90.98	8.70	0.32
291 *	1480	0.81	36.21	55.71	32.73	11.56

* ··· Preservation of pollen and spores are inperfection or their contents are very scarce.

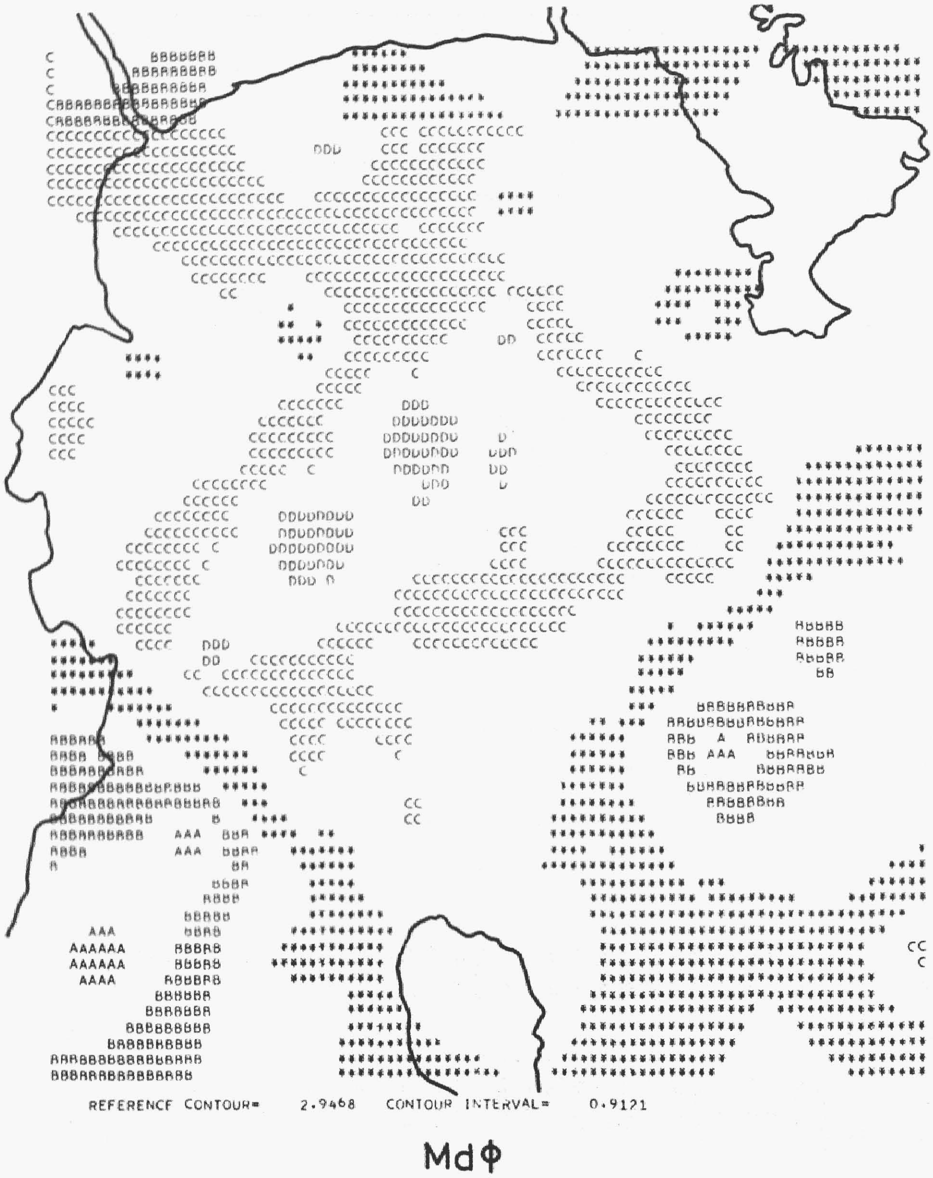


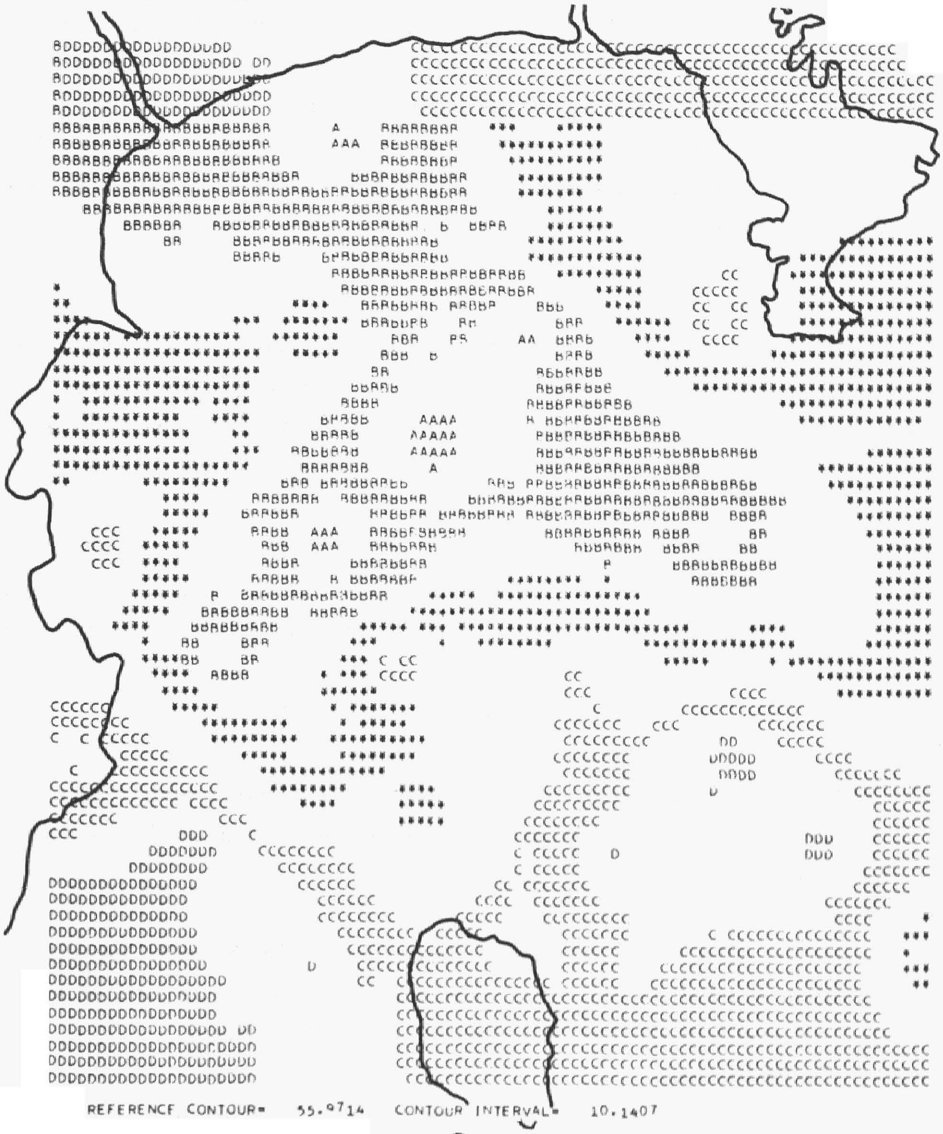
Fig.7 Contour interval is approximately 0.9ϕ. Reference band of yen sign (¥) shows the region between 2.04ϕ (edge nearest symbol B) and 3.86ϕ (edge nearest symbol C). Numerical figures of this table show the Mdϕ for each reference band of signs.

A	<	B	<	¥	<	C	<	D
−0.70	0.21	1.12	2.04	2.95	3.86	4.77	5.68	6.60

Mean diameter of grain size decreases in the central part of the bay, but on the other hand, it increases in the western side of Oshima Island and the area about 20 km distant from Oshima Island.

Sand

The distribution chart of sand is shown in Fig. 8. Sand consists of the grains from -1ϕ to 4ϕ and the sand content of a sample is represented by the weight percentage. The region of symbol "D" means high percentage of sand and sign "A" presents low percentage.



Sand

Fig.8 Contour interval is about 10.1%. Reference band of yen sign (¥) shows the region between 45.83% (edge nearest symbol B) and 66.11% (edge nearest symbol C). Numerical figures of this table show the percentage of sand for each reference band of signs.

A	<	B	<	¥	<	C	<	D
15.41	25.55	35.69	45.83	55.97	66.11	76.25	86.39	96.53

In the central part of the bay and the part of Sakawa River mouth except for the eastern part along the shore line, sand shows its low concentration, while it shows high concentration in the sea area of Kawana, the western part of the Boso Peninsula and the vicinty of Sakawa River mouth.

Silt

The distribution chart of silt is shown in Fig. 9. Silt consists of the grain size from 4ϕ to 8ϕ and the silt content of a sample is represented by the weight percentage. The region of symbol "D" means high percentage of silt and sign "A" presents low percentage. The results show the high concentration of silt in the vicinity of Sakawa River mouth and along the shore line, snd shows low cocentration in the western part of Tateyama, the eastern part of Kawana and in the northeast part of Oshima Island.

Clay

The distribution chart of clay is shown in Fig. 10. Clay consists of the grain size more than 8ϕ and the clay content of a sample is represented by the weight percentage. The regions of the symbol marks of "D" and "A" mean the same as sand and silt ones. In general, clay is highly concentrated only in the central part of the bay except for the sea area around Manazuru.

Pinus

The distribution chart of *Pinus* is shown in Fig. 11. It shows low concentration around Sakawa River mouth, in the area of Kawana and in the aera west to Oshima Island. A high concentration area of *Pinus* is found in the central part of the bay; especially in the area west to the Miura and Boso Peninsulas.

Tsuga

The distribution chart of *Tsuga* is shown in Fig. 12. It shows high concentration in the area, about 20 km southeast from Sakawa River mouth and in the western sea area of Tateyama.

Cryptomeria

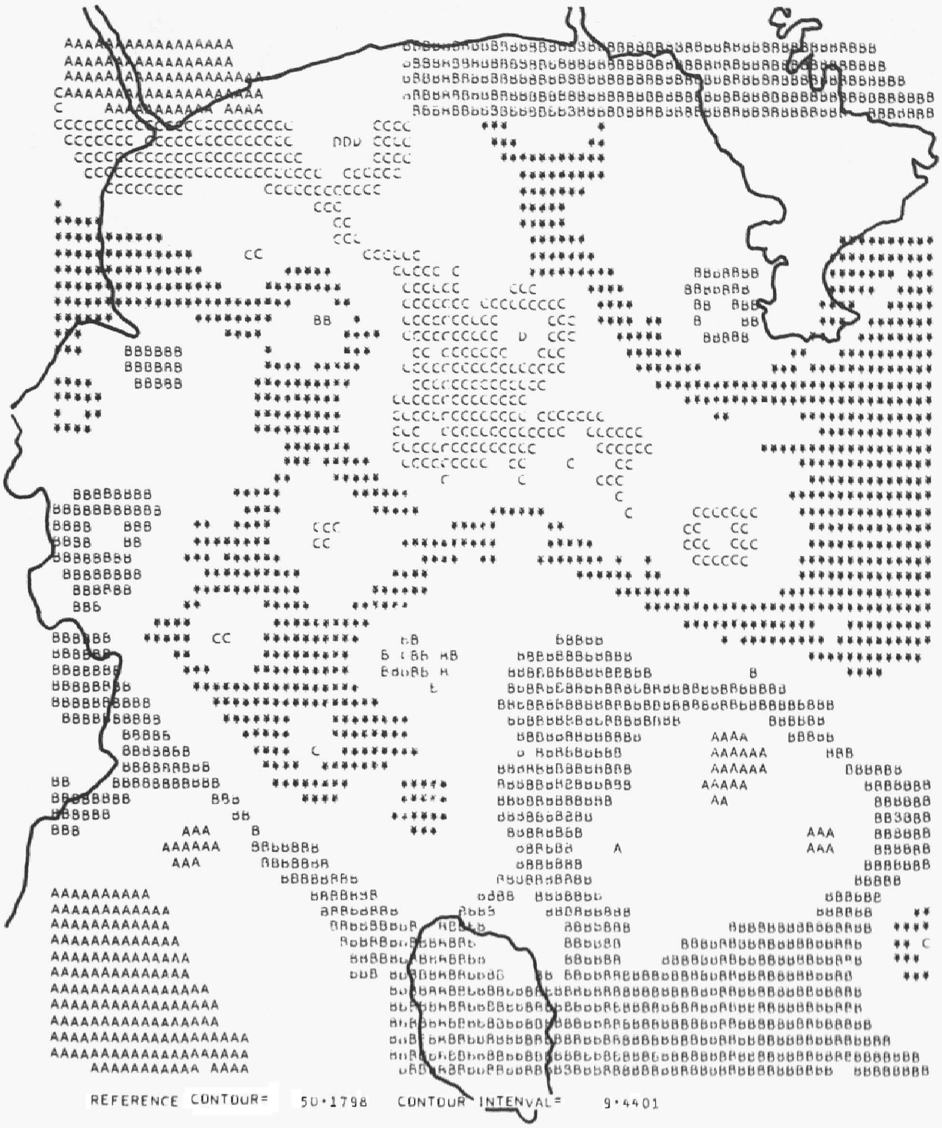
The distribution chart of *Cryptomeria* is shown in Fig. 13. Roughly speaking, the high concentration is found in two areas ; the one is the innermost part of the bay and the other the mouth of the bay near Kawana and Oshima Island.

Quercus + Cyclobalanopsis

The distribution chart of oak pollen is shown in Fig. 14. The high concentration is found in the wide area between Kawana and Tateyama, and in the eastern part of Sakawa River mouth along the shoreline.

Ulmus + Zelkova

The distribution chart of *Ulmus+Zelkova* is shown in Fig. 15. The concentration of this type is restricted only to the vicinity of the river mouth of Sakawa and Sagami Rivers.



Silt

Fig.9 Contour interval is about 9.4%. Reference band of yen sign (¥) shows the region between 40.74% (edge nearest symbol B) and 59.62% (edge nearest symbol C).

Numerical figures of this table show the percentage of silt for each reference band of signs.

A	<	B	<	¥	<	C	<	D
12.45	21.86	31.30	40.74	50.18	59.62	69.06	78.50	87.94

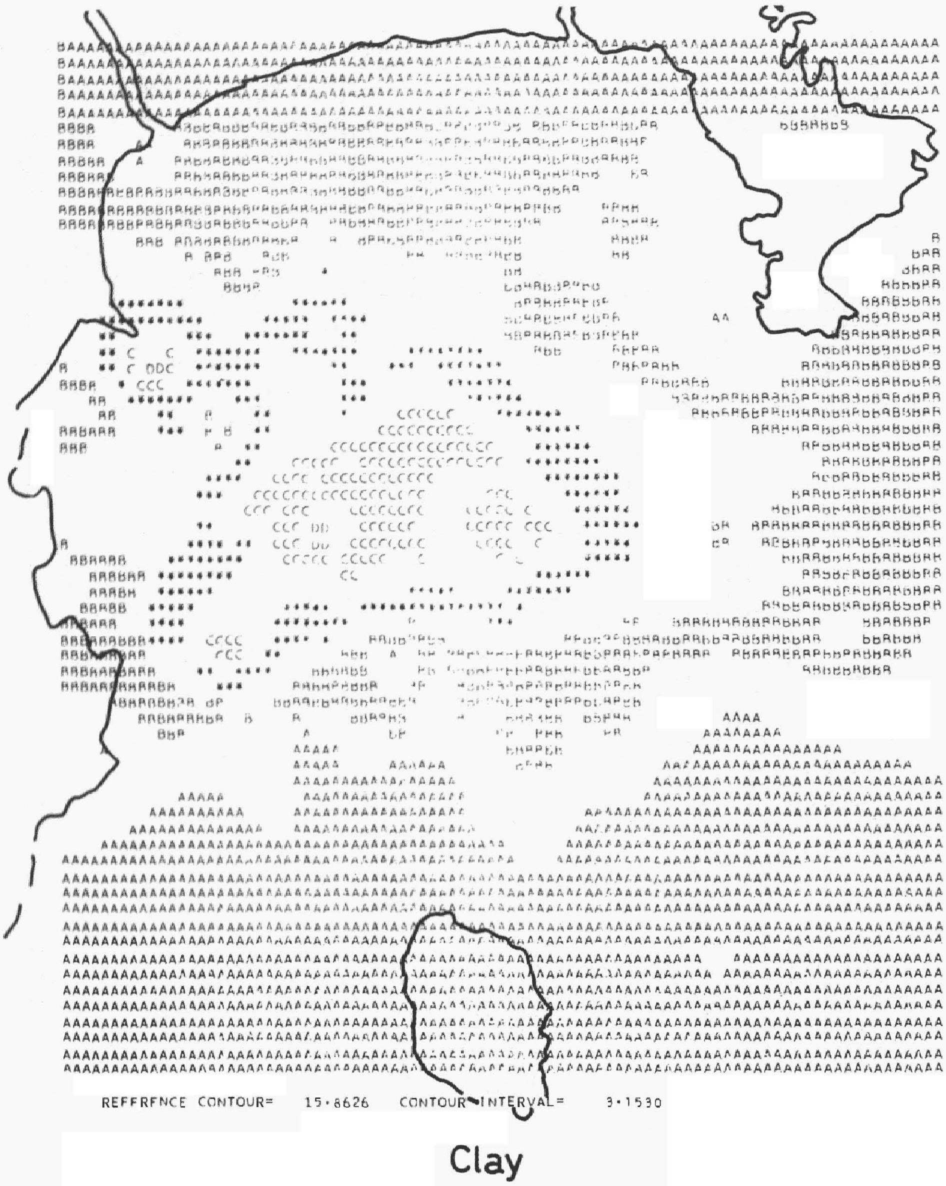
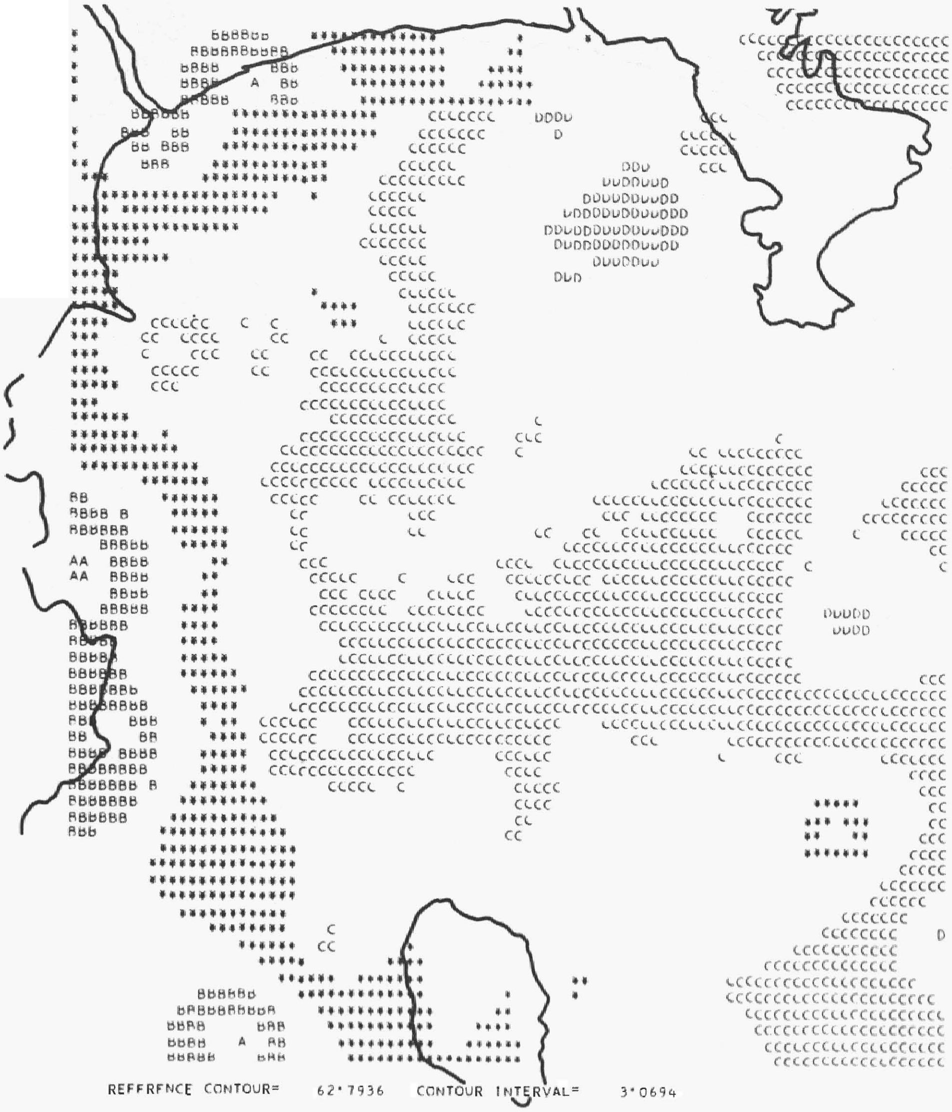


Fig.10 Contour interval is about 3.2%. Reference band of yen sign (¥) shows the region between 12.71% (edge nearest symbol B) and 19.02% (edge nearest symbol C).

Numerical figures of this table show the percentage of clay for each reference band of signs.

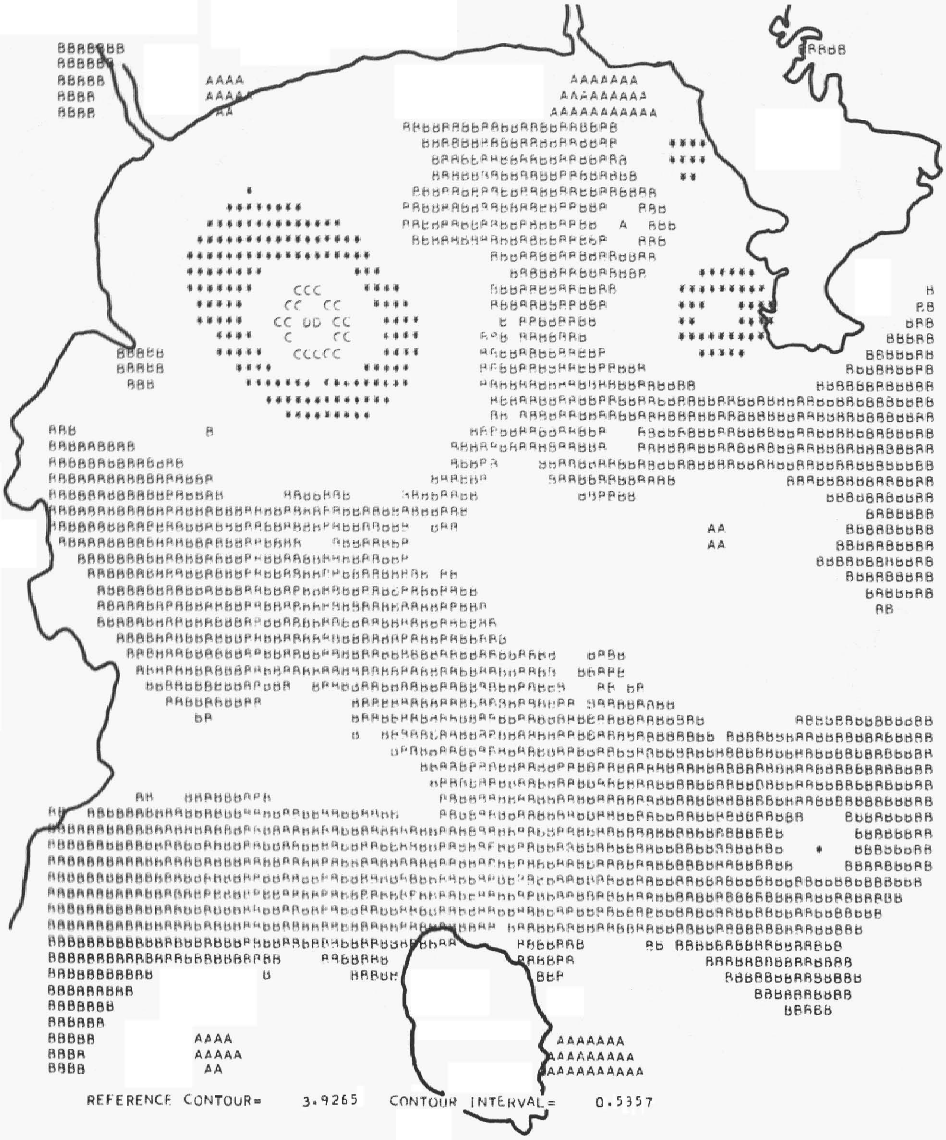
A	<	B	<	¥	<	C	<	D
3.25	6.40	9.56	12.71	15.86	19.02	22.17	25.32	28.47



Pinus

Fig.11 Contour interval is approximately 3.1%. Reference band of yen sign (¥) shows the region between 59.72% (edge nearest symbol B) and 65.86% (edge nearest symbol C).
Numerical figures of this table show the percentage of *Pinus* for each reference band of signs.

A	<	B	<	¥	<	C	<	D
50.52	53.56	56.66	59.72	62.79	65.86	68.93	72.00	75.07

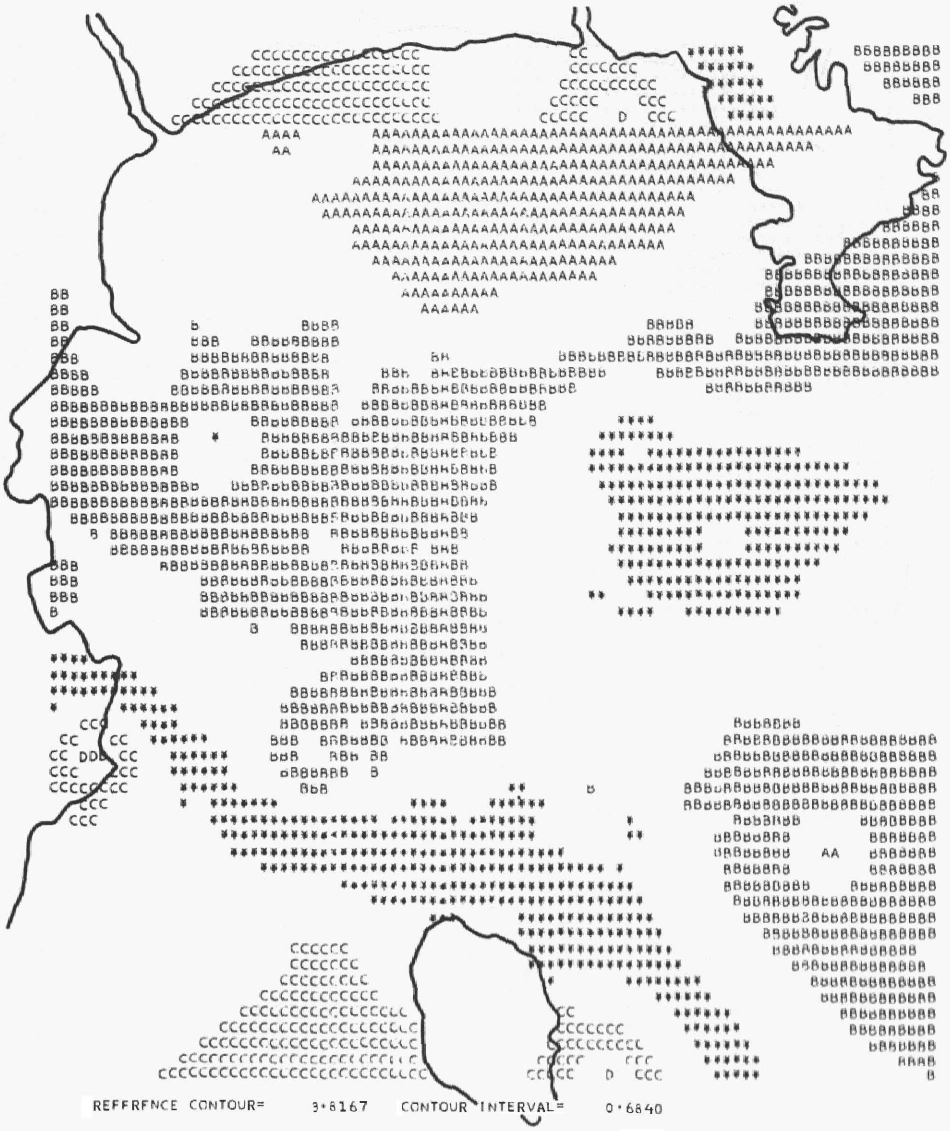


Tsuga

Fig.12 Contour interval is approximately 0.5%. Reference band of yen sign (¥) shows the region between 3.39% (edge nearest symbol B) and 4.46% (edge nearest symbol C).

Numerical figures of this table show the percentage of *Tsuga* for each reference band of signs.

A	<	B	<	¥	<	C	<	D
1.78	2.32	2.86	3.39	3.93	4.46	5.00	5.53	6.07

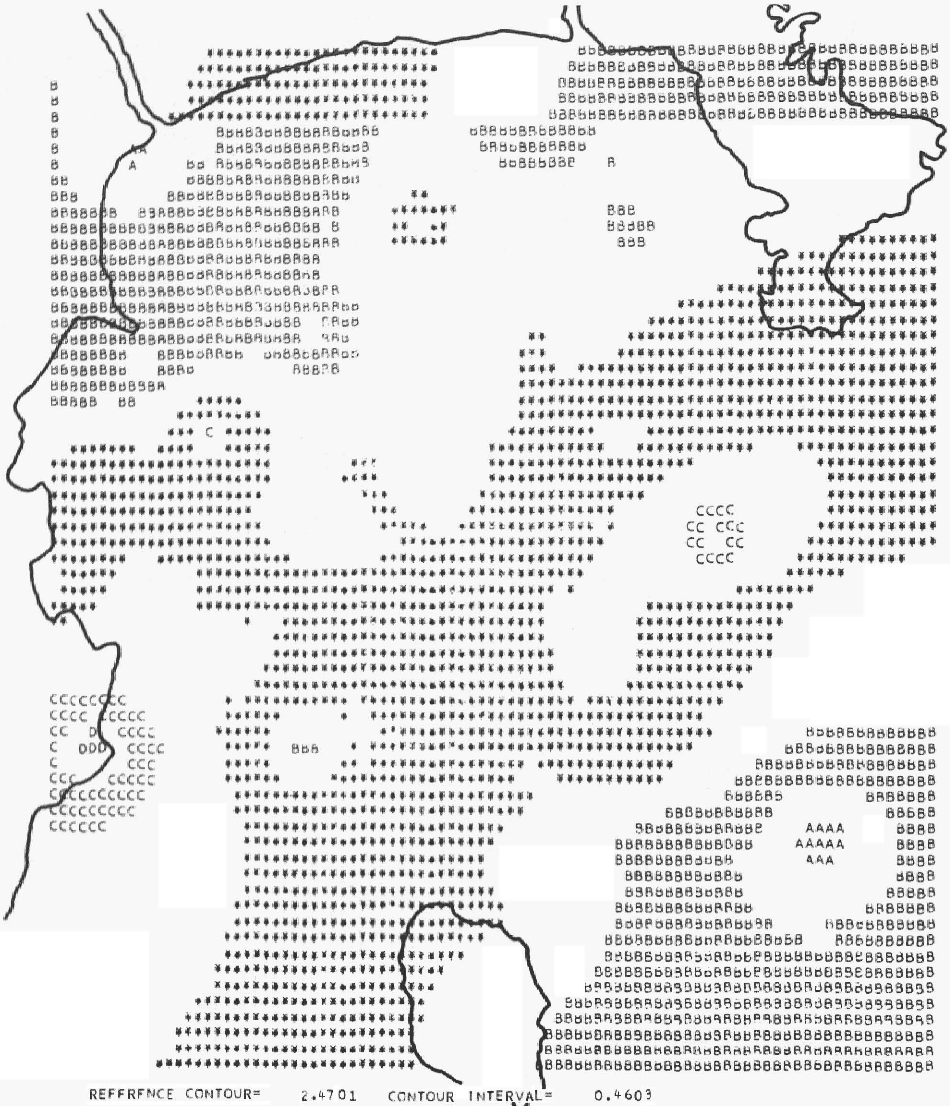


Cryptomeria

Fig.13 Contour interval is approximately 0.7%. Reference band of yen sign (¥) shows the region between 3.13% (edge nearest symbol B) and 4.50% (edge nearest symbol C).

Numerical figures of this table show the percentage of *Cryptomeria* for each reference band of signs.

A	<	B	<	¥	<	C	<	D
1.08	1.76	2.45	3.13	3.82	4.50	5.18	5.87	6.55



Quercus + Cyclobalanopsis

Fig.14 Contour interval is approximately 0.5%. Reference band of yen sign (¥) shows the region between 2.01% (edge nearest symbol B) and 2.93% (edge nearest symbol C).

Numerical figures of this table show the percentage of *Quercus + Cyclobalanopsis* for each reference band of signs.

A	<	B	<	¥	<	C	<	D
0.63	1.09	1.55	2.01	2.47	2.93	3.39	3.85	4.31

Fig.15 Contour interval is approximately 0.6%. Reference band of yen sign (¥) shows the region between 2.42% (edge nearest symbol B) and 3.56% (edge nearest symbol C).

Numerical figures of this table show the percentage of *Ulmus+Zelkova* for each reference band of signs.

A	<	B	<	¥	<	C	<	D
0.72	1.28	1.85	2.42	2.99	3.56	4.12	4.69	5.26

Alnus

The distribution chart of *Alnus* is shown in Fig. 16. It shows the high concentration in the relatively wide area north to Oshima Island and in the narrow area near Kawana. Roughly speaking, the regions of the low concentration are seen in the innermost part of the bay around Sakawa River mouth.

Total *Pinus* type

The distribution chart of total *Pinus* type; *Pinus*+*Abies*+*Picea*+*Podocarpus*, is shown in Fig. 17. Pollen of this type are not the same to one another in size but are similar concerning with external form and large buoyancy. Therefore we regard the pollen of the total *Pinus*-type as a single population in the sedimentary process. This type is closely similar to *Pinus* in respect of the distribution pattern (see Figs. 11 and 17).

AP

AP means total tree pollen. The distribution chart of AP is shown in Fig. 18. AP is highly concentrated in the central part of the bay, while it shows low concentration in four sea areas, Sakawa River mouth along the shoreline, the eastern part of Kawana and the western and eastern part of Oshima Island.

Whole AP except for *Pinus*-type

The whole AP except for *Pinus*-type (*Pinus*+*Abies*+*Picea*+*Podocarpus*) is highly concentrated in two sea areas in the innermost part of the bay along the shoreline and the central of the bay as shown in Fig. 19.

Gramineae

The distribution chart of Gramineae is shown in Fig. 20. It shows high concentration in the sea area of the belt zone between the vicinity of the Sakawa River mouth and Hayama. In addition, this shows high concentration in the sea area of the eastern part of Kawana and in the mouth of the Uraga Channel. Concentration is low in other parts.

NAP

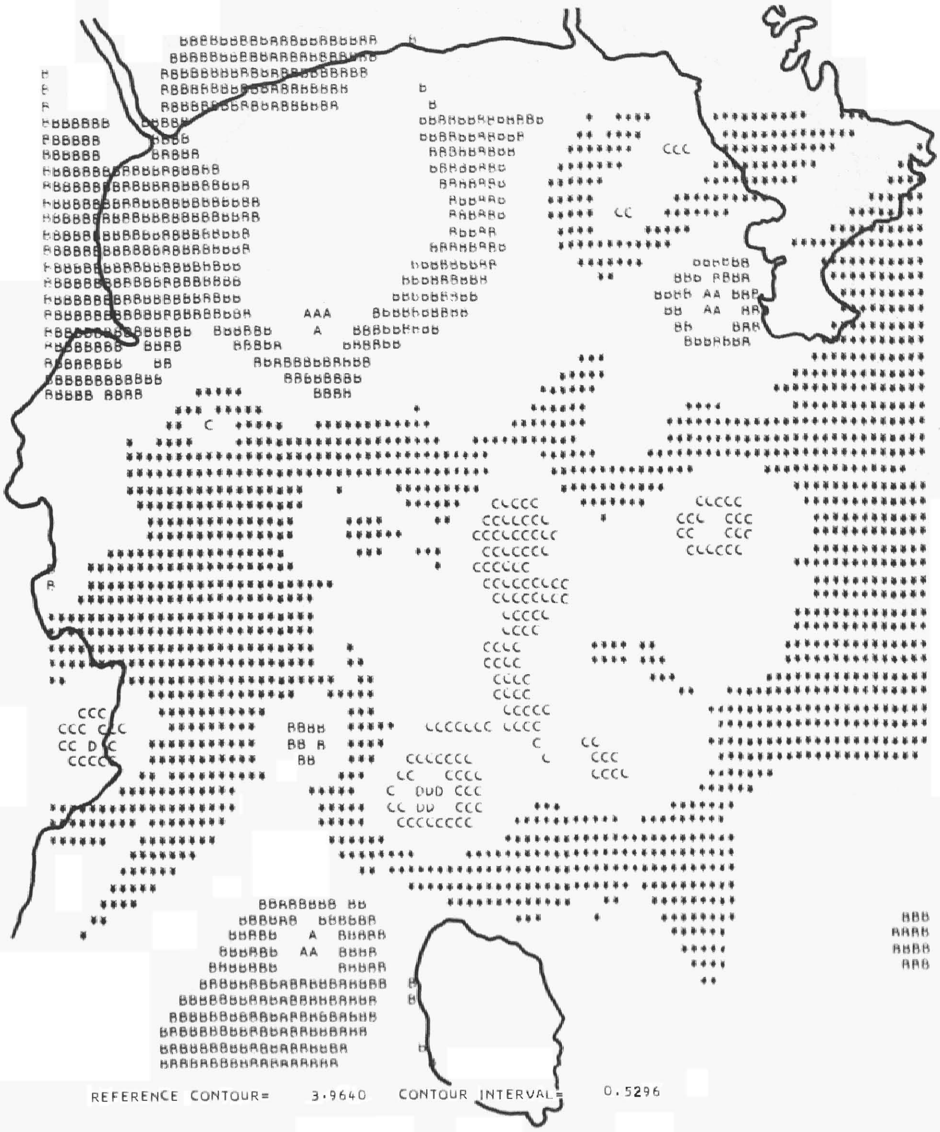
NAP means total herbaceous pollen. The distribution chart of NAP is shown in Fig. 21. The pattern of the distribution of NAP resemblance to that of Gramineae.

NAP excluding Gramineae

The distribution chart of NAP minus Gramineae is shown in Fig. 22. Most of the appearence of this typs is delimited to the areas of Sakawa River mouth and Kawana region.

Gleichenia

The distribution chart of *Gleichenia* is shown in Fig. 23. Fern spores of *Gleichenia* are concentrated in the innermost part of the bay near Sakawa and Sagami River mouths and in the entrance of Sagami Bay, but are small in quantity in the central part of the bay.



Alnus

Fig.16 Contour interval is approximately 0.5%. Reference band of yen sign (¥) shows the region between 3.43% (edge nearest symbol B) and 4.49% (edge nearest symbol C).

Numerical figures of this table show the percentage of *Alnus* for each reference band of signs.

A	<	B	<	¥	<	C	<	D
1.85	2.38	2.91	3.43	3.96	4.49	5.02	5.55	6.07

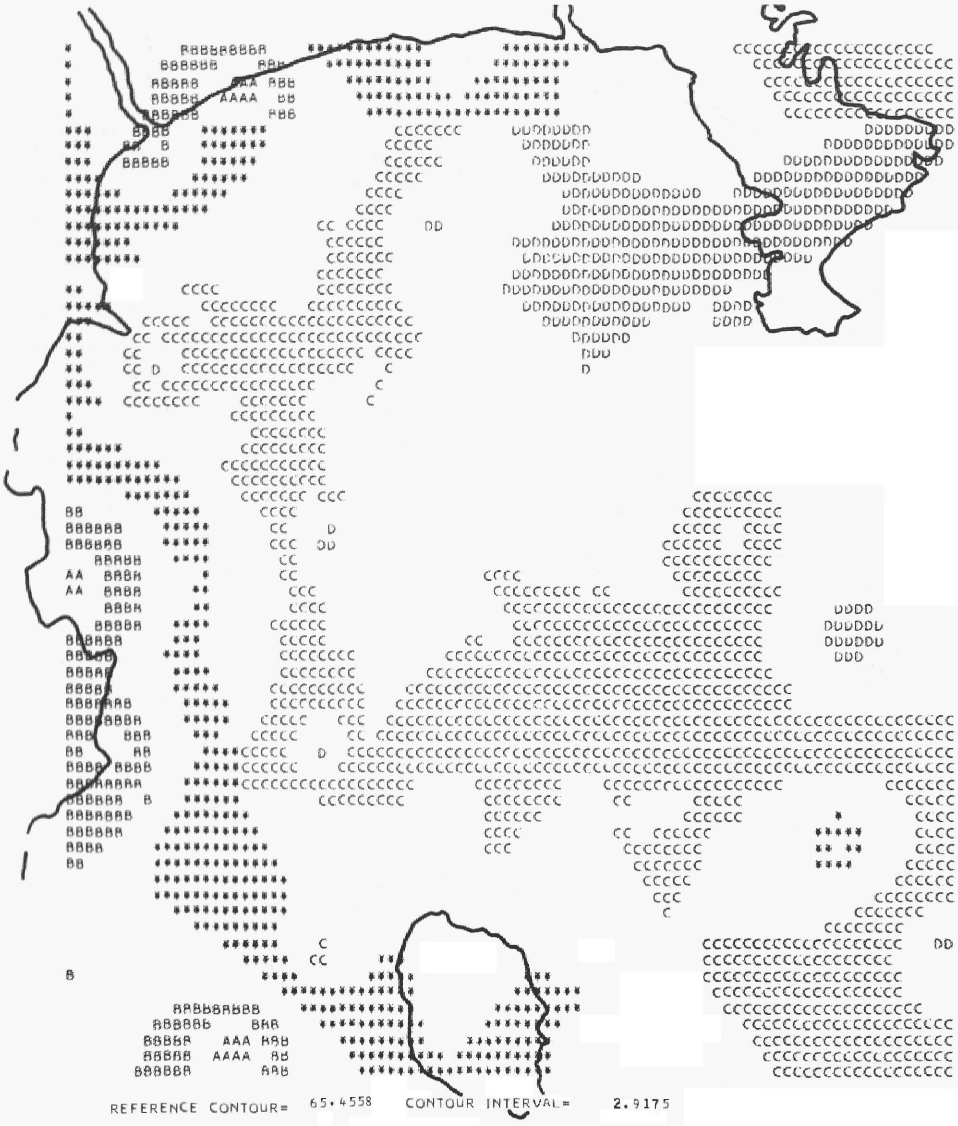
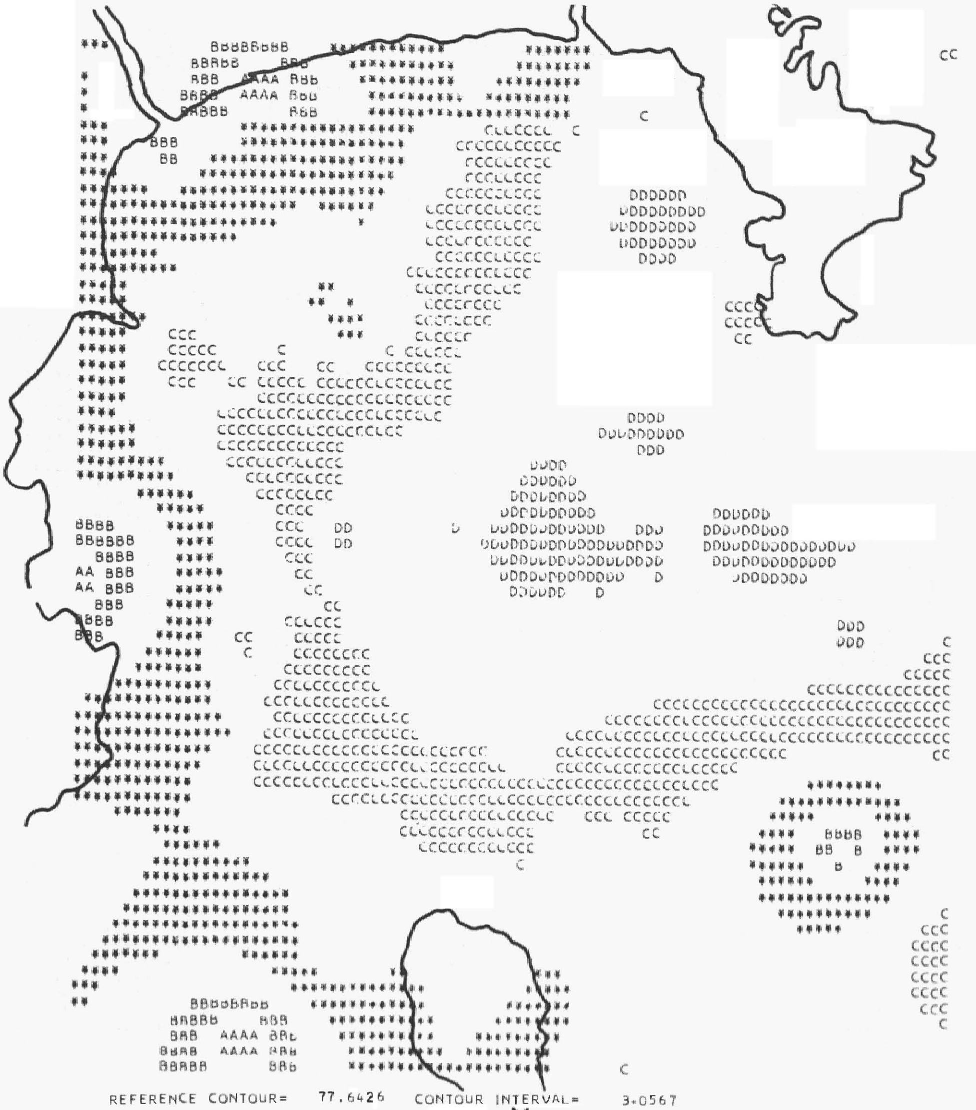


Fig.17 Contour interval is approximately 2.9%. Reference band of yen sign (¥) shows the region between 62.54% (edge nearest symbol B) and 68.37% (edge nearest symbol C).

Numerical figures of this table show the percentage of Total *Pinus* type for each reference band of signs.

A	<	B	<	¥	<	C	<	D
53.79	56.70	59.62	62.54	65.45	68.37	71.29	74.21	77.12

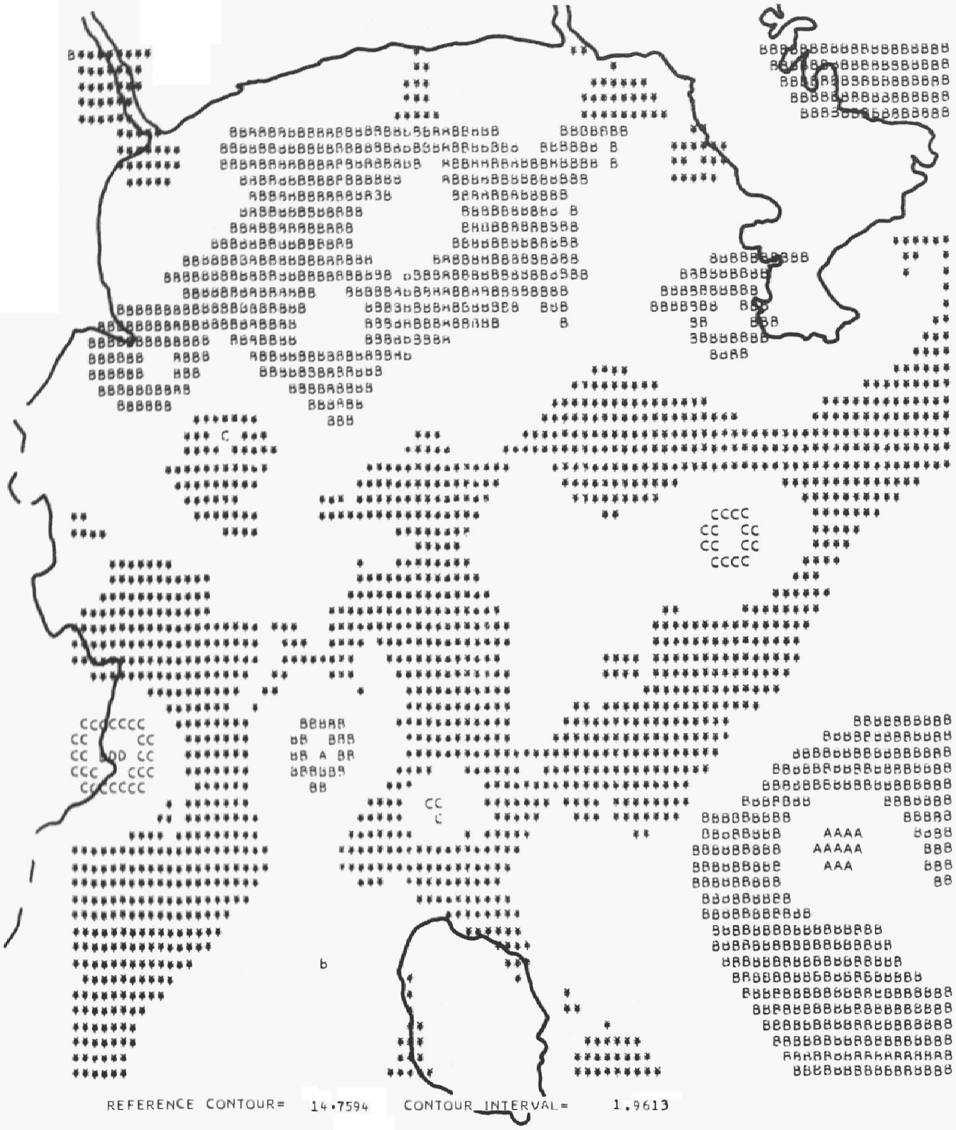


AP

Fig.18 Contour interval is approximately 3.1%. Reference band of yen sign (¥) shows the region between 74.59% (edge nearest symbol B) and 80.70% (edge nearest symbol C).

Numerical figures of this table show the percentage of A P for each reference band of signs.

A	<	B	<	¥	<	C	<	D
65.42	68.47	71.53	74.59	77.64	80.70	83.75	86.81	89.87

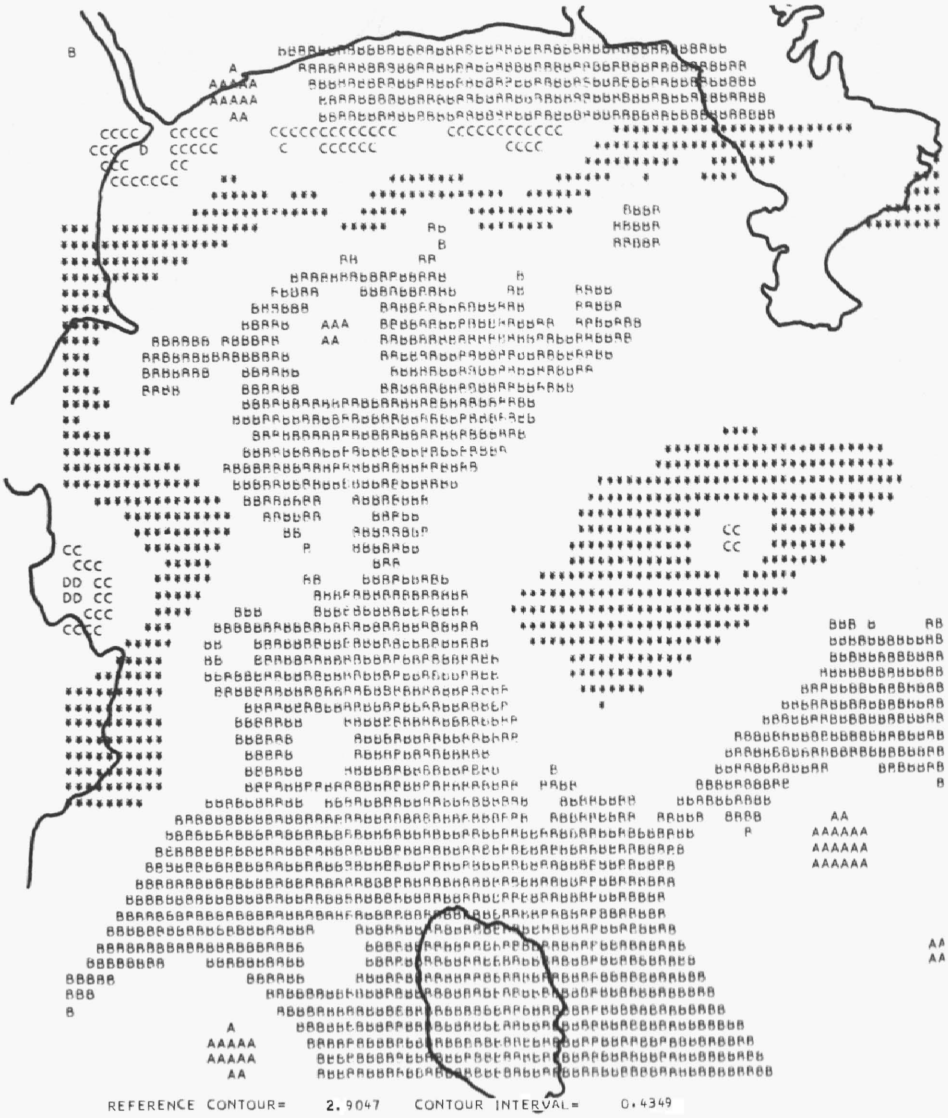


Whole A P except for Pinus-type

Fig.19 Contour interval is approximately 2.0%. Reference band of yen sign (¥) shows the region between 12.80% (edge nearest symbol B) and 16.72% (edge nearest symbol C).

Numerical figures of this table show the percentage of A P excluding *Pinus*-type for each reference band of signs.

A	<	B	<	¥	<	C	<	D
6.91	8.86	10.84	12.80	14.76	16.72	18.68	20.64	22.60

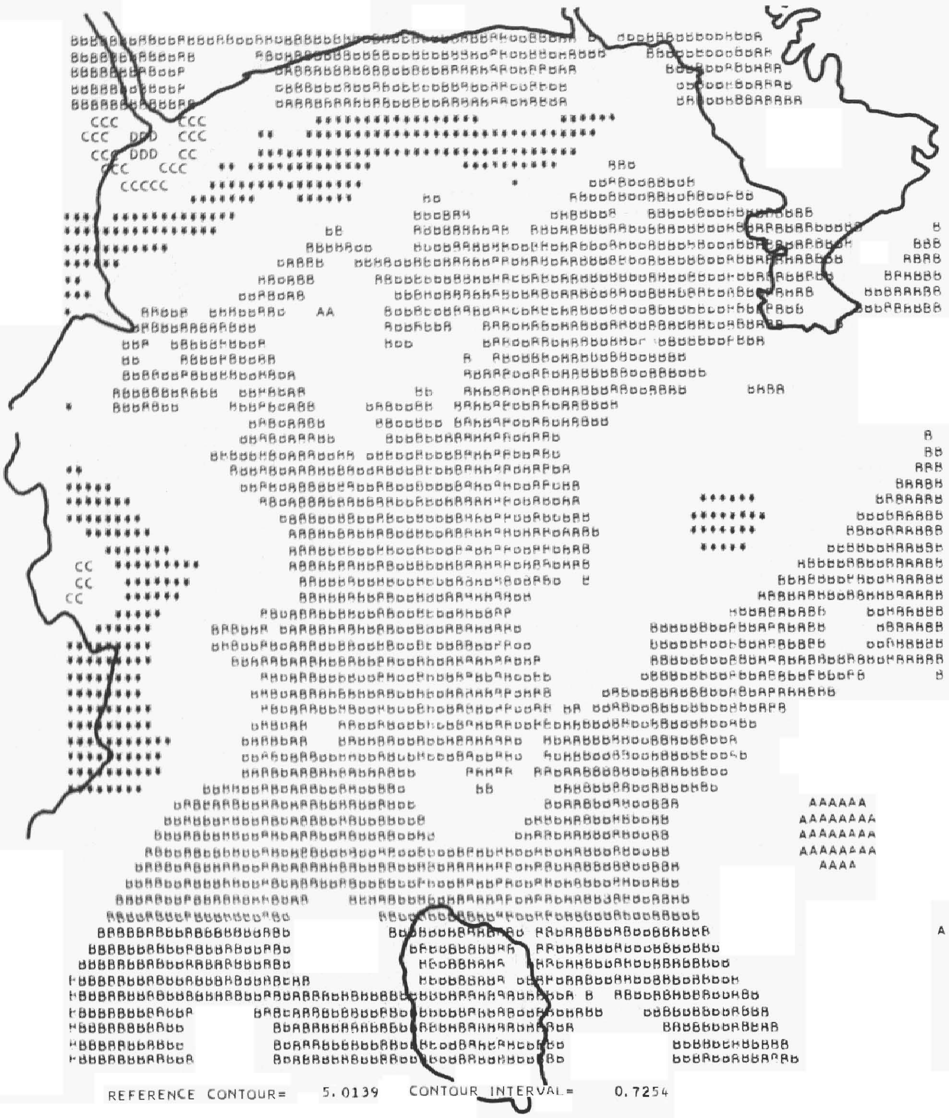


Gramineae

Fig.20 Contour interval is approximately 0.4%. Reference band of yen sign (¥) shows the region between 2.45% (edge nearest symbol B) and 3.34% (edge nearest symbol C).

Numerical figures of this table show the percentage of Gramineae for each reference band of signs.

A	<	B	<	¥	<	C	<	D
1.17	1.60	2.03	2.45	2.91	3.34	3.77	4.21	4.64

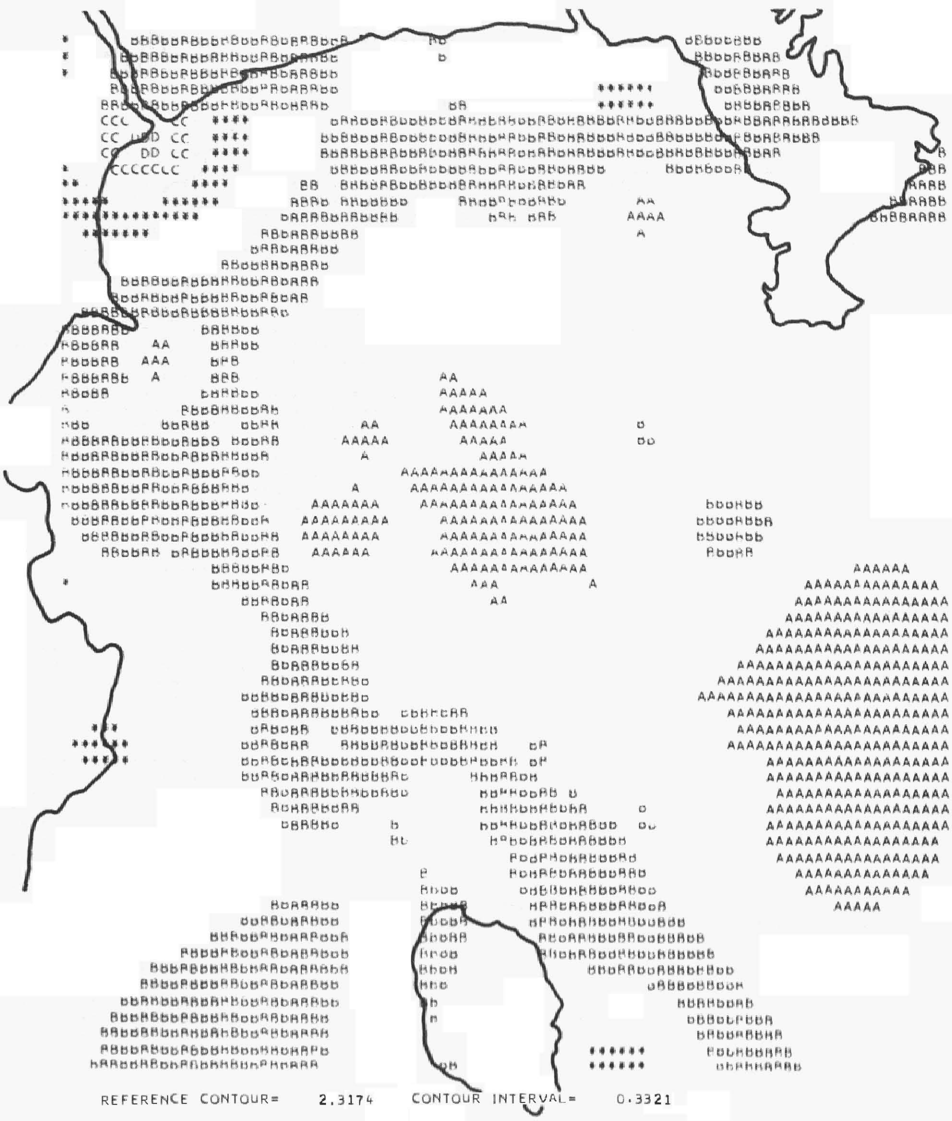


NAP

Fig.21 Contour interval is approximately 0.7%. Reference band of yen sign (¥) shows the region between 4.29% (edge nearest symbol B) and 5.74% (edge nearest symbol C).

Numerical figures of this table show the percentage of N A P for each reference band of signs.

A	<	B	<	¥	<	C	<	D
2.11	2.84	3.56	4.29	5.01	5.74	6.47	7.19	7.92



NAP excluding Gramineae

Fig.22 Contour interval is approximately 0.3%. Reference band of yen sign (¥) shows the region between 1.99% (edge nearest symbol B) and 2.65% (edge nearest symbol C).

Numerical figures of this table show the percentage of N A P excluding Gramineae for each reference band of signs.

A	<	B	<	¥	<	C	<	D
1.00	1.32	1.65	1.99	2.32	2.65	2.98	3.31	3.65

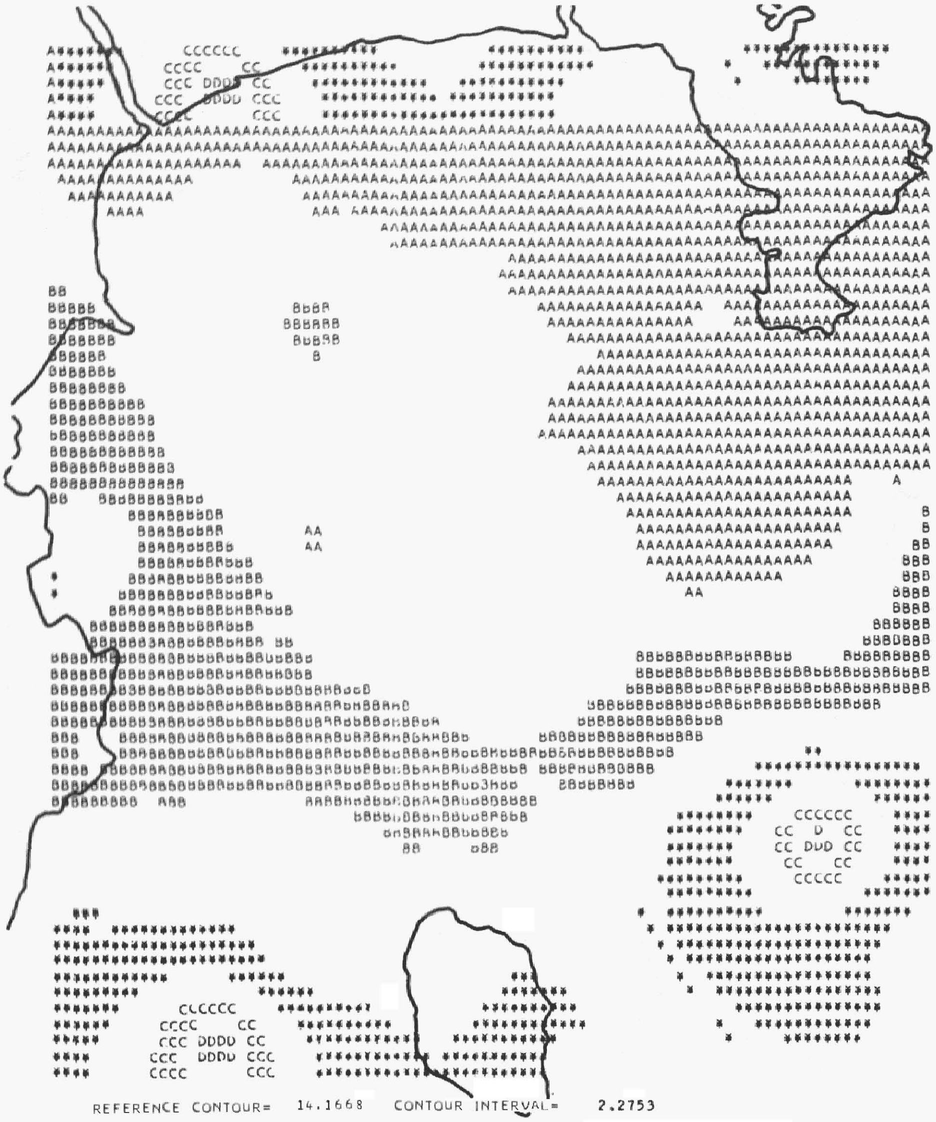


Fig.23 Contour interval is apporoximately 2.3%. Reference band of yen sign (¥) shows the region between 11.89% (edge nearest symbol B) and 16.44% (edge nearest symbol C).

Numerical figures of this table show the percentage of *Gleichenia* for each reference band of signs.

A	<	B	<	¥	<	C	<	D
5.07	7.34	9.62	11.89	14.17	16.44	18.72	20.99	23.27

FS

FS means total fern spores which mostly consists of *Gleichenia*. The distribution chart of FS is shown in Fig. 24. Roughly speaking, high concentration of FS is found in the areas around the mouth of Sagami Bay and in the vicinity of Sakawa River mouth.

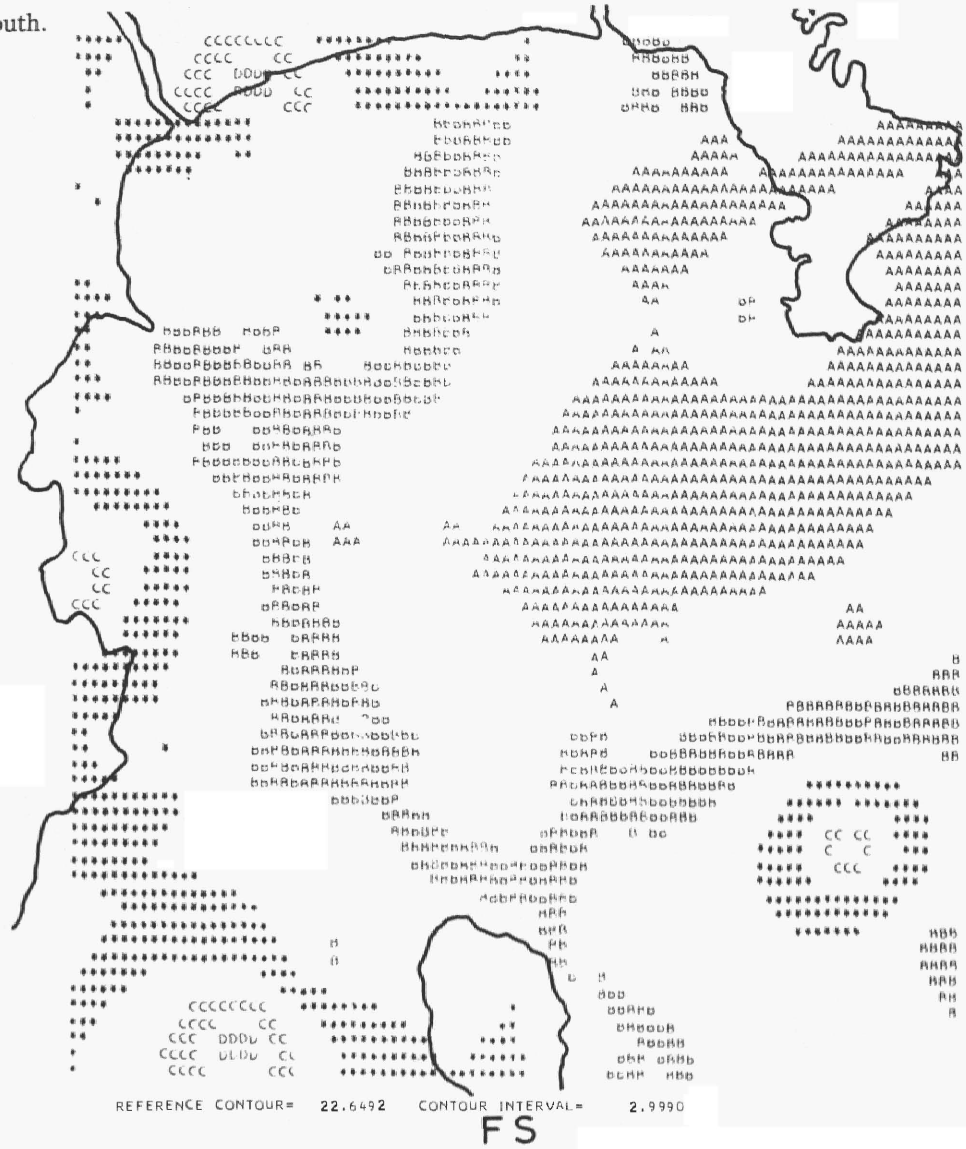


Fig.24 Contour interval is approximately 3.0%. Reference band of yen sign (¥) shows the region between 19.65% (edge nearest symbol B) and 25.65% (edge nearest symbol C).

Numerical figures of this table show the percentage of F S for each reference band of signs.

A	<	B	<	¥	<	C	<	D
10.65	13.65	16.65	19.65	22.65	25.65	28.65	31.65	34.65

Secondary palynomorph

Secondary palynomorph consists of Pre–Pleistocene palynomorphs (reworked fossils). The distribution chart of them is shown in Fig. 25. The high concentration of these

Secodary palynomorph

Fig.25 Contour interval is approximately 0.4%. Reference band of yen sign (¥) shows the region between 2.02% (edge nearest symbol B) and 2.78% (edge nearest symbol C).

Numerical figures of this table show the percentage of Secondary palynomorphs for each reference band of signs.

A	<	B	<	¥	<	C	<	D
0.89	1.26	1.64	2.02	2.40	2.78	3.15	3.53	3.91

Table 2. Results of pollen analysis of the surface sediments from Sagami Bay. Numerical figures show absolute counts of pollen grains and spores.

Sampling station	222	226	227	228	231	232	233	234
Pinus	611	420	592	95	346	1331	554	724
Abies	1	1	3	1	2	5	4	2
Tsuga	15	18	15	6	24	25	33	24
Picea	1	1	1		2			2
Cryptomeria	24	8	12	1	7	8	8	3
Sciadopitys		2						
Podocarpus	1	2	1			3		2
Quercus	11	8	5		8	17	13	7
Cyclobalanopsis	2	2	4		3	5	2	2
Betula	6	1	5			15	5	1
Carpinus	3	2	6		1	10	4	4
Shiia	2					3	1	
Fagus	1	1	1		3	3	1	1
Ulmus	1	4	7	1	3	25	24	9
Zelkova						9	3	
Celtis		1				8	5	3
Myrica	2	1	1			14	2	
Pterocarya	2				1	2	4	
Juglans	1		1			3	1	
Corylus						1	3	2
Styrax								
Fraxinus								
Cornus								
Ligustrum								
Symplocos	1							
Tilia	1							
Acer								
Mallotus	1	1			1	4	4	4
Irex						1		
Lagerstroemia								
Alnus	30	8	20	5	4	89	42	25
Elaeagnus								
Ephedra								
Ericaceae						2		
Gardenia								
A P total	717	481	674	109	405	1583	713	815
Gramineae	15	2	8	1	11	28	20	37
Fagopyrum								1
Cyperaceae	1	1			1	1		
Artemisia	1	2	4			6	3	4
Compositae		1			1		1	
taraxacum						1		
Persicaria								
Rynoutria			2					1
Chenopodium	2		1	1	3	3	5	7
Potamogeton								
Caryophyllaceae		1						3
Thalictrum	1					1		
Lonicera					1			
Umbelliferae								
Typha						1	3	
Myriophyllum								
N A P total	20	7	15	2	17	41	32	53
Gleichenia	43	61	79	41	28	76	22	27
Pteris	2		1	1				4
Pyrrosia		3						
Monolete Type	12	27	24	8	34	35	51	42
Trilete Type	15	18	14	6	15	14	9	18
F S total	72	109	118	56	77	125	82	91
Anthocerotaceae		1			1			2
TOTAL	809	595	808	167	500	1759	828	971
Reworked palynomorphs	4	10	9	7	8	29	24	9

Sampling station	235	236	237	238	239	241	242	244
Pinus	278	444	536	1319	566	366	400	345
Abies	3	7	1	8	1	2	1	8
Tsuga	10	22	17	55	17	20	13	38
Picea						1		2
Cryptomeria	2	10	3	29	34	9	5	11
Sciadopitys		1			1	1		2
Podocarpus	2	2		3		1		
Quercus	6	9	10	32	13	3	4	1
Cyclobalanopsis	2	1	3	8				3
Betula	3	3	2	9	5	4	1	
Carpinus	1	2	3	9	1	6		1
Shiia		2		13	1	1		
Fagus			3	1	1		1	3
Ulmus	17	16	11	29	14	34	10	6
Zelkova	3	5	4	9	2	7	3	2
Celtis	1			7	2	5		
Myrica		2	2	8	2	3		
Pterocarya		2		4		1		
Juglans	1	3	1	3		2		
Corylus				1				
Styrax								
Fraxinus	1			1	1			
Cornus					1			
Ligustrum								
Symplocos								
Tilia								
Acer								
Mallotus	3	3	4	8	2	9		
Irex						1	1	
Lagerstroemia								1
Alnus	7	15	13	67	21	23	10	8
Elaeagnus				1				
Ephedra								
Ericaceae		2		1			2	
Gardenia								
A P total	340	551	613	1625	685	499	451	431
Gramineae	26	25	13	37	18	33	8	4
Fagopyrum	1					2		
Cyperaceae				1	2	1		2
Artemisia	2	1	5	6	4	5	1	1
Compositae	1	4				2		
Taraxacum								
Persicaria		2				1		
Rynoutria	1	1		6	2	5		1
Chenopodium	3		3	8	2	8	2	1
Potamogeton								
Caryophyllaceae	2			1		3		
Thalictrum					1			
Lonicera						1		
Umbelliferae		1	1					
Typha	1							1
Myriophyllum								
N A P total	37	34	22	59	29	61	11	10
Gleichenia	15	32	34	118	32	26	36	53
Pteris		2	1	1	1	2	3	1
Pyrrosia						1		
Monolete Type	77	81	54	89	23	127	31	63
Trilete Type	13	16	12	26	12	8	7	20
F S total	105	131	101	234	68	164	77	137
Anthocerotaceae	1	1			1			
TOTAL	483	717	736	1918	783	724	539	578
Reworked palynomorphs	7	14	6	21	10	7	2	13

Sampling station	245	246	247	248	249	251	252	254
Pinus	737	908	412	346	338	677	642	407
Abies	1	3	2				1	
Tsuga	33	27	15	15	26	23	31	15
Picea		1					1	
Cryptomeria	40	17	17	17	12	49	36	15
Sciadopitys		1	1					1
Podocarpus	3	5		1	2	1		3
Quercus	31	17	16	9	10	18	22	13
Cyclobalanopsis	6	1	3	5	3	4	4	2
Betula	5	8	2	2	5	1	14	3
Carpinus	4	9	4	2	3	3	6	5
Shiia	11	1	4	2	2	4	8	2
Fagus	5	6	1	1	2		2	2
Ulmus	16	19	2	6	11	4	10	7
Zelkova	7	8	2	1	1	1	3	
Celtis	5		1	3	6	2	7	1
Myrica	6	5	4	3	2	1	5	2
Pterocarya		1		2			1	
Juglans	5	4		2	3	2	4	1
Corylus				1				
Styrax		1						
Fraxinus			1					
Cornus			1	1			1	
Ligustrum								
Symplocos								
Tilia			1					
Acer								
Mallotus	4	1			2	1	3	2
Irex	1			1	1			
Lagerstroemia								
Alnus	57	53	22	21	19	13	68	21
Elaeagnus								
Ephedra								
Ericaceae	1							
Gardenia								
A P total	978	1096	511	441	448	804	869	502
Gramineae	27	28	6	18	41	25	19	16
Fagopyrum			1		2			
Cyperaceae	1					1	2	1
Artemisia	10	2	1	1	2	6	10	2
Compositae	3	2	1		3	2		
taraxacum				1		1		
Persicaria				1				
Rynoutria	1	1	2		1			1
Chenopodium	6	1	4	3	4	3	6	2
Potamogeton							1	
Caryophyllaceae			1	1		2		
Thalictrum						1		
Lonicera					1			
Umbelliferae				1				
Typha					1			
Myriophyllum			2					
N A P total	48	34	18	26	55	41	38	22
Gleichenia	56	50	44	76	99	90	82	43
Pteris	3	1		2	4	1	1	
Pyrrosia	1							
Monolete Type	47	44	38	67	129	45	40	21
Trilete Type	26	10	8	11	32	15	6	8
F S total	133	105	90	156	264	151	129	72
Anthocerotaceae								
TOTAL	1159	1235	619	623	767	996	1036	596
Reworked palynomorphs	15	8	7	4	3	10	7	8

Sampling station	255	256	258	261	262	263	264	265
Pinus	107	855	542	298	476	302	502	80
Abies	9	2	1	2	1		2	
Tsuga	25	22	26	8	15	3	18	4
Picea	3	2	1	1	1	1	1	
Cryptomeria	74	30	6	17	7	6	22	2
Sciadopitys							1	
Podocarpus	7	3			1		1	
Quercus	54	29	7	29	12	8	29	1
Cyclobalanopsis	11	2	1	4	1		6	1
Betula	16	8		1	1		5	
Carpinus	20	8	4	3	1	1	4	
Shiia	12	6		5	2	4	7	
Fagus	11	7	1	2	3	1	6	2
Ulmus	28	17	7	4	7	5	14	1
Zelkova	5	5		1				
Celtis	10	10		1	1	2	3	1
Myrica	9	7		2		1	3	1
Pterocarya	1	2			1	1		
Juglans	3	5		2	1	3		
Corylus		1					1	
Styrax	1	2		1				
Fraxinus								
Cornus	1							
Ligustrum						1		
Symplocos		1						
Tilia	1			1		1	2	
Acer				1				
Mallotus	7	6	2	5	10	2	6	
Irex							1	
Lagerstroemia								
Alnus	101	64	14	34	12	6	46	6
Elaeagnus								
Ephedra								
Ericaceae								
Gardenia								
A P total	516	1094	612	422	476	348	680	99
Gramineae	63	29	10	43	44	34	32	12
Fagopyrum			1		1		2	
Cyperaceae	1		1			2	4	
Artemisia	12	6	4	7	1	1	2	
Compositae	1			3	2	1	1	
taraxacum	1			1				
Persicaria					1		1	1
Rynoutria			1	1	2	1	2	
Chenopodium	7		1	4	3	2	5	
Potamogeton								
Caryophyllaceae	1			1			1	
Thalictrum								
Lonicera					1		1	
Umbelliferae	3			2	1			
Typha	1	1			1	1	4	
Myriophyllum	1							
N A P total	91	36	18	62	57	42	55	13
Gleichenia	59	79	71	28	43	31	72	10
Pteris	4			1	6	2	2	1
Pyrrosia								
Monolete Type	48	26	44	73	92	37	87	29
Trilete Type	9	6	13	9	11	9	19	3
F S total	120	111	128	111	152	79	180	43
Anthocerotaceae	1	1		1				
TOTAL	728	1242	758	596	685	469	915	155
Reworked palynomorphs	19	13	8	70	189	76	169	20

Sampling station	266	274	278	279	287	290
Pinus	173	374	319	437	349	142
Abies		1				
Tsuga	3	7	13	12	22	4
Picea			2			
Cryptomeria	33	35	18	73	48	14
Sciadopitys			2			
Podocarpus			1	2		
Quercus	17	8	15	17	25	6
Cyclobalanopsis	2		8	1	2	1
Betula	1		4	4	8	1
Carpinus	2	3	3	1	4	1
Shiia	3	5	7	2		1
Fagus	2	2	2	1	4	
Ulmus	5	7	4	4	13	
Zelkova					1	
Celtis	3	1		2	8	
Myrica	1	2	2	4	2	
Pterocarya				1		
Juglans		1	1			1
Corylus						
Styrax						
Fraxinus						
Cornus					1	
Ligustrum						
Symplocos						
Tilia	1					
Acer						
Mallotus	2	1	1	3	3	
Irex						
Lagerstroemia						
Alnus	10	17	12	23	40	7
Elaeagnus						
Ephedra						
Ericaceae						
Gardenia						
A P total	258	464	414	587	530	178
Gramineae	18	11	7	16	18	2
Fagopyrum						
Cyperaceae	1	1	4	1		
Artemisia	3	5	3	5	10	3
Compositae						
taraxacum		1	1			
Persicaria						
Rynoutria		3	3	1	1	1
Chenopodium	1	1	3	2	3	
Potamogeton		1				
Caryophyllaceae						
Thalictrum						
Lonicera						
Umbelliferae		1			1	
Typha			1			
Myriophyllum						
N A P total	23	24	22	25	33	6
Gleichenia	30	54	70	96	42	76
Pteris						1
Pyrrosia						
Monolete Type	42	26	44	52	58	31
Trilete Type	10	5	24	18	23	4
F S total	82	85	138	166	123	112
Anthocerotaceae						
TOTAL	363	573	574	778	686	296
Reworked palynomorphs	77	9	18	27	14	11

palynomorphs can be seen in the coastal areas west to the Sakawa River mouth and off Zushi of the Miura Peninsula and off-shore areas 20 km west to Oshima Island and 30km northeast to it.

V. Discussion

Every pollen grain and spore liberated from a flower or sporongium is transported in the air to settle on land or directly on water. Once delivered to the water, they should act as the sedimentary particles. Infomations about the above processes have given by many workers (MULLER, 1959; TRAVERSE and GINSBURG, 1966; GROOT, 1966; STANLEY, 1966; MATSUSHITA, 1981, 1982, 1985 and many other workers).

Refering to these informations, the writers want to discuss the distribution pattern of pollen and spores in relation to palynosedimentological process. In other words, relation of the depositional patterns of pollen and spores to their source areas are investigated on the knowledge of the morphology and stracture of pollen and spores and of the meteorological and oceanographical conditions of the area under consideration.

1) *Pinus* and *Gleichenia*

Pinus and *Gleichenia* produce a large quantity of pollen and spores, which have large buoyancy. Particularly black and red pine (*Pinus Thunbergii* and *P. densiflora*) are distributed extensively everywhere in Japan except for Hokkaido. *Gleichenia* also flourishes widely on the floor of pine forests. And in this region but in the area surrounding Sagami Bay, *Gleichenia* is found densely distributed in the southern half of the Izu Peninsula.

The direction of prevailing winds and currents on Sagami Bay is shown in Figs. 3 and 4. In the flowering season of *Pinus*, the wind directions are usually east-west or northeast-southwest. According to HOPKINS (1950) and POHL (1933), most of *Pinus*, after falling down into the water, keep floating for a long time. In the present study it was found that the high concentration values of *Pinus* are found in the stagnated area surrounded by the circular current but such values were not seen near the river mouth. This fact suggests that the distribution pattern of *Pinus* is not much influenced by the wind directions, but is controlled by the hydraulic conditions.

As shown in Fig. 23, spores of *Gleichenia* are found in quantities at the mouth of Sagami Bay and in the area east and west to Oshima Island. This fact may be explained as following. They are transported by the oceanic current of Kuroshio directly from the source area of the southern half of the Izu Peninsula.

In conclusion, the pollen and spores of this type are transported to the sea by the streams and winds, but are not deposited within a short period beacause of their large buoyancy. Hence, they are much influenced by marine currents before settling on the sea floor.

2) *Quercus*, *Cyclobalanopsis* and *Alnus*

Oak and alder are anemophilous flowers. These trees are distributed widely around Sagami Bay but they are relatively scarce on the Shonan Plain and the Miura Peninsula owing to the urbanization. As shown in Fig. 4, the wind directions during their flowering season are north-east or north-south in the reagion of Shonan and Yokohama, while east-west or northeast-southwest in the Izu Peninsula. Therefore, it may be considered that most of these pollen in this study are transported from the Izu Peninsula.

According to HOPKINS (1950)[*], most of pollen of this type (approximately 95 to 100%) sunk through water column of 42.5cm within 5 min. after falling down into the still water. ERDTMAN (1943) and FAEGRI and IVERSEN (1964) assert that 90% of pollen of this type drift as long as 50-100km in the air bofore they fall down on the water. Consequently, it is concluded that pollen of this type are carried by wind at some distance and are deposited within a relatively short period after falling down to the sea. In other words, their influence of hydraulic coudition on this group is less than that on *Pinus*.

3) *Cryptomeria*

The source area of *Cryptomeria* lies in the Izu Peninsula and the northern land adjacent to Sagami Bay. *Cryptomeria* is also an anemophilous flower. The high concentration of its pollen is found not only in the vicinity of the river mouth but also around the mouth of the bay. This fact suggest that the pollen may have been carried from the source area to Sagami Bay both by the streams and the winds. Furthermore the above fact suggests the behavior of the pollen in the water, its settling velocity in the water, is fairly large. In conclusion, *Cryptomeria* is influenced only slightly by marine currents in the sedimentological process.

4) *Tsuga*, *Ulmus-Zelkova*, NAP, and FS of Monolete type

Tsuga flourishes in the Tanzawa mountain district and *Ulmus* and *Zelkova* are found broadly as the components of shelter belt. The source area of non arboreal pollen (NAP) and fern spores (FS) of Monolete type are densely distributed in this region but their productivity are low. Most of the components of NAP in the sediments of Sagami Bay are Gramineae.

Relatively high concentration of *Tsuga* and *Ulmus-Zelkova* is found only in the vicinity of the river mouth. Most of the pollen and spores of these taxa are supposedly transported by the river and deposited immediately after the river water poured into the sea. Hence, it is supposed that pollen and spores of this group are hardly influenced by the marine currents.

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* His experiment for comparison of rates of sinking of pine and oak pollen was performed in the absence of wind effects. —In the 6×6ft tank, the water level was brought to a depth of 17 inches.

5) Secondary palynomorph

Secondary palynomorphs, such as reworked or rebedded palynomorph, from the older sediments were recognized in the sea areas east and south to the Boso Peninsula (see the number of sampling stations particularly from St. 261 to St. 266 in Table 2).

Keteleeria, *Carya*, *Liquidambar*, etc. which belong to Pre-Pleistocene palynomorphs were found in the sampling materials of this study. These palynomorphs may be derived from the following Pre-Pleistocene submarine layers reported by KIMURA (1976). According to KIMURA (1976), these Pre-Pleistocene submarine layers are named the E and D layers on the basis of the sonic profiles. The E layer mainly correlates with the Oligocene-early Miocene Hayama Group cropping out in the Miura Peninsula and the Hota and Mineoka Groups cropping out in the Boso Peninsula. The D layer is unconformably underlain by the E layer and correlates with the Miocene Miura Group on land. Consequently palynological data of these secondary palynomorphs also may strongly support the presence of such Tertiary submarine layers cropping out near the Boso and Miura Peninsulas reported by KIMURA (1976).

The problem of reworked palynomorph has been already discussed by many workers (MULLER, 1959; DAVIS, M.B., 1961; GROOT, J.J. and GROOT, C.R., 1966; STANLEY, 1966 and many others). They asserted that the presence of reworked palynomorphs in significant numbers suggests the presence of the out crop where polleniferous sediments are exposed on the continental shelf or slope (GROOT, J.J. and GROOT, C.R., 1966) and the increase of erosion owing to sea-level lowering or continental glaciation (STANLEY, 1966).

VI. Conclusion and application

The distribution patterns of pollen and spores of Sagami Bay, as described in detail in the preceding chapters, were discussed on the basis of the principal relation between the location of the source areas of pollen and spores and their transporting mechanism. Some depositional selections of the grains take place in the process of gradual settling and transporting of pollen and spores by the water currents and winds. In these dispersal process of the pollen and spores from the land to Sagami Bay, the following groups are recognized:

Group A: Such as *Pinus* and *Gleichenia* belong to this group. Pollen and spores of this group have a large buoyancy and are consequently transported by the winds and water currents for a relatively long period. So the dispersal pattern of this group is much influenced by hydraulic conditions.

Group B: *Quercus*, *Cyclobalanopsis*, *Alnus* and *Cryptomeria* belong to this group and these are anemophilous flowers. Pollen grains of this group are carried to Sagami Bay by the winds and rivers and then deposited within a short period. So they are a little influenced by the marine currents. Because pollen grains of this group have not the same bladders with pine pollen, that is to say, they have a relatively small buoyancy.

Group C: *Tsuga*, *Ulmus–Zelkova*, NAP (Non Arboreal Pollen) and fern spores of Monolete type belong to this group. Pollen and spores of this group are transported to the bay mainly by the rivers and deposited immediately after the water poured out into the sea. Because herbaceous plants are low pollen producers and low in height, so their pollen are not dispersed widly by the winds. Fern spores of Monolete type show a similar tendency to herbaceous plants. On the other hand, since the arboreal pollen of *Tsuga*, *Ulmus* and *Zelkova*, had their source areas in an inland area, such as Tanzawa mountain district, their pollen grains could not reached to the bay by the winds because of the long distance between their source areas and the bay. Pollen and spores of this group, therefore, are hardly influenced by the winds and marine currents.

Group D: Secondary palynorphs such as *Keteleeria*, *Carya*, *Liquidambar*, etc. which are derived from the Pre–Pleistocene submarine layers at the sea bottom, belong to this type. They are little influenced by the factors mentioned above.

MULLER (1959) claimed that waterborne pollen grain could be compared with fine silt particles in settling speed, and same similarities in distributions between them are found. The distribution pattern of Group A which has a large buoyancy is roughly similar to silt particles. But the distribution pattern of the other groups are not always coincide with that of silt particles. This fact suggests that they are influenced in part by the abilities of dispersion and buoyancy.

It was found that the grid method using a computer is very useful to investigate the distribution patterns of sedimentary elements, and this method will be used broadly in palynology.

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