Preliminary Results from the R.V. Tansei-maru Cruise KT98-17 in the Southwestern Marginal Part of the Japan Sea : Sediments, Benthic and Planktonic Forminifers, and Ostracodes

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Preliminary Results from the R.V. *Tansei-maru* Cruise KT98-17 in the Southwestern Marginal Part of the Japan Sea

—Sediments, Benthic and Planktonic Forminifers, and Ostracodes—

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1. INTRODUCTION

Marine geology and micropalaeontology were investigated in the southwestern marginal part of the Japan Sea from the 25th September to the 2nd of October 1998, during the R.V. *Tansei-maru* cruise KT98-17 as a part in a series on pursuing time-spatial distribution of depositional facies and spatial distribution of present micro-organisms in the eastern marginal part of the Japan Sea. This cruise report is concerned with onboard observations, and preliminary results from sedimentological and micropalaeontological analyses of cored and surface sediments in the laboratory.

Many geological and geophysical studies have been made in the Japan Sea mainly by the Hydrographic Department, M.S.A., Japan (*e.g.* Iwabuchi, 1968), the Geological Survey of Japan (*e.g.* Arita *et al.* eds., 1987), Ocean Research Institute, the University of Tokyo (*e. g.*, Kobayashi, ed., 1984), the DSDP/ODP (*e.g. Ingle et al.*, 1990) and others (*e.g.* Oba *et al.*, 1991 ; Tsukawaki *et al.*, 1993, 1997, 1998, 1999). Taking these previous studies into account, piston coring and grab surface sampling sites were selected mainly in the southern slope of the Tsushima Basin and the related continental slope and shelf north off the Hagi City, Yamaguchi Prefecture, Southwest Japan for the purposes of the following scientific searching ; (1) time-spatial

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distribution of depositional facies in the southern slope of the basin, (2) spatial distribution of micro-organisms on the continental shelf and slope north off Yamaguchi Prefecture, and (3) palaeoclimatic and palaeoenvironmental changes of the southwestern part of the Japan Sea during the last 20,000 years (Fig. 1). One extra surface sampling site was located in the Aso Bay, the Tsushima Islands (Fig. 1). Three piston cored sediments from three sites in the southern slope of the Tsushima Basin, and 20 and two grab surface samples were successfully obtained in the basin and related slope and shelf areas, and the Aso Bay, respectively (Table 1). The site survey was always carried out with a precise depth recorder (PDR) of the R.V. *Tansei-maru* in order to obtain the topographic information of the sea floor.

Marine biological study was carried out during the cruise by the scientific staff of the Ocean Research Institute and Department of Geology, the University of Tokyo, and Japan Sea National Fisheries Research Institute in the northern part of the sea, but the result is not included in this report.

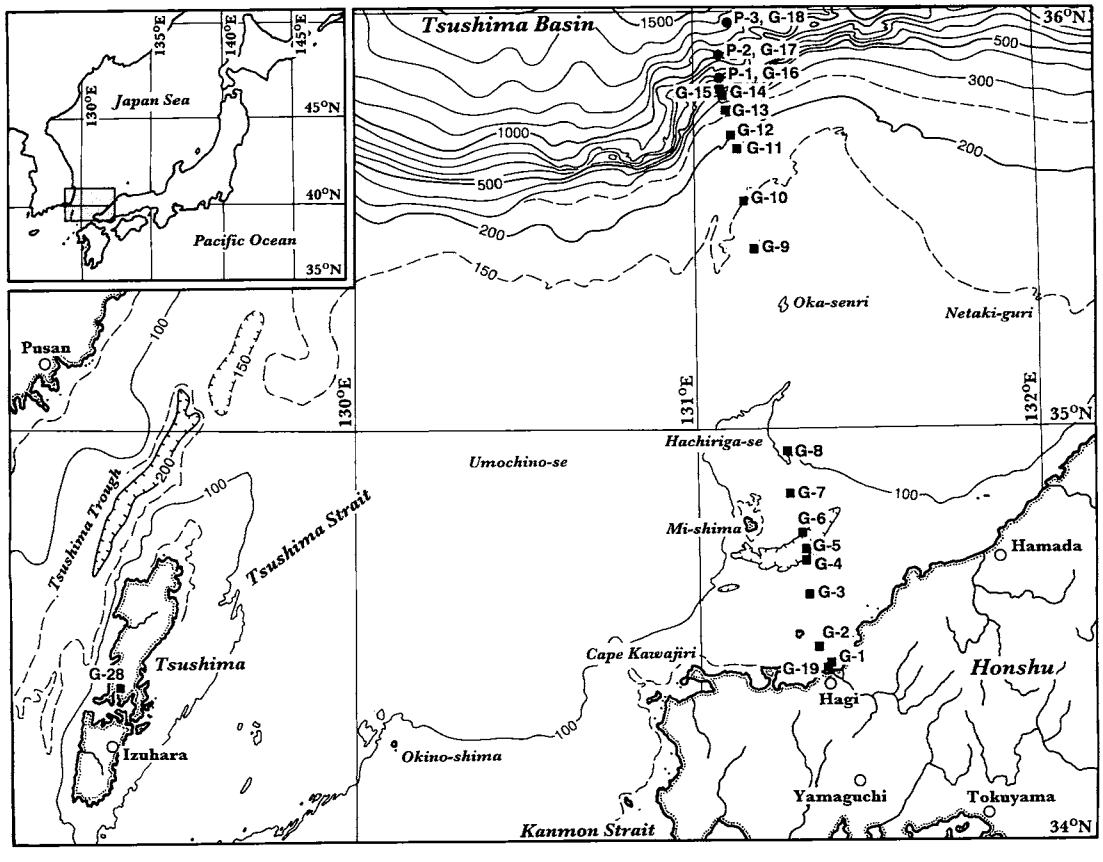

Fig. 1 Submarine topography of the southwestern marginal part of the Japan Sea north off Yamaguchi Prefecture, and sampling sites during the R. V. *Tansei-maru* cruise KT98-17 (based on Hydrographic Department, M. S. A., Japan, 1981).

Table 1 Log of sampling on the R. V. *Tansei-maru* Cruise KT98-17 in the southwestern marginal part of the Japan Sea.

Station	Sampling Device*	Date (D/M/Y)	Time Hit	Latitude (N)	Longitude (E)	Water Depth (m)	Locality	Sediment Type	Remarks
G-18	Okean (L)	28/09/98	09:42	35°56.8'	131°06.5'	1,322	Tsushima Basin	bluish grey mud	a lid did not close
G-18'	"	"	10:14	35°56.9'	131°06.2'	1,337	"	-	*no recovery*
P-3	6 m PC	"	11:12	35°56.9"	131°05.7'	1,340	"	-	
G-18"	Okean (H)	"	12:12	35°57.0'	131°05.5'	1,347	"	olive grey mud, reddish brown surface	
P-2	6 m PC	"	13:32	35°53.5'	131°04.5'	1,018	"	-	
G-17	Okean (H)	"	14:20	35°53.5'	131°04.4'	1,027	"	olive grey mud, reddish brown surface	
P-1	6 m PC	"	15:25	35°50.6'	131°05.2'	763	"	-	
G-16	Okean (H)	"	16:04	35°50.6'	131°05.1'	746	"	olive grey mud	over flowed
G-15	"	"	16:50	35°49.2'	131°05.4'	524	"	olive grey sandy mud	
G-14	"	"	17:26	35°48.0'	131°05.5'	361	"	olive grey sandy mud	
G-13	"	"	18:10	35°45.0'	131°06.5'	254	"	olive grey sandy mud	
G-12	"	"	18:50	35°42.0'	131°07.0'	208	NNW off-Hagi	olive grey sandy mud	
G-11	"	"	19:25	35°40.0'	131°07.4'	176	"	molluscan shell fragments bearing muddy f. sand	
G-10	"	"	20:46	35°32.6'	131°08.7'	152	"	yellowish olive grey muddy sand	
G-9	"	"	21:39	35°26.1'	131°09.7'	125	"	calcareous c. - vc. sand	
G-8	"	29/09/98	00:36	34°56.3'	131°15.1'	101	"	greenish grey f. - m. sand	
G-7	"	"	01:26	34°50.4'	131°16.4'	76	"	a small amout of calcareous fragments	*almost no recovery*
G-7'	"	"	01:32	34°50.5'	131°16.4'	75	"	calcareous c. - vc. sand	
G-6	"	"	02:19	34°44.4'	131°17.3'	100	"	calcareous rich yellowish grey f. - m. sand	
G-5	"	"	02:54	34°41.8'	131°17.7'	110	"	calcareous rich yellowish grey f. - m. sand	
G-4	"	"	03:17	34°40.7'	131°17.9'	102	"	calcareous rich yellowish grey f. - m. sand	
G-3	"	"	03:58	34°35.7'	131°18.6'	78	"	calcareous rich yellowish grey f. - m. sand	
G-2	"	"	04:53	34°27.9'	131°20.2'	52	"	calcareous rich yellowish grey f. - m. sand	
G-1	"	"	05:26	34°26.2'	131°22.4'	35	"	olive grey muddy sand	
G-19	"	"	05:42	34°25.8'	131°23.0'	28	"	olive grey muddy sand	
G-28	"	30/09/98	18:11	34°21.7'	129°17.7'	32	Aso Bay, Tsushima	olive grey soupy homogeneous mud	over flowed
G-28'	Okean (L)	"	18:22	34°21.7'	129°17.7'	32	"	olive grey homogeneous mud	over flowed

Okean Grab (L): normal type Okean grab sampler
Okean Grab (H): Okean grab sampler with extra weights
6m-PC: 6-m-long piston core sampler

2. SEDIMENTS

Sampling methods and sample preparation procedures

A 6-m-long stainless-steel pipe piston core sampler with a 500 kg weight and a 70-cm-long Nasu type pilot core sampler were utilized to obtain cored sediments from the southern slope of the Tsushima Basin, and an Okean type grab sampler were used to obtain bottom surface sediments and benthic organisms.

For cored sediments, volume magnetic susceptibility (VMS) were measured first at 1 cm intervals by using a Barrington pass through the type magnetic susceptibility system model MS -2 in comparison among the cored sediments obtained during this cruise. Then, each sediment that had been kept at about 4°C since it obtained was cut vertically into two halves by a nylon fishing line. One of these was processed for sedimentological investigations and the other was processed for micropalaeontological investigations as well as the further sample distributions at the laboratory of the General Education Hall, Kanazawa University. The cutting surface of the former was shaved first by a stainless-steel spatula, and then brushed well by spraying a water atomizer for detailed visual observations. After visual observations and core descriptions were made, an 8-mm thick, 7-cm wide and 20-cm long sliced sediment was cased in a plastic box from the cutting surface for soft X-ray radiograph observation through the core, then quantitative sampling for such measurements of sediment physical property as sediment

wet and dry densities, water contents, mud contents was conducted with a plastic cubic sampler, 2.2 cm in length and approximately 10.65 cm^3 in volume, and the rest sample was sliced into 2.2 cm thick segment samples to grasp sediment textural and compositional descriptions. On the other hand, quantitative sampling for such micropalaeontological analyses as planktonic foraminifers was carried out with a plastic cubic sampler, 1.9 cm in length, for the later halves, and the rest sample was sliced into 1.9 cm thick segment samples for other micropalaneontological analyses and sample distribution.

For X-raying, the boxed samples were placed on Fuji industrial X-ray film type IX-100. The source-to-sample distance on a X-ray unit, SOFTEX type M-60, was 70 cm. Voltage, amperage and exposure time were held constant at 50 kVp, 4 mA and 60-90 seconds, respectively. The exposed X-ray films were immediately processed by the EK type D-19 film developer for 5 minutes.

Microscopic observations using a number of smear slides for fine-grained sediments and thin sections for coarse-grained sediments were conduced to grasp the textural and compositional description both of all grab surface sediments and a certain number of horizons for cored sediments.

2-1. Tsushima Basin and Related Continental Shelf and Slope

Topography

A broad continental shelf is developed in the southwestern marginal part of the Japan Sea between Southwest Japan and the Korean Peninsula. A number of banks such as the Senriga-se, Umochino-se and Hachiriga-se are distributed in the shelf. The Mi-shima Island is situated in the shelf about 50 km north-northeast of the Cape Kawajiri. A trough shaped topographic depression having a NE-SW longitudinal axis of about 30 km and a maximum width of about 10 km is recognized south of the island. The shelf is followed northward by the continental slope as well as the southern slope of the Tsushima Basin through the shelf edge at water depths of around 200 m. The slope can be divided topographically into the comparatively steep upper slope, 200-1,000 m, and the gentle lower slope deeper than 1,000 m (Hydrographic Department, M.S.A., 1981). The Tsushima Basin, a square shaped basin having an E - W width of about 280 km, opens northward to the Japan Basin that is the largest sedimentary basin in the Japan Sea. The central part of the Tsushima Basin is more than 2,200 m deep. The Ulneung and Take Islands which are volcanic islands are situated in the basin. Topographic undulation is markedly recognized in the central part of the southern slope of the basin, but the eastern and western parts of the slope are rather smooth. Three piston cored sediments and 20 grab surface sediments were obtained from the southern slope of the Tsushima Basin, and the related continental slope and shelf in the area (Fig. 1, Tables 2 and 3).

Table 2 Results of grab samplings during the KT98-17 cruise.

Station	Water Depth (m)	Sediment Thickness (cm)	Mud Content (%)	Sediment Type
G-1	35	20	59	olive grey muddy sand
G-2	52	10	24	calcareous rich yellowish grey f. - m. sand
G-3	78	7	16	calcareous rich yellowish grey f. - m. sand
G-4	102	7	12	calcareous rich yellowish grey f. - m. sand
G-5	110	8	23	calcareous rich yellowish grey f. - m. sand
G-6	100	5	20	calcareous rich yellowish grey f. - m. sand
G-7'	75	1	6	calcareous rich c. - vc. sand
G-8	76	7	15	greenish grey f. - m. sand
G-9	125	5	32	calcareous c. - vc. sand
G-10	152	20	30	yellowish olive grey muddy sand
G-11	176	5	8	molluscan shell fragment bearing muddy sand
G-12	208	10	14	olive grey sandy mud
G-13	254	10	35	olive grey sandy mud
G-14	361	12	43	olive grey sandy mud
G-15	524	18	71	olive grey sandy mud
G-16	746	18	100	olive grey homogeneous mud
G-17	1,027	20+	100	olive grey mud. reddish brown mud in surface
G-18"	1,347	20+	100	olive grey mud. reddish brown mud in surface
G-19	28	12	51	olive grey muddy sand
G-28	32	20+	99	olive grey homogenesou mud
G-28'	32	20+	99	olive grey homogenesou mud

Table 3 Results of piston-cored samplings during KT98-17 cruise.

Station	Water Depth (m)	Core Length (cm)	Sediment Type
P-1	763	557	greyish olive green - dusky yellow green bioturbated and homogeneous mud
P-2	1,018	555	greyish olive green - dusky yellow green bioturbated mud in upper, thin laminated mud in middle and compact mud in lower
P-3	1,340	536	greyish olive green - dusky yellow green bioturbated mud in upper, thin alternation in middle and bioturbated sandy mud in lower

Cored sediments

KT98-17 P-1: This core, 557 cm in length, obtained from the upper slope of the southern part of the basin at a water depth of 763 m is composed mainly of dusky yellow green (5 GY5/2) or greyish olive green (5GY3/2) bioturbated mud (Fig. 2; Pl. 1, figs. 1-4). The uppermost 30 cm of the core consists of moderate olive green (5Y4/4) soft mud. Biogenic disturbance is particularly developed in the horizon between 460 and 520 cm below the sea floor. Molluscan shell fragments and plant debris are occationally recognized in part of the core. The muddy sediments are composed mainly of diatoms and volcanic glass shards with a small amount of clay minerals and coccolith. The sandy sediments consist chiefly of diatom and planktonic foraminifers with a small amount of such terrigenous sediments as volcanic glass shard, quartz, feldspar, biotite, hornblende and pyroxenes, and radioralians and benthic foraminifers as biogenic sediments. A volcanic ash layer K-Ah (Machida and Arai, 1978), about 2 cm thick is detected at 552 cm below the sea floor. The VMS of the core fluctuates less wide, and the values are markedly low (Fig. 5). The sediment wet and dry densities increase gradually downwards through the core (Fig. 5). The mud contents of the sediments are markedly high more than 96 % through the core (Fig. 5).

KT98-17 P-2: This core (Fig. 3), 555 cm in length, obtained from the uppermost lower southern

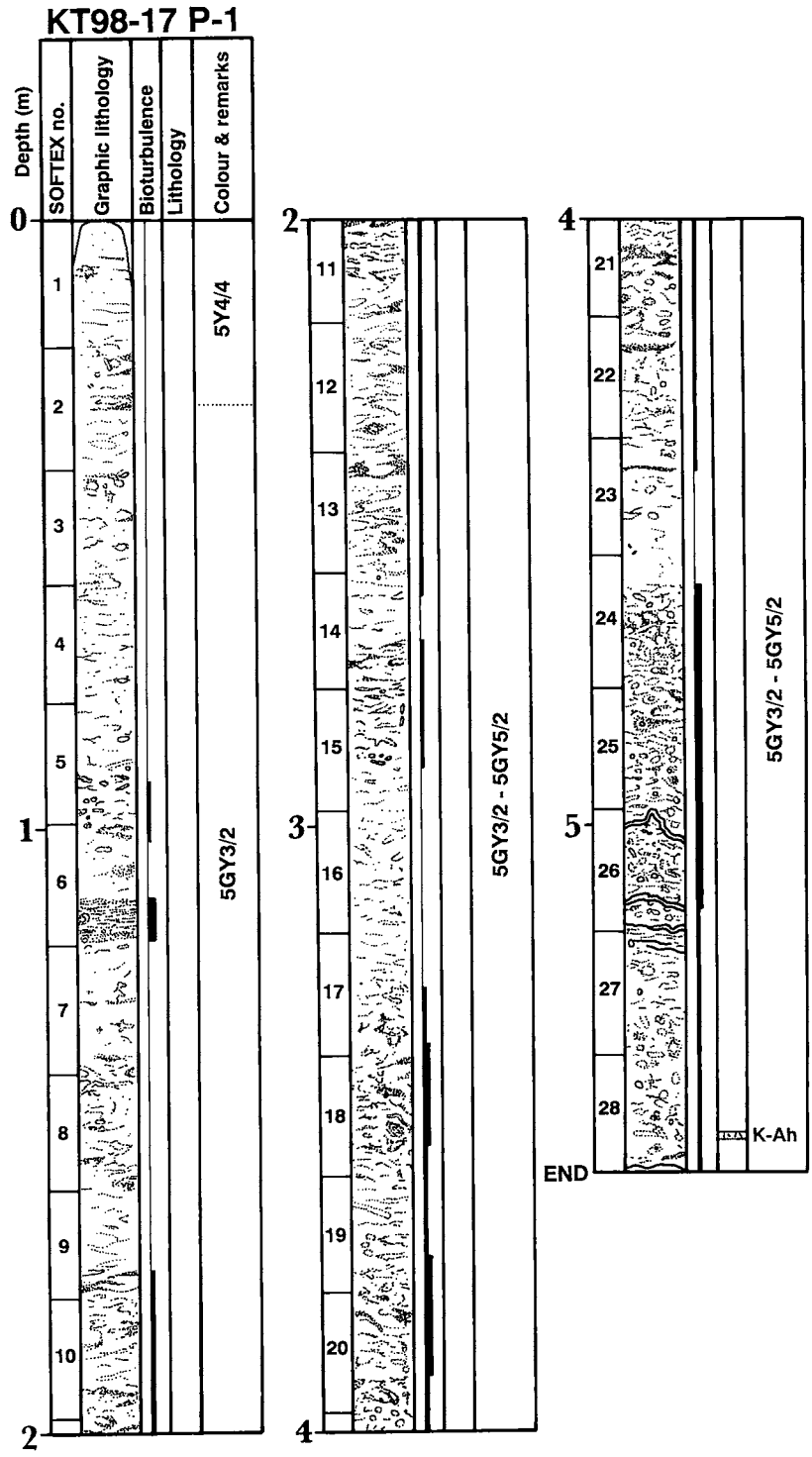

Fig. 2 Description of the core KT98-17 P-1 from the southern slope of the Tsushima Basin in the southwestern marginal part of the Japan Sea (see Fig. 4 for keys to illustration)

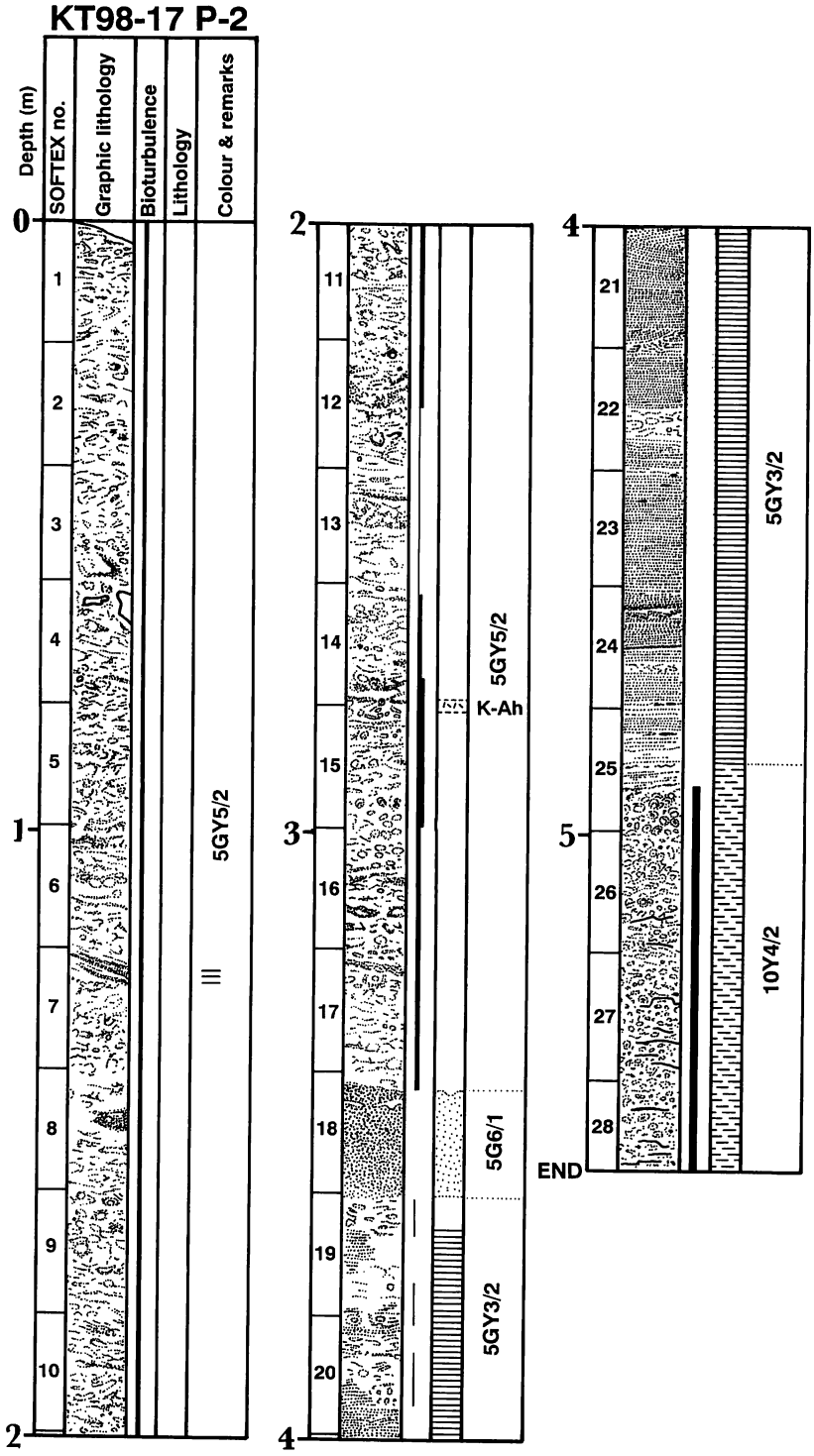

Fig. 3 Description of the core KT98-17 P-2 from the southern slope of the Tsushima Basin in the southwestern marginal part of the Japan Sea (see Fig. 4 for keys to illustration).

slope of the basin at a water depth of 1,018 m is composed of dusky yellow green (5GY5/2) bioturbated mud in the upper (Pl. 2, fig. 1), thinly laminated muds in the middle (Pl. 2, fig. 3) and greyish olive (10Y4/2) compact bioturbated mud in the lower (Pl. 2, fig. 4). The boundary between the middle laminated and lower compact muds is sharp. A greenish grey (5G6/1) very fine- to fine-grained sand layer, about 18 cm thick, is intercalated between the upper bioturbated and middle thinly laminated muds (Pl. 2, fig. 2), and the upper and lower boundaries of the sand layer are both transitional. Molluscan shell fragments and plant debris are occationally recognized in part of the upper bioturbated mud. The muddy sediments are composed mainly of diatoms and volcanic glass shards with a small amount of clay minerals and coccolith through the core. The sandy sediments in the upper bioturbated mud consist chiefly of diatom and planktonic foraminifers with a small amount of volcanic glass shards, quartz, feldspar, biotite, hornblende and pyroxenes, and radioralians and benthic foraminifers, but they in the middle laminated and lower compact muds are composed mostly of planktonic foraminiferal tests. The sandy sediments in the intercalated sand layer consist mainly of quartz, feldspar and biotite with a small amount of hornblende, pyroxenes, and benthic and planktonic foraminifers. A volcanic ash layer K-Ah (Machida and Arai, 1978), about 2 cm thick is detected at 278 cm below the sea floor. The VMS of the upper part of the core fluctuates less wide and the values are markedly low, but it increases in the lower corresponding to the horizons of laminated and compact muds (Fig. 5). The sediment wet and dry densities increase gradually downwards through the core with a peak at the horizon about 350 cm below the sea floor corresponding to the horizon of the fine-grained sand layer (Fig. 5). The mud contents of the sediments are markedly high more than 96 % through the core with the exception of the horizon of the sand layer (Fig. 5).

KT98-17 P-3: This core (Fig. 4), 536 cm in length, obtained from the lower slope of the southern slope of the basin at a water depth of 1,340 m is composed of greyish olive green (5GY3/2) bioturbated mud in the upper (Pl. 3, fig. 1), greyish olive green (5GY3/2) very fine- to fine-grained sand, and thin alternating layers of very fine-grained sand and mud in the middle (Pl. 3, figs. 2, 3), and olive grey (5Y3/2) bioturbated mud and sandy mud in the lower (Pl. 3, fig. 4). The boundary among them are transitional. Dusky yellow green (5G6/1) very fine- to fine -grained sand layers, 18 cm thick in maximum, having erosional bases are intercalated within the lower bioturbated mud. Molluscan shell fragments and plant debris are occationally recognized in part of the upper bioturbated mud. The muddy sediments are composed mainly of diatom tests and volcanic glass shard with a small amount of clay minerals and coccolith through the core. The sandy sediments in the upper bioturbated mud consist chiefly of diatom and planktonic foraminifers with a small amount of volcanic glass shard, quartz, feldspar, biotite, hornblende, pyroxenes, radioralians and benthic foraminifers, but they in the lower

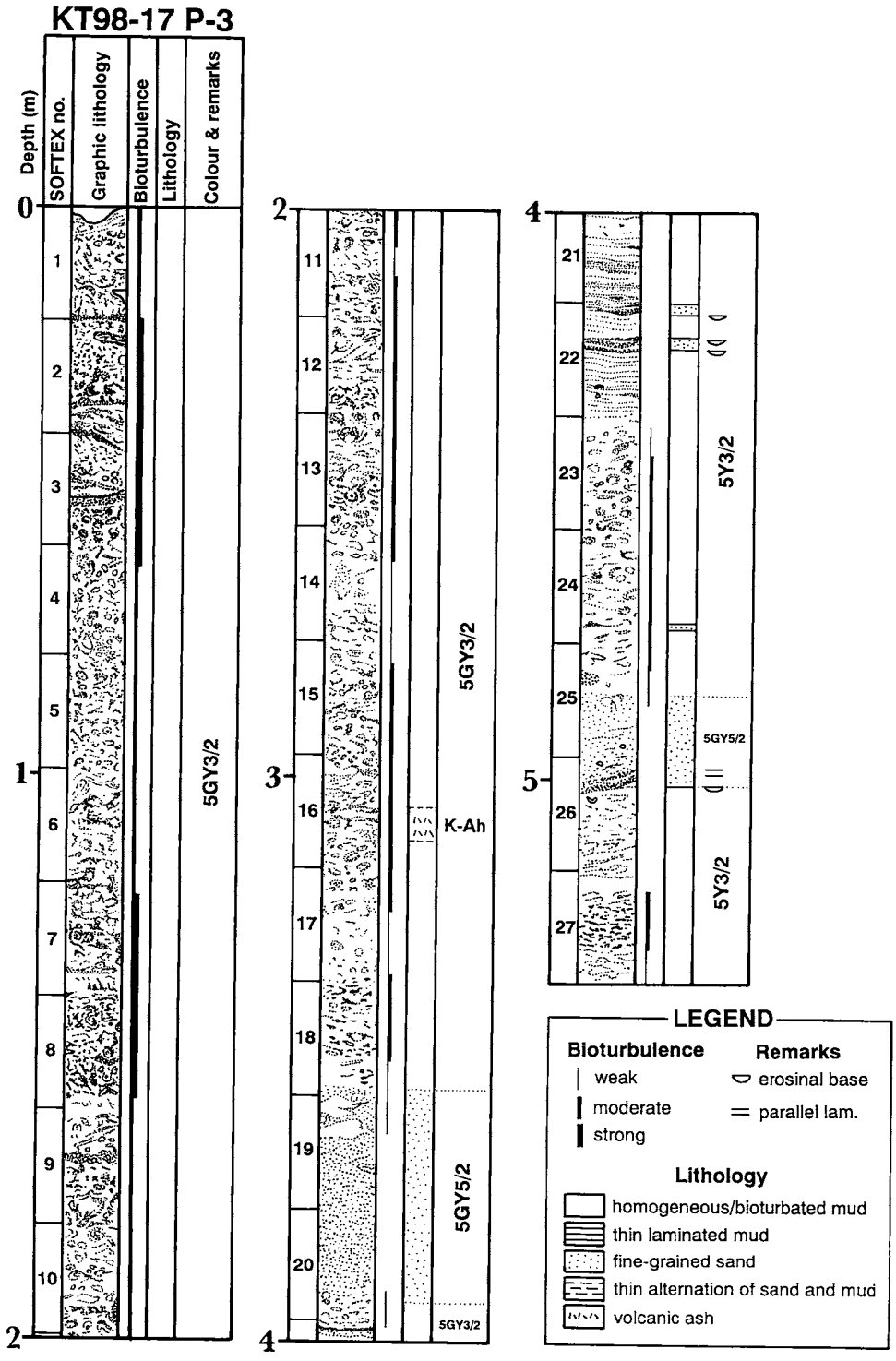

Fig. 4 Description of the core KT98-17 P-3 from the southern slope of the Tsushima Basin in the southwestern marginal part of the Japan Sea, and keys for illustration of cores.

bioturbated mud are composed mostly of planktonic foraminifers. The sandy sediments in the middle sand layer and the intercalated sand layers within the lower bioturbated mud consist mainly of quartz, feldspar and biotite with a small amount of hornblede, pyroxenes, and benthic and planktonic foraminifers. A volcanic ash layer K-Ah (Machida and Arai, 1978), about 4 cm thick is detected at 312 cm below the sea floor. The VMS of the upper part of the core fluctuates less wide and the values are markedly low, but it increases in the lower corresponding to the horizons of sandy sediments (Fig. 5). The sediment wet and dry densities are constant in the upper part, but they increase markedly in the lower part of the core (Fig. 5). The mud contents of the sediments are markedly high more than 96 % in the upper part, but are decrease to 63-95 % in the lower part of the core (Fig. 5).

Grab samples

KT98-17 G-1, 2 and 19 : These samples obtained from the upper continental shelf at water depths of 35, 52 and 28 m, respectively, are composed mainly of olive grey fine-grained sand or muddy sand. The mud contents are 24-59%. The sandy sediments consist mainly of quartz, feldspar, lithic fragments with a small amount of volcanic glass shard, biotite and pyroxenes as terrigenous sediments, and molluscan shells and shell fragments, sponge spicules, benthic foraminifers and ostracodes as biogenic sediments. Plant debris are commonly recognized in the sample G-2. The muddy sediments consist mainly of quartz and clay minerals.

KT98-17 G-3, 4, 5, 6, 7', 8 and 9 : These samples are obtained from the broad middle continental shelf at water depths of 78, 102, 110, 100, 75, 76 and 125 m, respectively. The sampling site G-5 is located at a narrow topographic depression south off the Mi-shima Island. These samples consist mainly of yellowish grey fine- to medium-grained calcareous sand. The mud contents of them are generally low less than 32 %. The sandy sediments are composed mainly of molluscan shells and shell fragments, quartz and feldspar with a small amount of biotite, volcanic glass shard, pyroxenes and lithic fragments as terrigenous sediments and benthic foraminifers, sponge spicules and ostracodes as biogenic sediments. The muddy sediments consist chiefly of clay minerals and quartz.

KT98-17 G-10, 11 and 12 : These samples obtained from the lower continental shelf to the shelf edge at water depths of 152, 176 and 208 m, respectively, are composed mainly of olive grey very fine- to fine-grained sand or muddy sand. The mud contents of them are 8-30 %. The sandy sediments are composed mainly of molluscan shell fragments, quartz and feldspar with a small amount of biotite, volcanic glass shard, pyroxenes and lithic fragments as terrigenous sediments and benthic foraminifers, sponge spicules, ostracodes, planktonic foraminifers and radioralians as biogenic sediments. The muddy sediments consist chiefly of clay minerals and quartz.

KT98-17 G-13, 14 and 15 : These samples obtained from the upper continental slope at water

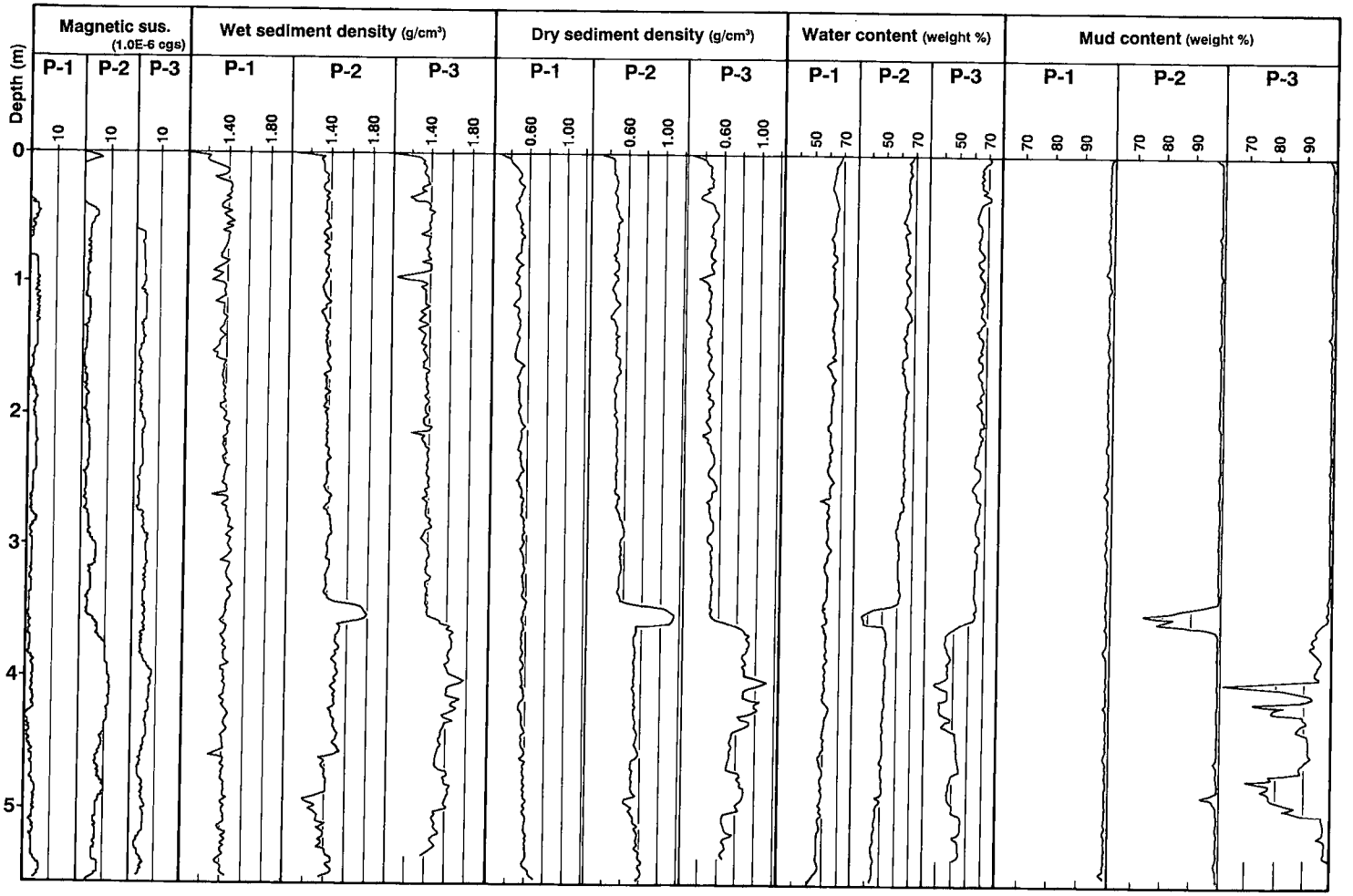

Fig. 5 Results of the measurements of such physical properties as volume magnetic susceptibility, sediment wet and dry densities, water content and mud content of the cores KT98-17 P-1, 2 and 3.

depths of 254, 361 and 524 m, respectively, are composed mainly of muddy very fine-grained sand or sandy mud. The mud contents of them show gradual increase from 35 % at G-13 to 71 % at G-15 with the increase of water depth. The sandy sediments are composed mainly of quartz and feldspar with a small amount of biotite, volcanic glass shards, pyroxenes and lithic fragments as terrigenous sediments and molluscan shell fragments, benthic foraminifers, sponge spicules, ostracodes, planktonic foraminifers and radiolarians as biogenic sediments. The muddy sediments are composed mainly of clay minerals, coccolith, diatom and quartz.

KT98-17 G-16, 17 and 18″ : These samples obtained from the lowermost upper continental slope to lower slope areas at water depths of 746, 1,027 and 1,347 m, respectively, are composed of olive grey homogeneous mud. The mud contents of all samples exceed 99 %. Reddish brown soupy mud, about 1 cm thick, covers the lower olive grey mud in all samples. The sandy sediments are composed mainly of very fine-grained quartz, biotite and volcanic glass shards with a small amount of lithic fragments as terrigenous sediments and planktonic foraminifers, radiolarians, sponge spicules and microscleres with a small amount of benthic foraminifers as biogenic sediments. The preservation of calcareous sediments in the sample G-18″ is poor due to probably by carbonate dissolution. The muddy sediments are composed mainly of clay minerals, coccolith, diatom and quartz.

2-2. Aso Bay in Tsushima Islands

One extra sampling site was located in the Aso Bay of the Tsushima Islands (Fig. 1). Two grab surface sediments were successfully obtained from one site (Table 2).

KT98-17 G-28 and 28′ : The samples G-28 and 28′ obtained from the inner part of the bay at water depths of both 32 m are composed mainly of dark olive grey homogeneous mud. The mud contents are both about 99 %. The sandy sediments consist mainly of such biogenic sediments as molluscan shells and shell fragments, ostracodes, benthic foraminifers with a small amount of lithic fragments, quartz and feldspar. The muddy sediments are composed mainly of clay minerals, quartz and diatoms.

3. BIOGENIC MATERIALS

3-1. Benthic Foraminifers

Analytical method

Approximately 10 ml surface wet sediments of grab samples from the continental shelf and slope areas north off the Hagi City were preliminary examined to clarify the depth distribution of Recent benthic foraminifers. Neutralized formalin in a concentration of approximately 10 % was added to these samples immediately after the sampling. The samples were washed through by water over a screen with an opening of 63 μm. To these samples which had been

preserved with formalin, an aqueous solution of rose Bengal by dissolving 0.5 g of rose Bengal in 1,000 ml of water was added. After keeping for about 24 hours in the rose Bengal solution, the samples were washed through the same screen mentioned above, and then preserved in hot water for several hours, after which they were washed again and dried. Before extracting the foraminifers, each samples were sieved through a screen with an opening of 125 μm, the benthic foraminifers were taken from the coarse fraction. In instance where benthic foraminifers were especially abundant, the samples were split into smaller aliquots, and about 100 specimens were removed.

Results

One hundred and thirty-five taxa of benthic foraminifers, including named and unnamed species, subspecies were recognized in all examined samples (Tables 4a, b). Three zones and one subzone were distinguished by the depth-frequency distribution. Zone A (samples G-19, 1, 2, 3, 5, 6, and 8 ; 28-110 m) is characterized by the assemblages of the Tsushima Warm-Current such as *Lugdunum karrerianum, Discorbinella convexa, Nonion japonicum, Anomalinoides glabrata, Hanzawaia nipponica, Ammonia ketienziensis angulata, Pseudorotalia gaimardii, Elphidium advenum* and Miliolidae. Subzone A1 (samples G-19, 2 and 3 ; 28-52 m) is characterized and distinguished from the main part of Zone A by the occurrence of *Textularia foliacea, Bolivina subangularis ogasaensis, Siphogenerina raphana, Reussella aculeata, Pseudononion japonicum, P. glateroupi* and *Ammonia japonica*. Zone B (samples G-9, 10, 11, 12, 13, 14, and 15 ; 125-524 m) and Zone C (samples G-16, 17 and 18″ ; 746-1,347 m) are characterized by cold water species of the fauna of the Japan Sea Proper Water. Zone B is characterized by the dominance of *Bolivina decussata, Cassidulina japonica, C. norcrossi, C. yabei, Uvigerina akitaensis, Angulogerina kokozuraensis,* and *Elphidium clavatum*. Zone C is distinguished by the abundance of such agglutinated foraminifers as *Reophax pilulifer, Cribrostomoides jeffreysii, C. triangularis* and *Reculvoides contortus*. The occurrence of *Cribroelphidium yabei* which is the important element of the Plio-Pleistocene fauna in the strata distributed in the coastal areas of the Japan Sea, suggests the possibility of cropping out the Plio-Pleistocene strata somewhere around this depth (samples G-11 and 12 ; 176-208 m).

3-2. Ostracodes

Analytical method

Approximately five-millimetres-thick and an area of about 1,250 cm^2 surface wet sediments of grab surface samples were preliminarily examined to clarify the depth distribution of Recent ostracodes. Neutralized formalin in a concentration of approximately 10 % was added to these samples immediately after the sampling, then washed by water with a screen with an opening of 63 μm. After drying in an oven, ostracode specimens were picked up from fractions

Table 4a **Abundance of benthic foraminifers from surface sediments of 18 grab samples (KT98-17 G1-G19). Abundance is recorded as a percentage of total benthic specimens counted (+ = <1 %)**

Sample Number	G-19	G-1	G-2	G-3	G-6	G-8	G-4	G-5	G-9	G-10	G-11	G-12	G-13	G-14	G-15	G-16	G-17	G-18
Species / Water Depth (m)	28	35	52	78	100	101	102	110	125	152	176	208	254	361	524	746	1,027	1,347
Agglutinated Foraminifers																		
Bathysiphone (?) sp.																		2
Marsipella cylindrica Brady							1	1		2		1						
Lagenammina tubulata (Brady)																		1
Lagenammina spp.		1			1		1	1				1			1		2	2
Hyperammina elongata Brady										2								
Hyperammina sp.				2														
Silicosigmoilina abyssalica Inoue											1				1	4	3	5
Reophax cf. *dentaliniformis* Brady				1											1			
Reophax excentricus Cushman														1				
Reophax guttifer Brady																		1
Reophax pilulifer Brady	5									5						3	15	29
Reophax scorpiurus Montfort									1	1	2	2			9	11		
Reophax spp.										15				5	7	1	1	
Cribrostomoides jeffreysii (Williamson)																		20
Cribrostomoides triangularis Saidova														1		1	23	13
Cribrostomoides sp. A				2						1		1				1	3	
Haplophragmoides sphaeriloculum Cushman																	1	
Ammoscalaria sp. A	1	1																
Adercotryma glomerata (Brady)					1						1	2	1	1	4	5	4	
Reculvoides contortus Earland																13	3	5
Thalmannammina parkerae (Uchio)					1					1			1			5	2	3
Alveolophragmium orbiculatum Stchedrina														2				1
Spiroplectammina sagittula Defrance				1	2	4	6	1										
Spiroplectammina sagittula fistulosa Brady				2														
Nouria sp. A																		
Trochammina japonica Ishiwada														1	1	8	26	15
Trochammina kellettae Thalmann							1				1							
Trochammina pacifica Cushman	1	1									1							
Trochammina pygmaea Hoeglund																	2	
Trochammina sp. A				2							2		1					
Gaudryina spp.	1	3	2	3		2	1	2										
Eggerella sp.				1														
Karreriella japonica Asano				1							4	3		7	18			
Textularia conica d'Orbigny			1	1		1		1										
Textularia foliacea Heron-Allen and Earland	1	5	3			2												
Textularia spp.		1				3			1									
Siphotextularia sp. A				1	2	1	1	1										
Agglutinated Foram. gen. et sp. indet.										1			2					
Calcareous, Porceraneous Foraminifers																		
Siphonaperta sp. A	1	1	2						1									
Massilina inaequaris Cushman			4	5	3		5	4		1								
Massilina sp.			1															
Quinqueloculina cf. *agglutinans* d'Orbigny		1																
Quinqueloculina lamarckiana d'Orbigny	1		9		3		1	1						1				
Quinqueloculina seminula (Linnaeus)	12	11	17	9	7	2	9	4										
Quinqueloculina cf. *seminula* (Linnaeus)	3	5				6		2										
Quinqueloculina cf. *yabei* Asano			2															
Quinqueloculina vulgaris d'Orbigny					5													
Quinqueloculina sp. aff. *Cribrolinoides curta* Cushman		1	2															
Quinqueloculina sp. A		5	4	5		3												
Quinqueloculina spp.									5									
Miliolinella circularis (Bornemann)				10	2	1	1		1							1		
Pyrgo murrhina Schwager															1			2
Pyrgo sp.					1													
Triloculina tricarinata d'Orbigny	4			2	1			1								1		
Triloculina sp.							1											
Sigmoilinita sp.					1													
Spirosigmoilina cf. *parri* Collins							1											
Miliolidae gen. et sp. indet.				1		3												
Calcareous, Hyaline Foraminifers																		
Dentalina ittai Loeblich and Tappan														1	1			
Dentalina sp.											1		1	1				
Nodosaria vertebralis (Batsch)							1											
Nodosalidae gen. et sp. indet.										1								
Lenticulina calcar (Linnaeus)		1					1											
Lenticulina lucida (Cushman)				3	2	3	1	3										
Lenticulina spp.									3	1	1							
Lagena clavata Williamson		1																
Lagena pliocenica Cushman and Gray		1		1	1													
Lagena striata (d'Orbigny)		1		2			2	1										
Lagena sulcata spicata Cushman and McCulloch										2								
Lagena sp.						1			1	1				2	1			
Sigmoidella kagaensis Cushman and Ozawa		1	1		2		1											
Polymorphinidae gen. et sp. indet.	1	2	1	1			1		1	1	2			1				
Oolina hexagona (Williamson)				1														
Oolina melo d'Orbigny										2								
Fissurina lucida (Williamson)												1	3					
Fissurina marginata d'Orbigny			1															
Fissurina sp.										1	3			1	3			
Hoeglundina elegans (d'Orbigny)				1	1	7	3		1									
Robertina sp. A			1															
Bolivina decussata Brady										4	1		3	11	1			
Bolivina hadai Uchio		1		3														
Bolivina pacifica Cushman and McCulloch													4	2	6	6	1	
Bolivina robusta Brady				5			3	3	1	1	1							

Table 4b continued.

Sample Number	G-19	G-1	G-2	G-3	G-6	G-8	G-4	G-5	G-9	G-10	G-11	G-12	G-13	G-14	G-15	G-16	G-17	G-18"
Species / Water Depth (m)	28	35	52	78	100	101	102	110	125	152	176	208	254	361	524	746	1,027	1,347
Bolivina sp. aff. *B. durrandii* Millett		2																
Bolivina subangularis ogasaensis Asano	1	7	1															
Lugdunum karrerianum (Brady)	1		1	7	7	2	5	5										
Cassidulina delicata Cushman					1	3	1											
Cassidulina japonica Asano and Nakamura											8	7	8	5	31			
Cassidulina norcrossi Cushman										1		5	7		10			
Cassidulina norvangi (Thalmann)				1	1	2		4		9	3	2	4		5			
Cassidulina yabei Asano										5	51	28	6	11	4			
Globocassidulina sp. A						1			21									
Siphogenerina raphana (Parker and Jones)	1	13	9					1										
Bulimina marginata d'Orbigny		4	4	7	5	6	3	4	21	15	2							
Bulimina tenuata (Cushman)										1								
Globobulimina auriculata (Bailey)										4			1			8		
Globobulimina sp. A									1	3		1						
Buliminella elegantissima d'Orbigny										2			1	2				
Euuvigerina sp. aff. *Uvigerina schencki* Asano			1		1	1	1											
Euuvigerina spp.		1						2										
Uvigerina akitaensis Asano										7	3	8	14	35	72	9	6	3
Uvigerina sp.									1									
Uvigerinella glabra (Millett)		1																
Angulogerina angulosa (Williamson)					1					2								
Angulogerina kokozuraensis Asano										4	7	9	26	28	53	3	1	
Reussella aculeata Cushman	3	2																
Reussella pacifica Cushman			3				1											
Reussella sp.									1									
Fursenkoina complanata (Egger)														1				
Fursenkoina pauciloculata (Brady)		2	1	2			1	1										
Fursenkoina sp.										1								
Suggrunda sp.										1								
Cancris auriculus (Fichtel and Moll)		3	1		2	1	1											
Valvulineria sadonica Asano														1				
Gavelinopsis praegeri (Heron-Allen and Earland)					3	5												
Neoconorbina stachi (Asano)						1												
Rosalina australis (Parr)					1													
Rosalina bradyi (Cushman)						1												
Rosalina globularis d'Orbigny	1	1	6	5	6	1		4	2									
Rosalina sp.		1																
Sphaeroidina bulloides d'Orbigny				1	3		1		1	4			1					
Glabratella spp.		2				1	4											
Siphonina tubulosa Cushman									1									
Cibicidoides subhaidingerii (Parr)			1	9	19		5	9	8			2			14		3	4
Eilohedra nipponica (Kuwano)										1			1	1	1			
Pseudoparrella naraensis Kuwano		2						1						4				
Pseudoparrella takayanagii (Iwasa)														2				
Discorbinella convexa (Takayanagi)		1	3	2	8	4	5	15										
Hyalinea balthica (Schroter)			6	4	1		1	3										
Cibicides lobatulus (Walker and Jacob)						7												
Cibicides cf. *refulgens* Montfort			9			14	2											
Cibicides spp.	1		4	4	8	24	9	4	21	9	17	3	1	4	2			
Fontbota wuellerstorfi (Schwager)									17									
Dyocibicides biserialis Cushman and Valentine				1														
Cymbaloporetta bradyi (Cushman)		4	2			1												
Amphistegina sp.						1												
Nonion japonicum Asano	2	16	2	5	3		1	4										
Nonionella sp.		4	2															
Nonionella stella Cushman and Moyer										5	1		1					
Nonionellina labradorica (Dawson)										3		4				3	3	
Nonionellina scaphum (Fichtel and Moll)		1																
Pseudononion glateroupi (d'Orbigny)	3	6																
Pseudononion japonicum Asano	5	3				2				1	1	1						
Astrononion umbilicatulum Uchio									1	2	1	1		2				
Pullenia apertula Cushman									6	7	2							
Pullenia quinqueloba (Reuss)					1													
Anomalinella sp.			1	3		1												
Oridorsalis tener (Brady)					1	1	1	2	5									
Anomalinoides glabrata (Cushman)		3	2			6	3	2	2									
Anomalinoides sp.												1						
Gyroidinoides nipponicus (Ishizaki)						2									2			
Gyroidina orbicularis d'Orbigny					1	1												
Hanzawaia nipponica Asano	7	8	6	2	2	11	3	3	2			1						
Buccella inusitata Anderson											23	17	7					
Buccella sp.									3		3	1			2	3		
Pararotalia nipponica (Asano)			1			1												
Ammonia japonica (Hada)	2	7	2															
Ammonia ketienziensis angulata (Kuwano)	2	3	9	11	11	4	16	11	6		5							
Ammonia tepida (Cushman)		1																
Ammonia sp.						2												
Pseudorotalia gaimardii (d'Orbigny)	9	5	3	4	5	2	6	7					1					
Cribroelphidium yabei (Asano)											8	3						
Elphidium advenum (Cushman)	6	7	6	6	12	3	13	13	9	4								
Elphidium clavatum (Cushman)										11	63	50	30	7	5			
Elphidium crispum (Linnaeus)	1						2	1										
Elphidium jenseni (Cushman)	1		1		1						1							
Elphidium reticulosum Cushman	1																	
Elphidium subarcticum Cushman										8	7	3						
Elphidium subgranulosum Asano	2	1				1												
Elphidium spp.			3			2	1			7	13	6		1				
Total number of benthic forams examined	80	155	141	140	140	154	127	122	145	160	240	164	125	142	256	86	99	106
Number of benthic forams in 10cc surface sediment	1,280	620	2,256	4,480	8,960	19,712	4,064	1,952	9,280	2,560	1,920	5,248	4,000	1,136	2,048	86	198	106
Ratio of Agglutinated Foraminifers	11.3	7.7	4.3	12.1	5.0	8.4	8.7	5.7	1 4	17.5	5.0	6.1	4.0	12.7	16.4	60.5	85.9	91.5
Ratio of Calcareous, Porceraneous Foraminifers (%)	26.3	15.5	29.1	22.9	16.4	9.7	14.2	9.8	4 8	0.6	0.0	0.0	0.0	0.7	0.4	2.3	0.0	1.9
Ratio of Calcareous, Hyaline Foraminifers	62.5	76.8	66.7	65.0	78.6	81.8	77.2	84.4	93.8	81.9	95.0	93.9	96.0	86.6	83.2	37.2	14.1	6.6

between one millimetre and 250 μm to sum up 200 individuals in total from the quantitatively divided samples. Five of 18 grab surface samples yielded less than 100 individuals in total even though all the ostracode specimens were picked up from the fractions.

Results

One hundred and sixty-three species belonging to 80 genera were identified from 18 samples (Tables 5a, b). Based on the combination of main species, three ostracode assemblages were recognized as follows.

Assemblage 1 (28-35 m deep) characterized by existence of *Loxoconcha tosaensis, Bicornucythere bisanensis, Loxoconcha viva, Pistocythereis bradyi, Trachyleberis scabrocuneata, Amphileberis nipponica, Cytheromorpha acupunctata* and *Nipponocythere bicarinata* is composed of the inner-bay species and shallow-sea species under the warm-water condition around the Japanese Islands. On the other hand, Assemblage 2 (52-125 m) that contains dominantly *Cytheropteron uchioi, Bradleya* spp., *Neonesidea oligodentata, Cytheropteron miurense, Cytheropteron subuchioi, Hirsutocythere? hanaii* and *Abrocythereis guangdongensis* consists of characteristic species of the lower half of the Tsushima Warm-Current in the southwestern part of the Japan Sea, almost the same as known species composition of "Biofacies II" off Shimane Peninsula (80-150 m deep; Ikeya and Suzuki, 1992) "Assemblage 2" off Oki Islands (105-154 m; Tsukawaki *et al.*, 1998) and "Group 2" off Noto Peninsula (101-151 m; Tsukawaki *et al.*, 1997). Assemblage 3 (deeper than 208 m) characterized by such species of the cold Japan Sea Proper Water as *Krithe sawanensis, Acanthocythereis dunelmensis, Krithe* sp. 1, *Robertsonites hanaii, Robertsonites reticuliforma* and *Argilloecia toyamaensis*. Species composition and the content of this assemblage basically resemble those reported from the lower shelf to continental slope area from off Oki Islands in the southwestern part of the Japan Sea to off Northwest Hokkaido in the northeastern part of the sea (Ikeya and Suzuki, 1992; Tsukawaki *et al.*, 1997, 1998, 1999; Ozawa *et al.*, 1999).

It is remarkable that the sample G-11 at a water depth of 176 m contains highly unique assemblage at the present southwestern Japan Sea, such as characteristic species occurrences of *Yezocythere hayashii, Normanicythere*? sp., *Johnnealella nopporensis, Daishakacythere abei, Howeina higashimeyaensis, Finmarchinella nealei, Baffinicythere reticulata, Acuticythereis*? cf. *sendaiensis, Hemicythere orientaris, Howeina* sp. and *Munseyella hokkaidoana* with very bad -preservation state, and these species occupy ca. 60 % in this sample. Most of them are the member of the cryophilic species called the "Omma-Manganji ostracode fauna (Cronin and Ikeya, 1987)" dominantly occurred from the Plio-Pleistocene strata along the coastal area of the Japan Sea (*e.g.* the Lower Pleistocene Omma Formation; Ozawa, 1996). It is known that the Late Pleistocene or Holocene strata (younger than 73 ka) are distributed at the bottom surface or subsurface around the shelf edge in this area at a water depth of about 200 m (Ogawa

Table 5a List of ostracode species from surface sediments of grab samples. Numerals in parentheses indicate the number of living specimens.

Sample Number	G-1	G-2	G-3	G-4	G-5	G-6	G-8	G-9	G-10	G-11	G-12	G-13	G-14	G-15	G-16	G-17	G-18**	G-19
Species name/ Water depth	35	52	78	102	110	100	101	125	152	176	208	254	361	524	746	1027	1347	28
Abrocythereis guangdongensis Gou							1	40										
Acanthocythereis dunelmensis s.l. (Norman)									22	8	26	3	3 (1)	15 (1)	9	2		
Acanthocythereis munechikai Ishizaki								1	1									
Acanthocythereis mutsuensis Ishizaki								1		4								
Acanthocythereis sp.									19	1	1	3						
Actinocythereis kisarazuensis Yajima	3	17	13	6	10	7	5											
Acuticythereis? cf. sendaiensis Ishizaki										2								
Ambocythere japonica Ishizaki							1											
Ambtonia obai (Ishizaki)	7							1	1									8
Amphileberis nipponica (Yajima)	20	48			4	1	2		16 (4)									2
Aponesidea? sp.		1																
Argilloecia hanaii Ishizaki						1		6	2 (2)									
Argilloecia lunata Frydl	4	5	9	6	9	4	2											
Argilloecia toyamaensis Ishizaki & Irizuki						1			15		3 (1)	2 (1)	7 (4)	13 (9)	2 (1)	6 (3)	3 (1)	
Aurila corniculata Okubo				1	2													2
Aurila cymba (Brady)	3	9		1	1		3											7
Aurila disparata Okubo							2											
Aurila hataii Ishizaki																		3
Aurila imotoi Ishizaki						1												
Aurila cf. *imotoi* Ishizaki						2												
Aurila kiritsubo Yajima	1	7	1	7	1	10	7											12
Aurila tosaensis Ishizaki		1						2										
Aurila uranouchiensis Ishizaki				1			3											
Australimoosella tomokoae (Ishizaki)						1												1
Baffinicythere reticulata Irizuki										3								
Bicornucythere bisanensis (Okubo)	20				1		4			2								46
Bradleya spp.		29	25	33	34	22	10	32										
Buntonia hanaii Yajima								2										
Bythoceratina sudjaponica Zhou		1		1	1		1											1
Bythoceratina sp. 1		1					1											
Bythoceratina sp. 2		1																
Bythoceratina sp. 3		1																
Bythoceratina sp. 4							1											
Bythoceratina sp. 5					1													
Bythocythere angulata Yajima	5	6	4	5		1	7											
Bythocythere cf. *angulata* Yajima							3											
Bythocythere sp.		1																
Callistocythere alata Hanai																		13
Callistocythere hayamensis Hanai					1	1												
Callistocythere setanensis Hanai										1								
Callistocythere undulatifacialis Hanai	1																	3
Celtia japonica Ishizaki					2		1											
Cletocythereis? sp.																		1
Cluthia sp.									2 (2)									
Coquimba ishizakii Yajima		4				1	1											2
Coquimba? sp.							1											
Cornucoquimba cf. *moniwensis* (Ishizaki)							1	30	1									
Cornucoquimba tosaensis (Ishizaki)	1	3				1	5											
Cythere golikovi Schornikov							1											
Cythere nishinipponica Okubo							3											2
Cythere omotenipponica Hanai							1											
Cytherelloidea hanaii Nohara	8	2			2	11												5
Cytherelloidea senkakuensis Nohara			3	2		2	1											
Cytherois? sp.																		4
Cytheromorpha acupunctata (Brady)	8																	11
Cytheropteron higashikawai Ishizaki	17	16	7	9	1	5	1	3	2	1								10
Cytheropteron miurense Hanai	4	38	21	21	12	21	8	10	3									
Cytheropteron cf. *paralatissium* Swain													1	1	1			
Cytheropteron sawanense Hanai								2	1	1	7							
Cytheropteron subuchioi Zhao	2	3	16	17	15	6	15											
Cytheropteron cf. *tabukii* Zhou									1		3	1	1					
Cytheropteron uchioi Hanai	2	51	23	48	33	21	13	7	1									
Cytheropteron sp.										1	11							
Cytheropteron? sp.							4											
Daishakacythere abei (Tabuki)							2			11								
Echinocythereis? sp.									1									
Falsobuntonia taiwanica Malz		25						1	12 (1)									
Falsobuntonia cf. *taiwanica* Malz									3 (2)									
Falsobuntonia sp. 1													1	3		5 (2)		
Falsobuntonia sp. 2												10 (9)	7 (5)	12 (6)				
Falsobuntonia sp. 3															1	1 (1)		
Falsobuntonia sp. 4												1 (1)						
Falsobuntonia sp. 5									11 (1)	1	1							
Finmarchinella japonica (Ishizaki)										1	3							
Finmarchinella nealei Okada							1			4								
Finmarchinella uranipponica Ishizaki						1	2											
Hanaiborchella triangularis (Hanai)	1		1															
Hemicythere orientaris Schornikov										2								
Hemicythere sp.							1											
Hirsutocythere? hanaii Ishizaki		1	15	14	11	5	3	11	2									

Table 5b continued.

Sample Number	G-1	G-2	G-3	G-4	G-5	G-6	G-8	G-9	G-10	G-11	G-12	G-13	G-14	G-15	G-16	G-17	G-18**	G-19
Species name/ Water depth	35	52	78	102	110	100	101	125	152	176	208	254	361	524	746	1027	1347	28
Howeina camptocytheroidea Hanai				1														
Howeina higashimeyaensis Ishizaki										5	2							
Howeina sp.										2	1							
Johnnealella nopporensis Hanai & Ikeya										17								
Kobayashina sp.											2			9	2		1	
Krithe antisawanensis Ishizaki								5										
Krithe sawanensis s.l. Hanai										1		2	22 (8)	41 (2)	23 (2)	14 (1)	23 (1)	
Krithe sp. 1									67		9 (2)	1 (1)		4		1 (1)	3	
Krithe sp. 2															1			
Krithe? sp.										3	2	1						
Kotoracythere sp. 1											5							
Kotoracythere sp. 2											1							
Loxoconcha epetersoni Ishizaki		1																
Loxoconcha japonica Ishizaki	1	1																6
Loxoconcha optima Ishizaki				8			1											10
Loxoconcha ozawai Tabuki										2								
Loxoconcha cf. *tamakazura* Yajima			5	20	17	15	3											
Loxoconcha tosaensis Ishizaki	45	7																79
Loxoconcha uranouchiensis Ishizaki					1													3
Loxoconcha viva Ishizaki	38	53	9	3	5	1	2											1
Loxoconcha zamia Ishizaki							3											
Loxoconcha sp. 1							1											
Loxoconcha sp. 2							2											
Loxoconcha sp. 3													3 (2)	2 (1)				
Loxoconchidea? sp.		7		1		1												
Macrocypris? sp.								1	2									
Metacytheropteron sp.							1											
Monoceratina? sp.			3	1				1										
Munseyella hatatatensis (Ishizaki)											2							
Munseyella hokkaidoana (Hanai)										1								
Munseyella sp.					1													
Neonesidea oligodentata (Kajiyama)	1	22	18	6	3	13	85	31										8
Nipponocythere bicarinata (Brady)	4																	7
Nipponocythere obesa Hu	1				1													
Nipponocythere? sp.	1																	
Normanicythere? sp.										26								
Pacambocythere reticulata (Jian & Wu)								3										
Pacambocythere sp.			1	1	8	4												
Pacambocythere? sp.								1										1
Paijanborchella iocosa Kingma			1					1										
Palmenella limicola (Norman)										7	3	1	1					
Paracypris? sp.								1					2					
Paracytheridea dialata Gou & Huang		3					2											1
Paracytherideа neolongicaudata Ishizaki		1					1											
Paradoxostoma spp.	1	1	3	3	4	3	11	10					1					2
Paradoxostoma? sp.						1			1									
Parakrithe? sp.								1										
Parakrithella pseudadonta (Hanai)	3																	7
Parrissocytheridea inabai Okubo																		1
Phlyctocythere sp.			1															
Pistocythereis bradyformis (Ishizaki)	3					1	4											6
Pistocythereis bradyi (Ishizaki)	17	12		4	3	1												19
Pontocythere kashiwarensis (Hanai)				1														1
Pontocythere miurensis (Hanai)		1																1
Pontocythere subjaponica (Hanai)		2		1														10
Pontocythere sp.							1											
Propontocypris cf. *uranipponica* (Ishizaki & Irizuki)														1	1			
Propontocypris sp. 1												3 (2)	1	1 (1)		1 (1)		
Propontocypris sp. 2								1										
Propontocypris sp. 3		1	6	1	6	1	11	1										
Propontocypris? sp.		1					2											
Pseudoaurila japonica (Ishizaki)		2				1												1
Pseudocythere sp.		1					1											
Rabilimis septentrionalis (Brady)										1	11							
Robertsonites hanaii Tabuki										24	17	10	1	7	1			
Robertsonites reticuliforma Tabuki									2	19	36	1						
Robertsonites tsugaruana Tabuki										1								
Robertsonites sp.									1									
Robustaurila ishizakii (Okubo)	3	5					1											3
Robustaurila salebrosa (Brady)		1																
Schizocythere kishinouyei (Kajiyama)		2	6	1	1	12	22		1									
Sclerochilus sp.																		1
Sclerochilus? sp.												2 (2)						
Spinileberis quadriaculeata (Brady)																		1
Spinileberis rhomboidaris Chen							1											
Trachyleberis niitsumai (Ishizaki)	1	7	1	9	4	4	10	1										1
Trachyleberis scabrocuneata (Brady)	18	55	15	12	13	2	13											18
Trachyleberis sp.		3	10	12	12	15	9	3										1
Xestoleberis hanaii Ishizaki	3	2					3											2
Xestoleberis sp.		3	25	1	1	7	7											1
Xiphichilus sp.					1	1	1		3 (3)		1							
Yezocythere hayashii Hanai &Ikeya									1	39	3							
Miscellaneous	1							1			3						1	
Total number	248	465	240	258	222	209	296	211	194	192	153	41	51	109	41	30	31	325

et al., 1986). The sampling site of G-11 is located at the distributed area of these strata. Under the present oceanic condition of the Japan Sea, the Omma-Manganji species inhabits only the coastal areas around Hokkaido under the particular cold- and relatively lower salinity-water mass conditions (*e.g.* Ozawa, 1998 ; Ozawa *et al.*, 1999). Accordingly, these specimens found in bad-preservation state from the sample G-11 are judged to be derived fossil specimens from the strata exposed in/around the sampling site.

Around the southern part of the Japan Sea, occurrence of a limited number of ostracode species of the Omma-Manganji fauna was reported only from the Lower Pleistocene Seoguipo Formation (ca. 1.7-0.9 Ma ; Yi *et al.*, 1998) distributed in the Cheju Island, south of the Korean Peninsula (Paik and Lee, 1988) as the youngest and southernmost records of the fauna. Since many species of the Omma-Manganji ostracodes are recognized from the sample G-11 at the shelf edge of the studied area, there is a high possibility that the sample renews the record of the Omma-Manganji ostracode fossil assemblage around the Japanese Islands.

3-3. Planktonic Foraminifers

Analytical method

Samples from the top and bottom of piston cored sediments P-1, 2 and 3 were preliminarily examined to clarify planktonic foraminiferal assemblages. Each wet sediment collected with plastic cubic sampler (1.9 cm in length and approximately 6.86 cm^3 in volume) was washed by water over a screen with an opening of 63 μm. The remaining particles were dried and weighed. In instance where planktonic foraminifers were relatively abundant, sediments coarser than 63 μm were split into smaller aliquots with a microsplitter to obtain more than 200 specimens. Then, each sample was sieved through a screen with an opening of 125 μm. Then, all planktonic foraminifers larger than 125 μm were picked up from the aliquots, mounted on assemblage-slides and identified under a binocular microscope.

Results

Preservation of planktonic foraminiferal specimens in six samples of piston cored sediments is generally good except the top sample of the core P-3 obtained at a water depth of 1, 340 m. In this sample, some of specimens are found leaving only irregular portions of the wall, inner chambers and septa which are probably signs of dissolution, In the present oceanic condision of the Japan Sea, calcium carbonate compensation depth (CCD) stands at the depth of about 2,000 m that is much shallower than that of ordinary ocean (Ichikura and Ujiié, 1976). Therefore, the upper part of the core P-3 may have experienced slight carbonate dissolution.

Sixteen species belonging to six genera of planktonic foraminifers were identified in the six samples (Table 6). Planktonic foraminiferal assemblages in all top samples are dominated by *Neogloboquadrina incompta* that is also known as dextrally-coiled *Neogloboquadrina*

Table 6 List of planktonic foraminiferal species from the top, middle and bottom sediments of the cores KT98-17 P-1, 2 and 3.

Core Number	P-1				P-2				P-3			
Water Depth	776 m				1,018 m				1,340 m			
Mean Depth Below the Sea Floor	1.1 cm (top)		555.8 cm (bottom)		1.1 cm (top)		553.9 cm (bottom)		1.1 cm (top)		534.8 cm (bottom)	
Species Name / Number and Percentage Frequency	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Globigerina bulloides d'ORBIGNY	2	1.6	53	23.7	6	1.9	0	0	7	3.0	169	67.6
Globigerina quinqueloba NATLAND	2	1.6	35	15.6	6	1.9	107	50.5	13	5.7	35	14.0
Globigerina sp.	0	0	0	0	2	0.6	0	0	0	0	0	0
Globigerina rubescens HOFKER	0	0	2	0.9	0	0	0	0	0	0	0	0
Globigerinella calida (PARKER)	0	0	1	0.4	0	0	0	0	0	0	0	0
Globigerinita glutinata (EGGER)	0	0	1	0	2	0.6	0	0	2	0.9	0	0
Globigerinita uvula (EHRENBERG)	0	0	2	0.9	0	0	2	0.9	0	0	4	1.6
Globigerinoides conglobatus (BRADY)	0	0	1	0.4	0	0	0	0	0	0	0	0
Globigerinoides ruber (d'ORBIGNY)	0	0	6	2.7	8	2.5	1	0.5	3	1.3	0	0
Globigerinoides sacculifer (BRADY)	0	0	1	0.4	1	0.3	0	0	0	0	0	0
Globigerinoides tenellus PARKER	0	0	0	0	3	0.9	0	0	1	0	0	0
Globigerinoides sp.	0	0	0	0	1	0.3	0	0	0	0	0	0
Neogloboquadrina dutertrei (d'ORBIGNY)	0	0	18	8.0	8	2.5	0	0	2	0.9	0	0
Neogloboquadrina incompta (CIFELLI)	111	86.0	2	0.9	254	78.6	0	0	158	68.7	0	0
Neogloboquadrina pachyderma (EHRENBERG)	11	8.5	93	41.5	29	9.0	98	46.2	36	15.7	42	16.8
Pulleniatina obliquiloculata (PARKER and JONES)	3	2.3	8	3.6	3	0.9	0	0	2	0.9	0	0
others	0	0	1	0.4	0	0	4	1.9	6	2.6	0	0
Total Planktonic Foraminifers	129	100	224	100	323	100	212	100	230	100	250	100
Division	1/1		3/4		1/1		1/4		1/1		1/8	
Sediment Dry Weight (g)	0.039		0.047		0.021		0.014		0.037		0.007	

pachyderma. Its percentage frequencies exceed 68 % and the maximum is 86 % in the top of the core P-1. *N. incompta* and *N. pachyderma* attributed to arctic to subarctic faunas (Bé, 1977) constitute more than 80 % of the assemblages in all top samples. On the contrary, such subtropical to tropical species as *Globigerinoides ruber, Neogloboquadrina dutertrei* and *Pulleniatina obliquiloculata* (Bé, 1977) are recognized with low frequency less than 3 % in these samples.

N. pachyderma, Globigerina bulloides and *Globigerina quinqueloba* attributed to arctic to subarctic faunas (Bé, 1977) predominate the planktonic foraminiferal assemblage in the bottom sample of the core P-1. These three species constitute more than 80 % of the assemblage. However, *G. ruber, N. dutertrei* and *P. obliquiloculata* are relatively abundant, more than 14 % of the assemblage, in the bottom sample of the core P-1. It suggests that the surface water had been already warm at that time. Since, Oba *et al.* (1991, 1995) suggested that the Tsushima Warm-Current had flowed into the Japan Sea continuously since 8 Ka, the bottom sediments of the core P-1 is assumed to be younger than 8 Ka. The assemblage of the bottom of the core P-2 consists mainly of *G. quinqueloba* and *N. pachyderma* which show high percentage frequency greater than 96 % in the assemblage. In the bottom of the core P-3, the assemblage is characterized by the dominance of *G. bulloides* associated with *N. pachyderma* and *G. quinqueloba*, and these three species constitute more than 98 % of the assemblage.

4. CONCLUDING REMARKS

The preliminary results from marine sedimentological and micropalaeontological (benthic

and planktonic foraminifers, and ostracodes) investigations on KT98-17 in the southwestern marginal part of the Japan Sea are summarized as follows:

1. Cored sediment P-1 from the upper southern slope of the Tsushima Basin are composed of bioturbated mud. The core P-2 from the upper to lower parts of the slope consists of bioturbated mud in the upper, thinly laminated muds in the middle with an intercalation of fine-grained sand layer and compact bioturbated mud in the lower. The core P-3 is composed of bioturbated mud in the upper, fine-grained sand and thin alternation of sand and mud in the middle, and bioturbated sandy mud in the lower. The volcanic ash layer K-Ah is recognized in all cores.
2. Surface sediments from the continental shelf and continental slope north off the Yamaguchi Prefecture are composed mainly of fine-grained sand in the upper shelf, fine- to medium-grained calcareous sand in the broad middle shelf, very fine- to fine-grained sand or muddy sand in the lower shelf, olive grey muddy sand or sandy mud in the upper slope and olive grey homogeneous mud in the lower slope. Surface sediments from the inner part of the Aso Bay, the Tsushima Island are composed of olive grey homogeneous mud.
3. One hundred and thirty-five taxa of benthic foraminifers, including named and unnamed species, subspecies were recognized from 19 surface sediments north off Yamaguchi Prefecture, and three zones; Zone A (28-52 m), Zone B (125-524 m) and Zone C (746-1,347 m), and one subzone (176-208 m) were distinguished by the depth-frequency distribution.
4. One hundred and sixty-three species belonging to 80 genera of ostracodes were identified from 18 surface sediments north off Yamaguchi Prefecture, and three ostracode assemblages; Assemblage 1 (28-35 m), Assemblage 2 (52-125 m) and Assemblage 3 (deeper than 208 m) attributed to the difference of water depth and water mass structure were recognized.
5. Sixteen species belonging to six genera of planktonic foraminifers were identified in the top and bottom samples of the cores P-1, 2 and 3. Planktonic foraminiferal assemblages are characterized by frequent occurrence of *Neogloboquadrina incompta* in all top samples.

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REFERENCES

Arita, M., Okuda, Y. and Moriya, T., 1987: *Research on Submarine Geology of the Continental Shelf around Southwest Japan -off-Hino-misaki and off-Tottori-*. Geol. Surv. Japan, 233p (in Japanese).

Bé, A.W.H., 1977: An ecological, zoogeographic and taxonomic review of recent planktonic foraminifera. In Ramsay, A.T.S., ed., *Oceanic Micropaleontology, vol. 1*, Academic Press, London, 1-100.

Cronin, T.M. and Ikeya, N., 1987: The Omma-Manganji ostracod fauna (Plio-Pleistocene) of Japan and zoogeography of circumpolar species. *Journal of Micropalaeontology*, **6**, 65-88.

Hydrographic Department, M.S.A., Japan, 1981: *1: 1,000,000 Bathymetric Chart, no. 6314, South-West Nippon*. Maritime Safety Agency, Tokyo.

Ichikura, M. and Ujiié H., 1976, Lithology and planktonic foraminifera of the Sea of Japan piston cores. *Bull. Nat. Sci. Mus., Ser. C*, **2**, 151-178.

Ikeya, N. and Suzuki, C., 1992: Distributional patterns of modern ostracodes off Shimane Peninsula, southwestern Japan Sea. *Report of Faculty of Science, Shizuoka University*, **26**, 91-137.

Ingle, J.C., Jr., Suyehiro, K., von Breymann, M.T., *et al.*, 1990: *Proceedings of the Ocean Drilling Program, Initial Reports, 128*. College Station, Texas, USA (Ocean Drilling Program), 652p.

Iwabuchi, Y., 1968: Submarine geology of the southeastern part of the Japan Sea. *Contr., Inst. Geol. Paleontl., Tohoku Univ.*, **66**, 1-76 (in Japanese with English abstract).

Kobayashi, K. ed., 1984: *Preliminary Report of the Hakuho Maru Cruise KH82-4, Geophysical and Geological Investigation of Seafloor around Ogasawara (Bonin) Islands, Amami Plateau and Southwestern Part of the Sea of Japan*. Ocean Res. Inst., Univ. Tokyo, 267p.

Machida, H. and Arai, F., 1978: Akahoya Ash - a Holocene widespread tephra erupted from the Kikai Caldera, South Kyushu, Japan. *The Quaternary Research*, **17**, 143-163 (in Japanese with English abstract).

Oba, T., Murayama, M., Matsumoto, E. and Nakamura, T., 1995,: AMS-14C ages of Japan Sea cores from the Oki Ridge. *The Quaternary Research*, **34**, 289-296 (in Japanese with English abstract).

Oba, T., Kato, M., Kitazato, H., Koizumi, I., Omura, A., Sakai, T. and Takayama, T., 1991: Paleoenvironmental changes in the Japan Sea during the last 85,000 years. *Palaeocenography*, **6**, 499-518.

Ogawa, T., Ikehara, K. and Kawabata, H., 1986: Unconformity around 200 m deep off Mishima Island of Yamaguchi Prefecture (Preliminary report). *Preliminary Report on Researches in the 1986, Geological Survey of Japan, 137-145 (in Japanese)*.

Ozawa, H., 1996: Ostracode fossils from the late Pliocene to early Pleistocene Omma Formation in the Hokuriku district, central Japan. *Science Report of Kanazawa University*, **41**, 77-115.

Ozawa, H., 1998: Geographical differences of vertical distribution of the Recent ostracode assemblages in the Japan Sea. *Abstracts with programs of the 1998 Annual Meeting of the Palaeontological Society of Japan*, p. 39 (in Japanese).

Ozawa, H., Ikehara, K. and Katayama, H., 1999: Recent ostracode fauna in the northeastern part of the Japan Sea, off northwestern Hokkaido. *Preliminary Report on Researches in the 1998 Fiscal Year, GSJ Interim Report no. MG/99/1*, Geological Survey of Japan, 103-117 (in Japanese).

Paik, K.-H. and Lee, E.-H., 1988: Plio-Pleistocene Ostracods from the Sogwipo Formation, Cheju Island, Korea. In: Hanai, T., Ikeya, N. and Ishizaki, K. eds., *Evolutionary Biology of Ostracoda - Its fundamentals and applications*. Kodansha, Tokyo and Elsevier, Amsterdam, 541-556.

Tsukawaki, S., Kamiya, T., Ozawa, H. and Kato, M., 1998, Preliminary results from sediment samplings during the R.V. *Tansei-maru* cruise KT96-17 Leg 2 in the southwestern part of the Japan Sea - sediments, benthic foraminifers and ostracodes-. *Bull. Japan Sea Res. Inst., Kanazawa Univ.*, **29** 67-89.

Tsukawaki, S., Ozawa, H., Domitsu, H., Tanaka, Y., Kamiya, T., Kato, M. and Oda, M., 1999: Preliminary results from the R.V. *Tansei-maru* cruise KT97-15 in the eastern marginal part of the Japan Sea off Tsugaru Peninsula, Northeast Japan - sediments, benthic and planktonic foraminifers and ostracodes-. *Bull. Japan Sea Res. Inst., Kanazawa Univ.*, **30**, 99-140.

Tsukawaki, S., Kamiya, T., Kato, M., Matsuzaka, T., Naraoka, H., Negishi, K., Ozawa, H. and Ishiwatari, R., 1997: Preliminary results from the R.V. *Tansei-maru* cruise KT95-14 Leg 2 in the southern marginal area in the Japan Sea - Part I: sediments, benthic foraminifers and ostracodes-. *Bull. Japan Sea Res. Inst., Kanazawa Univ.*, **28**, 13-43.

Tsukawaki, S., Nemoto, N., Maruyama, T., Shimamoto, M., Sasaki, O., Motoyama, I., Irizuki, T., Kato, H., Chatterjee, D., Fujimoto, E. and Hasegawa, S., 1993: Preliminary results from the R.V. *Tansei-maru* cruise KT92-13 (Leg 2) in the eastern marginal area of the Japan Sea. *Sci. Rep., Hirosaki Univ.*, **40**, 61-99.

Yi, S., Yun, H., and Yoon, S., 1998: Calcareous nannoplankton from the Eoguipo Formation of Cheju Island, Korea and its paleoceanographic implications. *Paleontological Research*, **2**, 253-265.

日本海南西縁部における淡青丸 KT 98-17 次航海の予察的成果
—堆積物・底生有孔虫・浮遊性有孔虫・介形虫—

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要　　旨

1998年9月25日～10月2日，日本海南西縁部での海洋研究船淡青丸の研究航海 KT 98-17 おいて，対馬海盆南側斜面よりピストン柱状試料3点，同海盆南側斜面から山口県萩市沖陸棚にかけての海底より表層試料20点，および対馬の麻生湾より表層試料1点が得られた。これらの試料を堆積学的ならびに微古生物学的に検討した結果，以下の予察的成果が得られた。

1．対馬海盆南側斜面上部の試料 P-1 は生物擾乱の発達する泥から構成される。これに対し，同斜面上～下部の試料 P-2，3 は，上半部はいずれも生物擾乱の発達する泥からなる。しかし，P-2 が中部が極細粒～細粒砂ならびに葉理の発達する泥，そして下部が生物擾乱の発達する緻密な泥からなるのに対し，P-3 は中部が極細粒砂と泥との細互層，そして下部が生物擾乱の発達する砂質泥からそれぞれ構成される。すべての試料に K-Ah 火山灰が挟在する。

2．山口県萩市沖から対馬海盆南側斜面にかけての表層堆積物試料は，陸棚最上部では細粒砂，陸棚中部では石灰質細～中粒砂，陸棚下部では極細～細粒砂，斜面上部では砂質泥～泥，そして斜面下部では均質な泥からそれぞれ構成される。

3．麻生湾の表層堆積物は暗緑灰色を呈する均質な泥より構成される．

4．表層試料より135種の底生有孔虫が同定され，これらは深度分布もとづき群集A（28-110 m），群集B（125-524 m），および群集C（746-1347 m）の3群集に分けられる。また，陸棚外縁部の試料G-11および12からは，鮮新—更新統からの再堆積と考えられる底生有孔虫群集が産出する。

5．表層試料より80属163種の介形虫が同定され，これらは深度分布ならびに水塊構造にもとづき，群集1（25-35 m），群集2（52-125 m）および群集3（208 m 以深）の3群集に区分される。また，陸棚外縁部の試料 G-11 からは，大桑-満願寺動物群に属する介形虫が産出し，これらは殻の保存状態などから付近に露出する更新-完新統からの再堆積物と考えられる。

6．柱状試料 P-1，2，3 の最上部ならびに最下部の試料より6属14種の浮遊性有孔虫が同定される。

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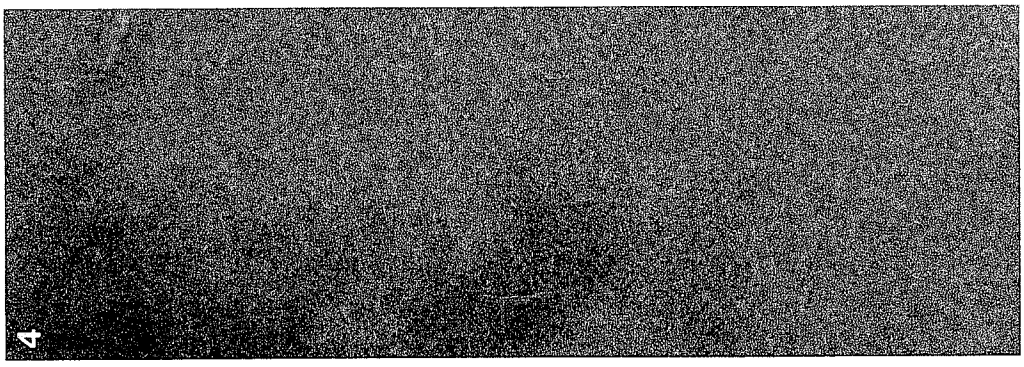
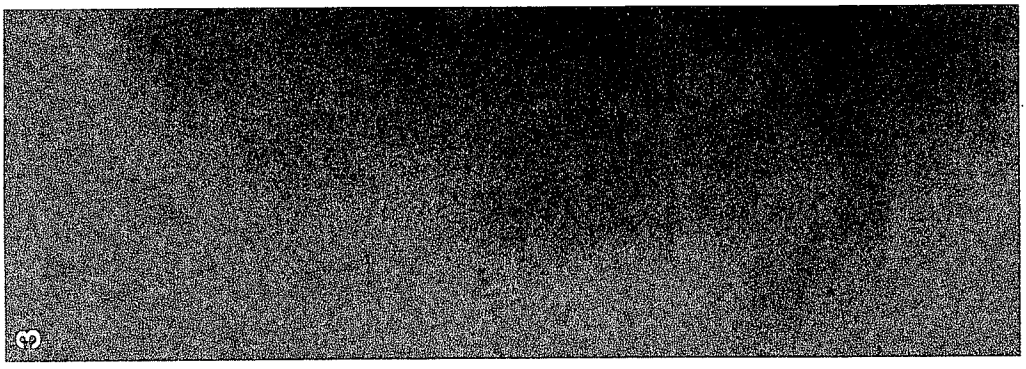
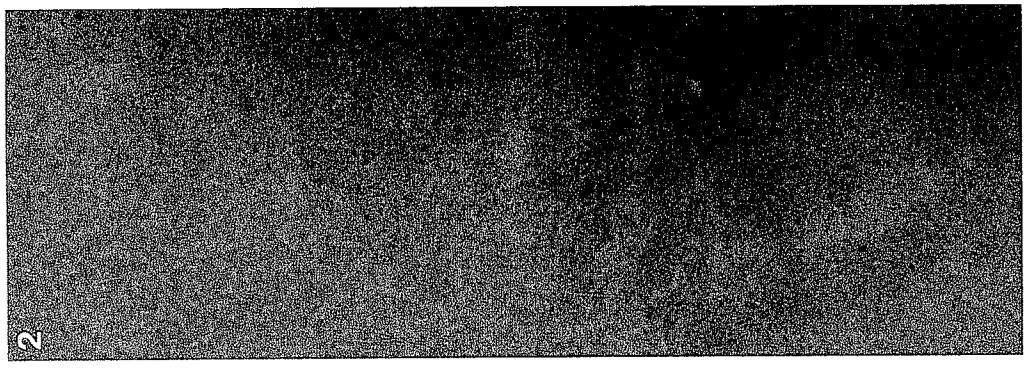
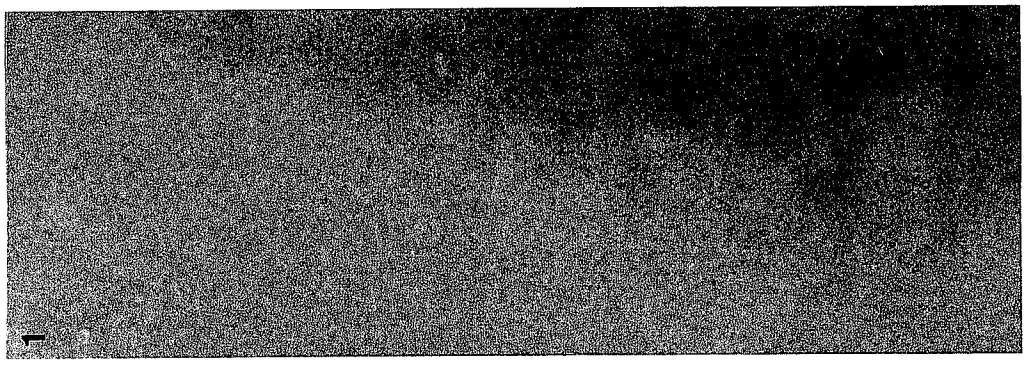
Plato 1









Explanation of Plate 1

Selected X-ray radiographs of the core KT98-17 P-1 from the upper slope of the Tsushima Basin in the southwestern marginal part of the Japan Sea at a water depth of 763 m.

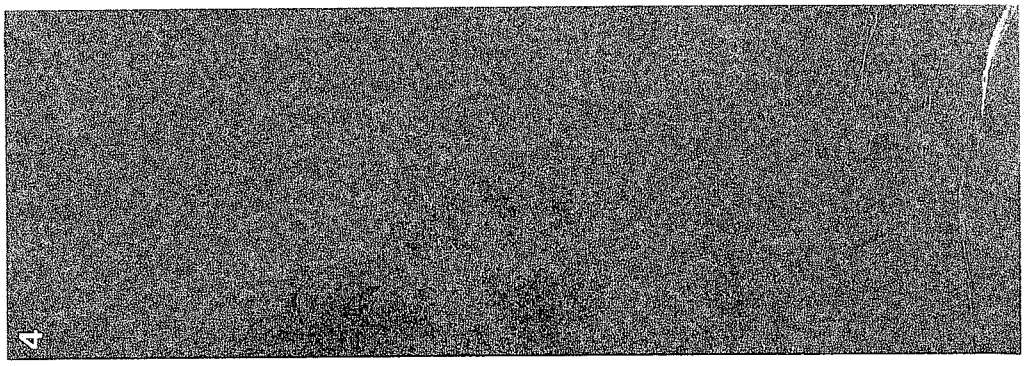
fig. 1 : Strongly bioturbated dusky yellow green mud in the upper part of the core (120-137cm).

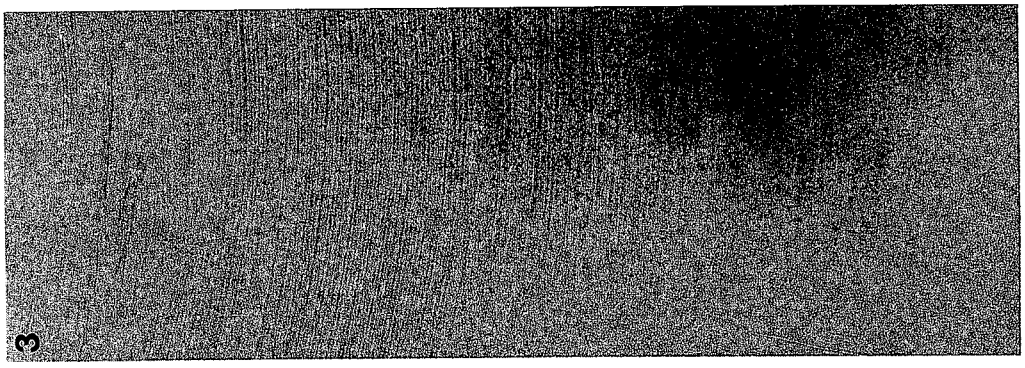
fig. 2 : Strongly bioturbated dusky yellow green mud in the middle part of the core (198-215 cm).

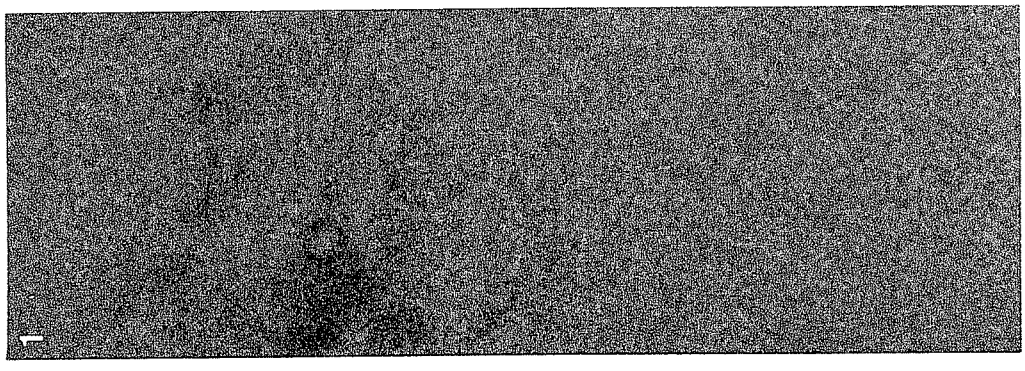
fig. 3 : Strongly bioturbated greyish olive green mud in the middle part of the core (278-295 cm).

fig. : Strongly bioturbated greyish olive green mud in the lower part of the core (338-355 cm).

Plato 2







Explanation of Plate 2

Selected X-ray radiographs of the core KT98-17 P-2 from the lower slope of the Tsushima Basin in the southwestern marginal part of the Japan Sea at a water depth of 1,018 m.

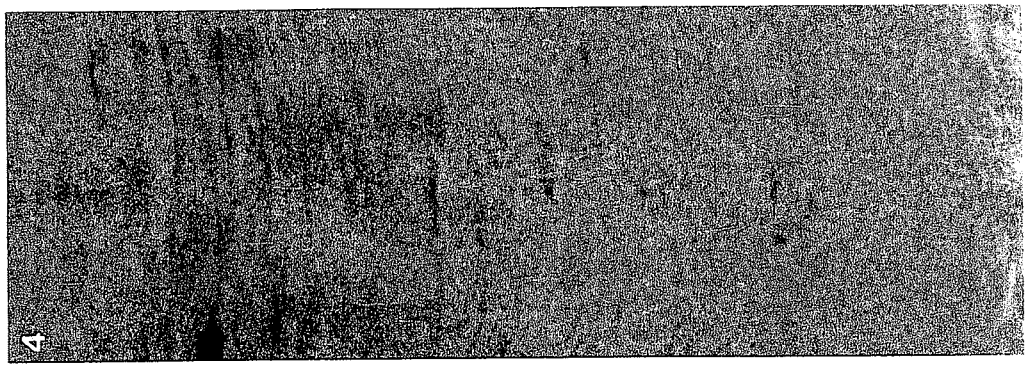
fig. 1 : Strongly bioturbated dusky yellow green mud in the uppermost part of the core (21-38 cm).

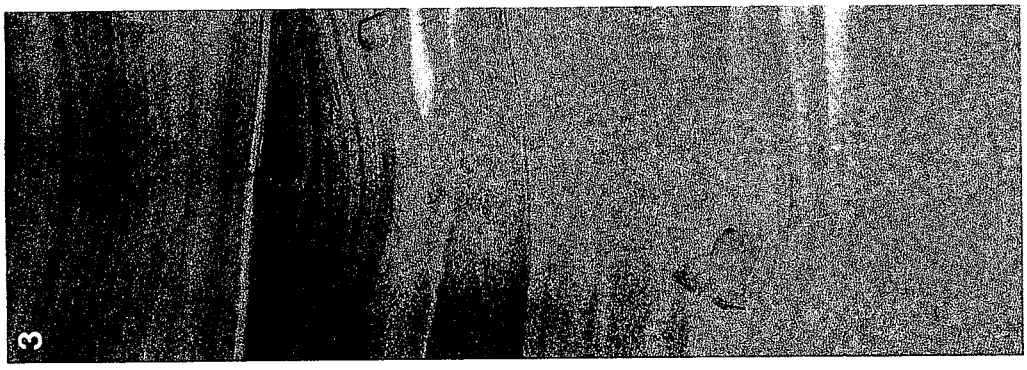
fig. 2 : Greenish grey fine-grained sand between the upper bioturbated and middle laminated muds in the middle part of the core (340-357 cm).

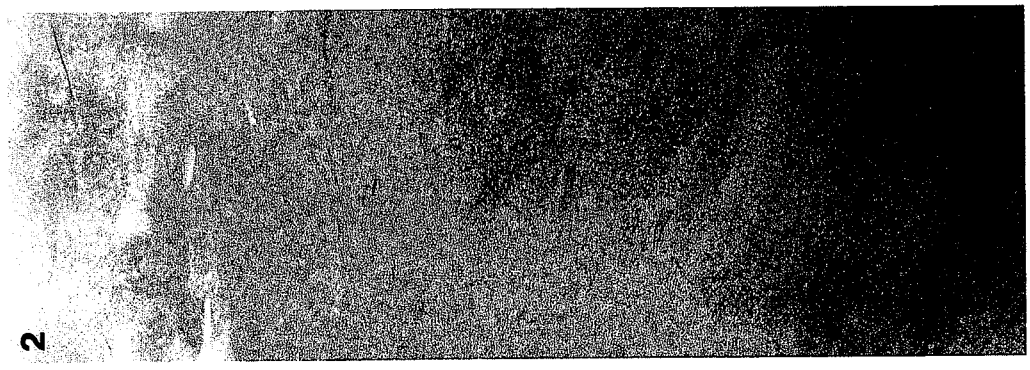
fig. 3 : Thinly laminated mud in the middle part of the core (360-377 cm).

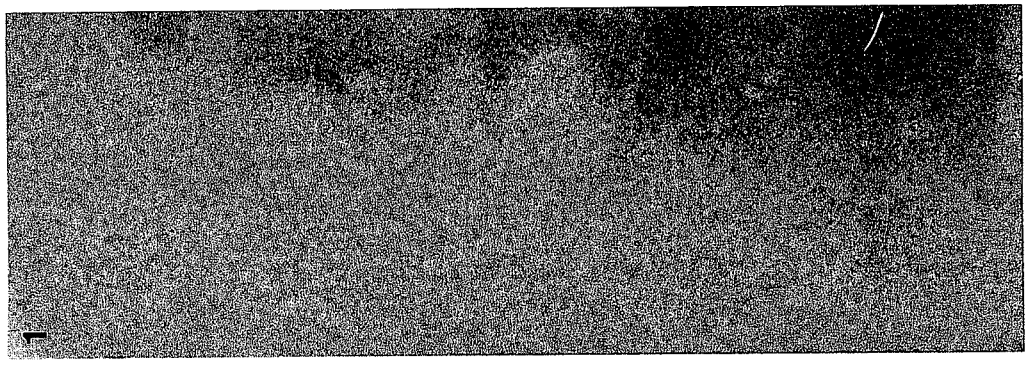
fig. 4 : Greyish olive compact mud in the lowermost part of the core (500 -517 cm).

Plate 3









Explanation of Plate 3

Selected X-ray radiographs of the core KT98-17 P-3 from the lower slope of the Tsushima Basin in the southwestern marginal part of the Japan Sea at a water depth of 1,340 m.

fig. 1 : Greyish olive green bioturbated mud in the upper part of the core (120-137 cm).

fig. 2 : Greyish olive green very fine-to fine-grained sand in the middle part of the core (340-357 cm).

fig. 3 : Thin alternating beds of very fine-grained sand and mud in the middle part of the core (360-379 cm). Erosional surfaces and trapped molluscan shell fragments are recognizable.

fig. 4 : Olive grey bioturbated mud/sandy mud in the lower part of the core (477-494 cm).