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Paleoceanographic Records from the Northern Shelf of the East China Sea since the Last Glacial Maximum

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Both benthic and planktonic foraminifera from Core 97-02 obtained in the northern East China Sea are quantitatively analyzed for reconstructing the paleocenography of late Quaternary. Since the earliest time of the core sediment (last not older than 18000 yr B.P.), the paleo-water depth has changed from less than 20 m to near 100 m at present, which is reflected by the benthic foraminiferal assemblages: before 14000 yr B.P., the water depth was shallower than 20 m; from 14000 to 7500 yr B.P., water depth was 20-50 m; and after 7500 yr B.P., water depth was 50-100 m. The foraminiferal fauna also disclose the water mass history: during the last glacial maximum, the water that dominated the study area might be the coastal water; at the end of the last glacial maximum (14000-9500 yr B.P.), the Yellow Sea Cold Water mostly affected this area; then it gave way to the Yellow Sea Warm Current after 9500 yr B.P.; and finally, the warm water has dominated this area since 9500 yr B.P. because of the westward shift and enhancement of the Kuroshio Current.

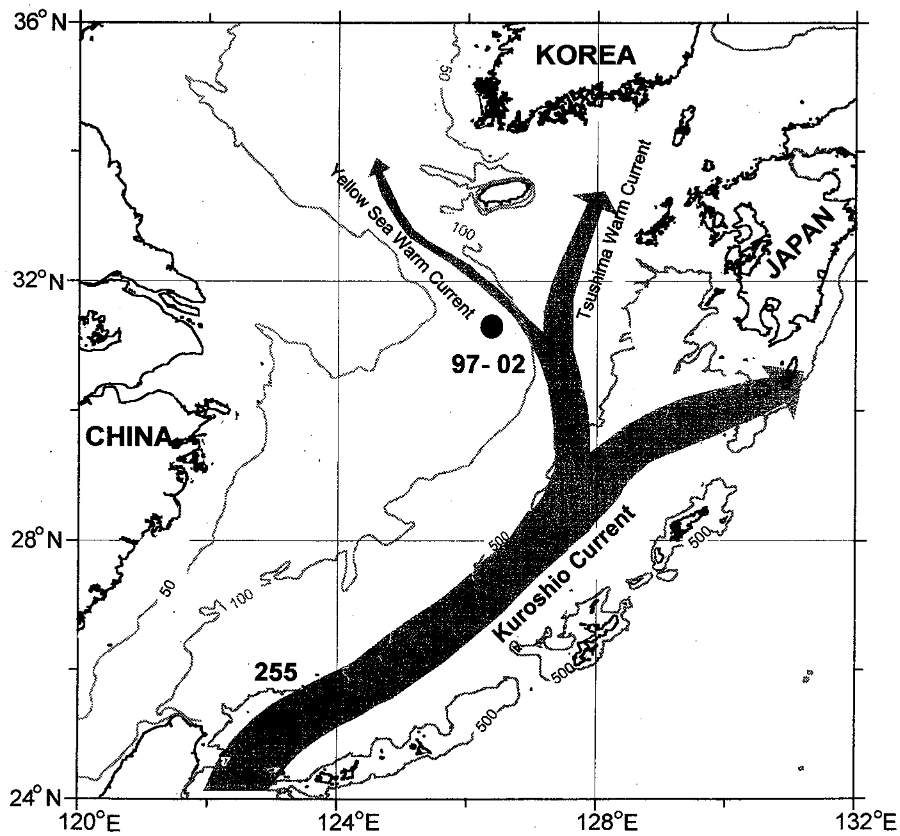
INTRODUCTION

The last glacial cycle has been intensely concerned in the paleoceanographical study of the East China Sea (Wang, 1990; Ujiie *et al.*, 1991; Yan and Thompson, 1991) and its understanding has enabled us to appreciate the mechanism of climatic change and to predict what it will be in future. Most of the paleoceanographic and paleoclimatic works in this area, however, have been done through the continuous semi-deep sea sediment (Wang, 1992; Xu and Oda, 1994; Jian *et al.*, 1996; Li *et al.*, 1997). Because of poor preservation of the sediments during the glacial cycles, the land-ocean interaction belt or the shallow-water shelf sediment was often ignored. In fact, however, it provides a direct record of the climatic changes on the near land, and at the same time, the paleoceanographic changes in the shelf may affect the coastal life very much. For example, the rising of the sea level will change huge land areas into sea, and many cities will disappear (Min and Wang, 1979; Yang, 1986).

With the sea-level changes, the Kuroshio Current had been shifted to the outside of Ryukyu Islands during the last glacial (Chinzei *et al.*, 1987) and finally returned to the Okinawa Trough about 7000 yr B.P. (Jian *et al.*, 1998). The shelf of East China Sea had such a big change from being completely exposed above the sealevel (Wang, 1992) in the last glacial maximum to the present status of submergence. Xu and Oda (1994) reported that there was a notable salinity decrease in the northern slope of East China Sea between 16000 and 10000 yr B.P. due to the huge amount of fresh-water discharge from the paleo-Yellow River. In that case, there should exist more evidence on the changes of salinity in the shelf area.

Until now, the microfossil analyses of Core DZQ-4 from the shelf of East China Sea (Tang, 1996) and Core QC-2 from the Yellow Sea (Yang *et al.*, 1996) are the most detailed work on the shelves. However, since the water depth at which Core QC-2 was collected is only 49.05 m at present, it has a strong shortcoming in recording the continuous marine strata during the late Quaternary when the sea level dropped more than 50 m below the present. Not to mention Core DZQ-4 that has a stratigraphy of very low resolution for post-glacial case. Thus they can not provide continuous and detailed information of paleoclimate and paleoceanogaphy.

Recently, we have taken serial cores from the northern East China Sea. Core 97-02 was retrieved from which the Yellow Sea Warm Current influences strongly (Fig. 1). The Coastal Current and Yellow Sea Cold Water also have an important effect on the sediment of this area (Qin and Zhao, 1986). Though



Fg. 1. Core location and bathymetry of the East China Sea. Contours are in meters.

this is only the preliminary results of foraminiferal analysis of Core 97-02, it shows how useful foraminifera is for studying the post-glacial changes of paleo-climate, water depth and water masses.

MATERIAL AND METHODS

Core 97-02 is a 545 cm-long piston core taken at the water depth of 93.9 m at 31°21.67′ N and 126°33.11′ E in October 1997. It is composed of silty clay (core depth of 0–60 cm), muddy sand (60–150 cm), silt (150–250 cm) and fine sand (250–545 cm). Thirty-nine samples were collected for the foraminiferal analyses with an interval of 10–20 cm (Table 1) and were processed by standard microfossil treatment.

In the core sediment, benthic foraminifera were very small sized and sometimes there were only a few specimens, thus, we used CCl_4 to float the foraminifera, but we still checked the sediment after the treating to make sure that all the foraminifera were picked up. Benthic foraminifera were analyzed for the fractions larger than 63 μm. The standard for benthic foraminifera identification was based on the

Table 1. Samples of Core 97-02 analyzed in this study

Depth (cm)	Dryweight (g)	Depth (cm)	Dry weight (g)	Depth (cm)	Dry weight (g)
0–2	2	130–132	3	260–262	8
10–12	2	140–142	3	270–272	8
20–22	2	150–152	3	280–282	8
30–32	2	160–162	5	300–302	8
40–42	2	170–172	5	320–322	8
50–52	2	180–182	5	340–342	8
60–62	2	190–192	5	360–362	8
70–72	3	200–202	5	380–382	8
80–82	3	210–202	5	400–402	8
90–92	3	220–222	5	420–422	8
100–102	3	230–232	5	460–462	12
110–112	3	240–242	5	480–482	12
120–122	3	250–252	8	510–512	12

descriptions of He *et al.* (1965), Zheng *et al.* (1978) and Wang *et al.* (1988). The benthic foraminifera specimens were mounted on the cardboard slide and counted (Appendix 1).

Planktonic foraminifera were identified in the fractions larger than 125 μm (Appendix 2). The taxonomy of planktonic foraminifera was referred to Be (1977), Thompson (1981) and Hemleben *et al.* (1988). We also counted the total number of planktonic foraminifera in the fractions greater than 63 μm. The planktonic ratio to total foraminifera was then calculated in the fractions large than 63 μm.

We used the Shannon-Wiener information function [H(S)] to calculate the faunal diversity (Gibson and Buzas, 1973). The equation is:

$$H(S) = \sum_{i=1}^{S} P_i * \ln P_i$$

where S is the number of species or subspecies and P_i is the proportion of the i th species in each sample. High value of H(S) indicates great species diversity, and occurs when all species are relatively equally distributed.

RESULTS

Stratigraphy

Planktonic foraminifera *Pulleniatina obliquiloculata* has played an important and valid role in subdividing the late Quaternary stratigraphy and reconstructing paleo-ocean environments. The variations of its relative abundance could be correlated with the glacial/interglacial cycles in the northwest Pacific marginal seas (Wang *et al.*, 1996; Li, 1997; Li *et al.*, 1997).

Since no age dating was carried out for of Core 97-02, its chronosratigraphy was pursued by comparing with that of Core 255 (25°12′ N, 123°06′ E; water depth of 1575 m), from the southern East China Sea, of which the chronological model with numerous age-control points had been established (Li *et al.*, in preparation). From identical variation patterns of abundance of *Pulleniatina obliquiloculata* between the two cores (Fig. 2), we presume the strata at depths of 200 and 270 cm in Core 97-02 can be correlated to those of 370 cm (about 10,000 yr B.P.) and of 430 cm (about 12000 yr B.P.) in Core 255,

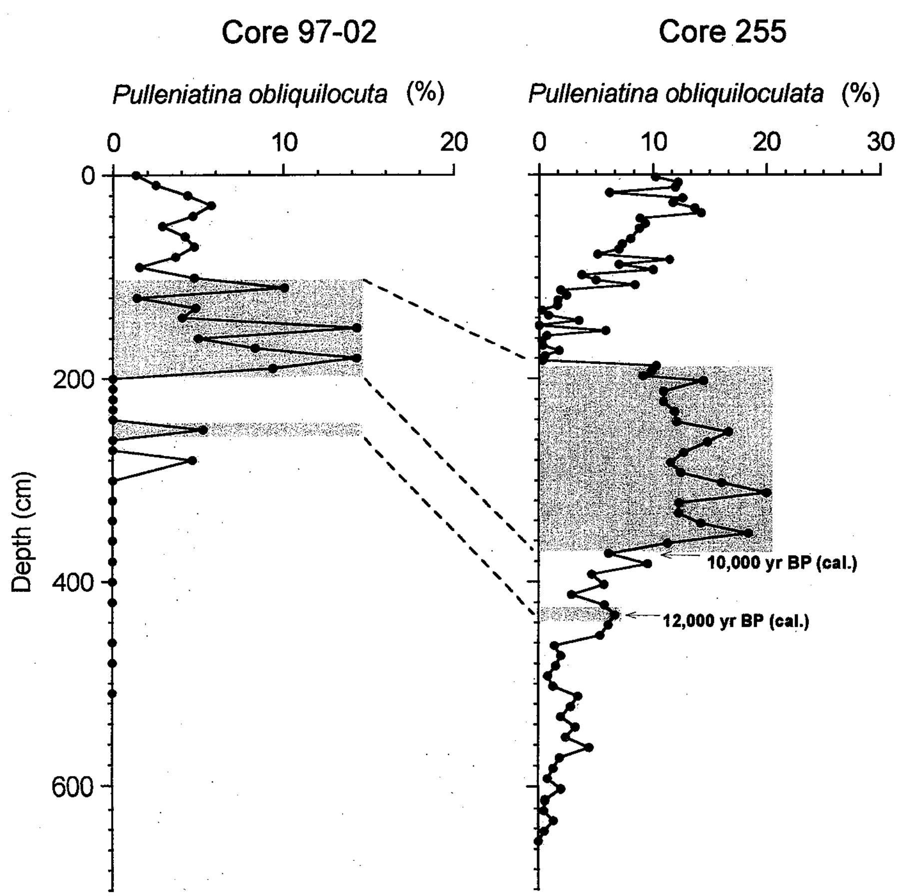


Fig. 2. Stratigraphy and correlation of Core 97-02 and Core 255 from the southern East China sea (after Li *et al.*, 1997). The chronology at the depths of 200 and 250 cm in Core 97-02 is correlated to the ages 10,000 cal. yr BP (370 cm) and 12,000 cal. yr BP (430 cm) in Core 255.

respectively. According to the average sedimentary rate of 20 cm/ky at the interval of 0 to 200 cm in Core 97-02, the strata at depth of 150 cm was interpolated as 7500 yr B.P., while that at depth of 300 cm was extrapolated as 14000 yr B.P., based on the average sedimentary rate of 25 cm/ky at the core interval of 200 to 250 cm.

During the last glacial maximum, the sea level of the eastern flank of China had been -150 to -160 m and the sea level began to rise very quickly after 15000 yr B.P. (Zhao *et al.*, 1979). According to our data, there is no fresh-water microfossils found in the bottom of the Core 97-02. Therefore, this core sediment is regarded to have been deposited after the sea-level rise, suggesting that the bottom sediment may not be older than 18000 yr B.P.

Foraminiferal assemblages

One hundred and twenty-nine benthic and twenty planktonic foraminifera species or subspecies are recognized (Appendix 1 and 2). The most abundant benthic species (>15%) in the core are *Elphidium magellanium*, *Bolivina robusta* and *Ammonia beccarii* var.; the common species (5–15%) include *Elphidium advenum*, *Quinqueloculata vulgaris*, *Florilus decorus*, *Cassidulina carinata*, *Ammonia kienziensis*, *Pararotalia nipponica*, *Bulimina marginata*, *Epistominella naraensis*, *Cribrononion subincertum*, *Gyroidina nipponica* and *Ammonia compressiuscula* in decreasing order (Table 2).

Benthic foraminifera of the East China and Yellow Seas can be classified into three assemblages of species according to their modern distribution in the surface sediment (Wang *et al.*, 1985a, 1985b, 1985c, 1988). Assemblage A that includes two sub-assemblages with the boundary of 20 m in water depth, especially in the Yellow Sea, mostly occurs in the coastal and inner-shelf waters (water depth less than 40–50 m), and comprises *A. beccarii* var. (including *A. beccarii*, *A. tepida* and *A. limbatobeccarii*), *Ammonia convexdorsa*, *E. magellanicum*, *F. decorus*, *Cribrononion vitreum*, *E. advenum*, *Buccella frigida*, *C. subincertum* and *P. nipponica*. Assemblage B is often found in the middle shelf with water depths of 50-100 m, and includes *A. compressiuscula*, *A. Ketienziensis angulata*, *B. robusta*, *B. marginata*, *Astrononion tasmanensis* and *Hanzawaia nipponica*. Assemblage C species are *C. carinata*, *Globocassidulina subglobosa* and the Lagenids, and they mostly live in the outer shelf where the water depth is greater than 100 m. In Core 97-02, Assemblage A appears mainly in the lower part (510–150 cm), while Assemblages B and C dominate the upper part (300-0 cm) of the core (Fig. 3).

The planktonic foraminifera assemblage is mainly composed of *Globigerinoides ruber*, *Globigerinoides sacculifer*, *Neogloboquadrina dutertrei*, *Globigerinita glutinata*, *Globigerina bulloides*, *Globigerina calida* and *Pulleniatina obliquiloculata* (Appendix 2). They are mostly the temperate-water species of the north Pacific (Be, 1977). Compared with Core 255 of the southern Okinawa Trough (Li *et al*, 1997), Core 97-02 has more abundant left-coiled *Neogloboquadrina pachyderma* (up to 14.3%) which tends to proliferate in cold water. Only *P. obliquiloculat* displays distinct boundaries in abundance variation at the core depths of 300 and 200 cm and a dood correlation with that

Table 2. The most abundant and common benthic foraminifera species in Core 97-02

Type	Species	Peak abundance and depth
abundant (more than 15% at least in one sample)	*Elphidium magellanium*	43.2% at 380 cm
	Bolivina robusta	36.1% at 60 cm
	Ammonia pauciloculina	18.1% at 0 cm
	Ammonia beccarii	17.8% at 290 cm
common (5-15% at least in one sample)	*Elphidium advenum*	13.8% at 460 cm
	Quinqueloculata vulgaris	13.4% at 210 cm
	Florilus decorus	12.0% at 10 cm
	Cassidulina carinata	9.7% at 150 cm
	Ammonia kienziensis	7.8% at 0 cm
	Pararotalia nipponica	7.7% at 270 cm
	Bulimina marginata	7.4% at 50 cm
	Epistominella naraensis	6.9% at 0 cm
	Cribrononion subincertum	6.0% at 320 cm
	Gyroidina nipponica	5.3% at 20 cm
	Ammonia compressiuscula	5.1% at 110 cm

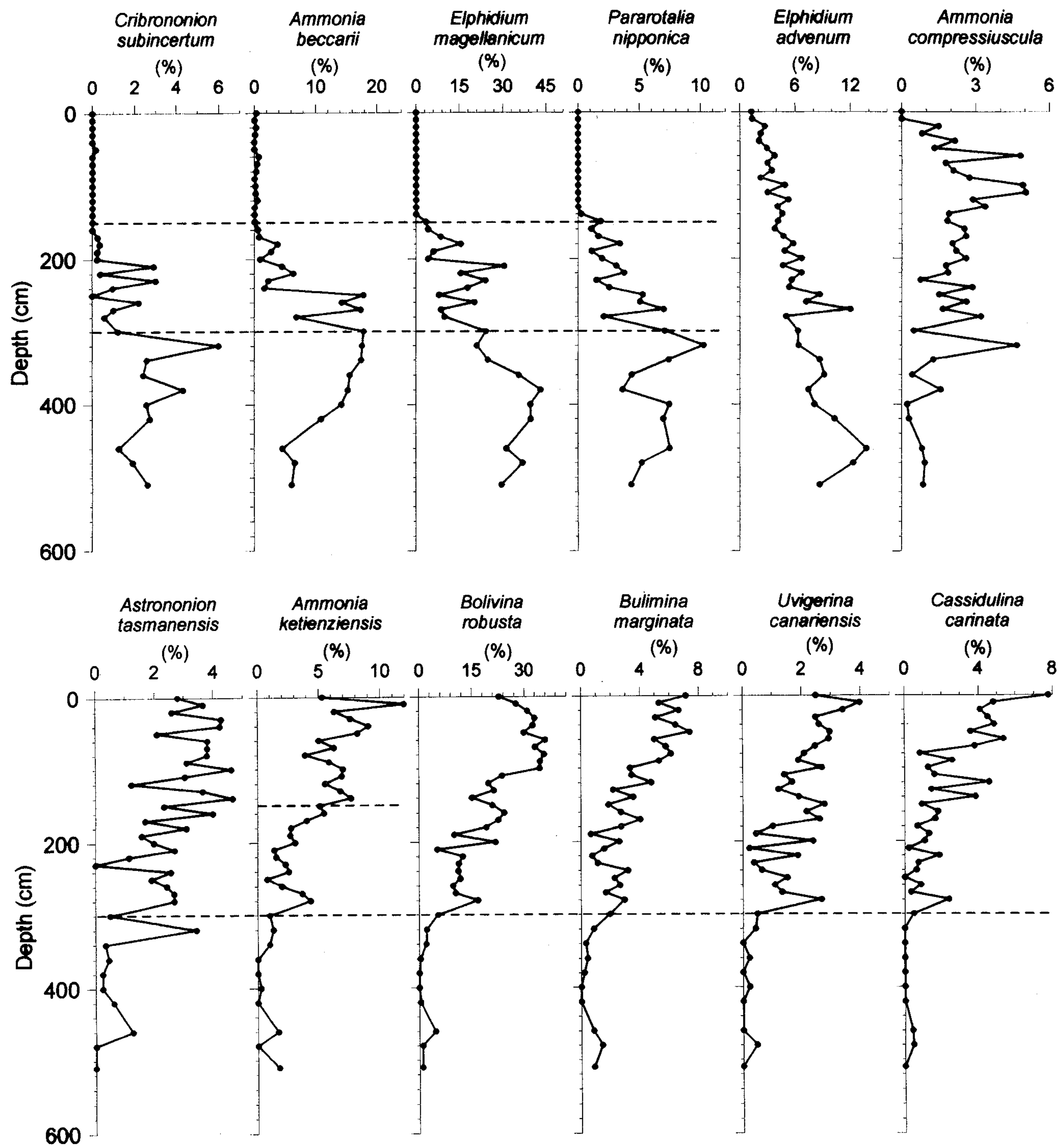


Fig. 3. Down-core variations of benthic foraminifera species.

of Core 255 (Fig. 2).

Down-core variations of benthic foraminifera

Benthic foraminifera are mostly controlled by the water depth in the East China Sea and Yellow Sea areas (Wang *et al.*, 1988). Their modern distribution ecology provide bases for the reconstruction of paleo-water depth during the late Quaternary. Here are their down-core variations in Core 97-02 (Fig. 3):

A. beccarii, *Pararotalia nipponica*, *Elphidium magellanicum* and *Cribrononion subincertum* percentages show similar down-core variation trends: high values at depth of below 300 cm (average 13.1, 6.4, 32.6, and 2.9, respectively), medium-to-low values at the core interval of 150–250 cm (average 2.6, 2.8, 11.9, and 1.0, respectively), and almost bare in the top 150 cm. Considering that *Ammonia beccarii* var. distributes mostly in the water less than 50 m deep in the present East China Sea, and in the coastal water within 20 m deep in the present Yellow Sea. The paleo-water depth is estimated during the depositional period of core sediment: below 300 cm, the water depth was much shallow about 0–20 m; then, the water depth might become deeper and deeper, and have remained deeper than 50 m since the deposition of the strata at core depth of 150 cm.

E. advenum that is often seen in the shelf of the East China Sea, especially in the inner shelf (Wang *et al.*, 1988), gradually decreases in abundance from about 10% at the bottom to about 2% at the top of the core, implying that the water depth has become deeper gradually.

A. compressiuscula and *A. tasmanensis* have the same down-core variations: at the core depths below 300 cm, there are low values (average 1.2 and 0.7%, respectively), and relatively high values at the upper part of the core (average 2.3 and 2.8%, respectively). Since *A. compressiuscula* is most abundant in the middle shelf with water depths of 50–100 m, and in the Yellow Sea, it has a high percentage in water of 20–50 m deep where the Yellow Sea Cold Water dominates (Wang *et al.*, 1985c), this down-core changes reflect that the core interval above 300 cm were deposited at water depth of more than 20 m, while that below 300 cm was formed at water depth less than 20 m.

A. ketienziensis angulata shows three stepped changes in abundance: from average 0.7% below the core depth of 300 cm, to average 3.0% at the core interval of 300–150 cm and to average 6.9% above the core depth of 150 cm. This implies that the core depths of 300 cm and 150 cm are the boundaries of paleo-water depths of 20 and 50 m, respectively, since *A. ketienziensis angulata* distributes in the water deeper than 20 m, and it becomes very abundant in water deeper than 50 m, and is the dominant species of Yellow Sea Cold Water together with *A. tasmanensis*.

B. robusta, *B. marginata*, *Uvigerina canariensis* and *C. carinata* have the same trend in the down-core variation of abundance. They have very low values (almost zero) below the core depth of 300 cm and increase gradually in the upper part up to 40, 7, 4 and 8%, respectively. This trend of the deep-water species reflects the deepening of water depth with time.

Paleo-water depth reconstruction

The down-core variations of abundance of benthic

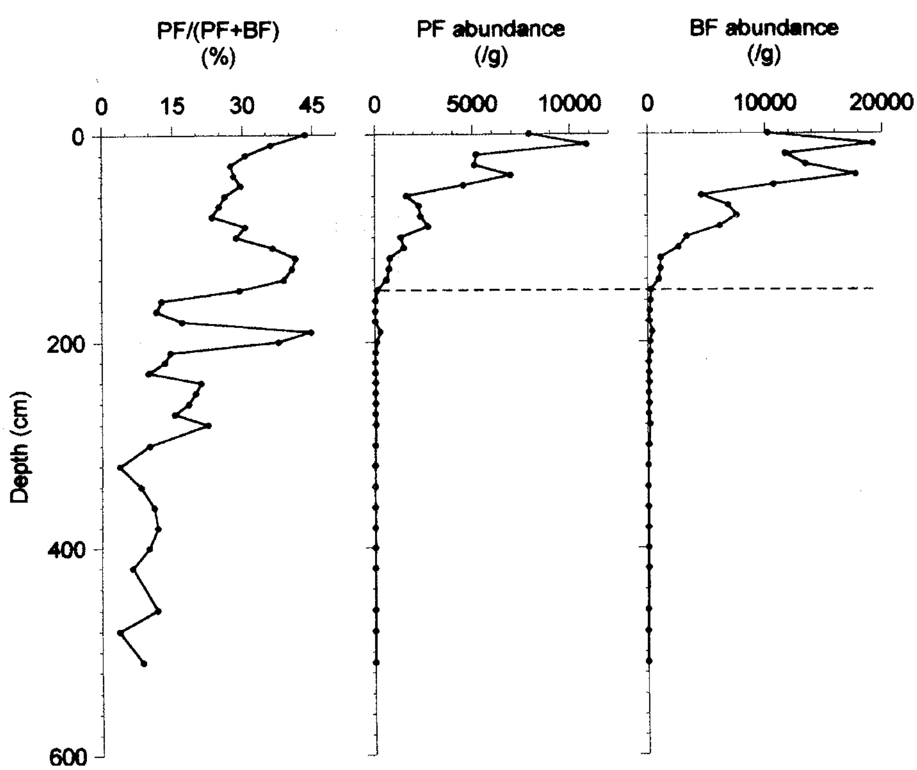


Fig. 4. Down-core variations of the foraminifera abundances and planktonic foraminifera percentage.

foraminifera species shown above collectively indicate the changes of the paleo-water depth, from shallower than 20 m (at the core interval of 510–300 cm), to about 20–50 m (at the core interval of 300–150 cm) and to about 50–100 m (at the core interval of 150–0 cm). This can also be indicated by other lines of evidence.

The absolute abundances of both benthic and planktonic foraminifera have a trend to increase sharply when water becomes deeper in the shelf (Wang *et al.*, 1985c). Both benthic and planktonic foraminiferal abundances of Core 97-02 show a rapid upcore increase: from a few to several thousands specimens per gram of dried sediment from bottom to surface of the core. The ratio of planktonic to total foraminifera also increases from a few to about 40 percent at the same time (Fig. 4; Appendix 3). All these indicate that the paleo-water depth of Core 97-02 has become deeper after the last glacial maximum.

Benthic foraminifera can be subdivided into six groups according to the test component, the mode of wall-crystal formation, and the arrangement of chambers: the agglutinated, the porcelaneous, the Lagenids, the serial hyaline, the planispiral hyaline and the trochospiral hyaline. In the East China Sea, the inner shelf is dominated by the trochospiral and planispiral hyaline groups, while the deeper area of middle to outer shelf is mostly by the serial hyaline group and deeper slope and the trough are by the Lagenids (Wang *et al.*, 1985c). The planispiral and serial groups are the main types of benthic foraminifera in Core 97-02 and display large variations through the core. Figure 5 shows down-core variations of both groups. We can see that the abundance of serial group increases above the core depth of 300 cm (from 13.5 to 51.5%), while that of planispiral group increases below the core depth of 150 cm (from 20.8 to 58.7%). This implies that the water depth of this location has become deeper since the depositional time of the core depth of 300 cm and has deepened to a greater degree since the core depth of 150 cm.

On the basis of the above analysis, we think that paleo-water depth in the shelf environment of the East China Sea became deeper and deeper during the period from the bottom to the top of Core 97-02.

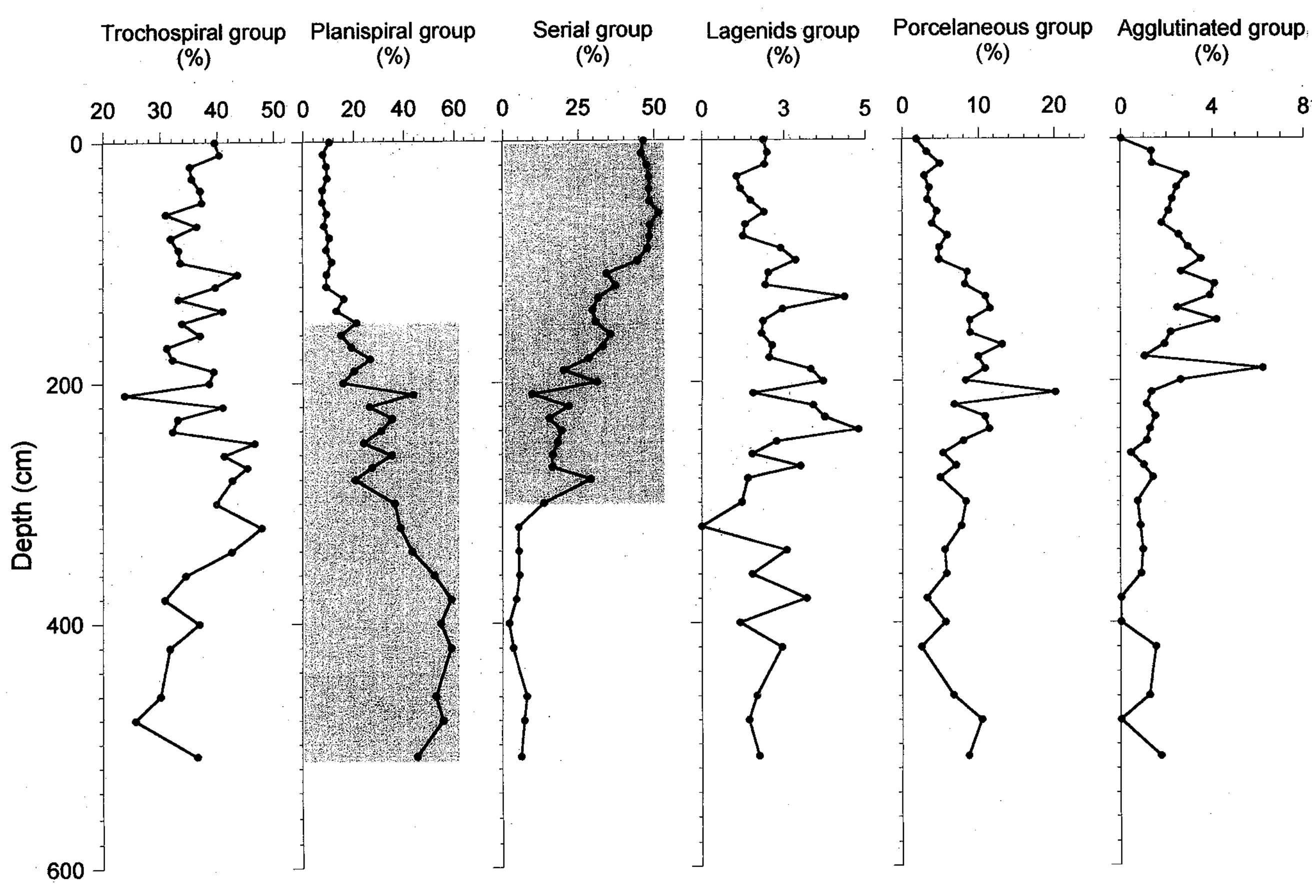


Fig. 5. Down-core variations of six groups of benthic foraminifera in Core 97-02.

At the core interval of 510–300 cm (before 14000 yr B.P.), the water depth was shallower than 20 m (coastal environment) as indicated by the high percentages of *A. beccarii* and of planispiral hyaline benthic foraminifera; and then at the core interval of 300–150 cm (about 14000–7500 yr B.P.), it became deeper about 20-50 m (inner shelf) which was indicated by the still high content of planispiral hyaline benthic foraminifera; and at the core interval of 150–0 cm (after 7500 yr B.P.), it reached up to 50–100 m (middle shelf), given the higher percentage of the serial hyaline benthic foraminifera.

DISCUSSION

Paleo-ocean environment and water mass/current after the LGM

The water was probably cold during the period of lower sea level (at the core interval of 510–300 cm), given the abundance of cold-water foraminiferal species. The water began to get warmer after 14000 yr B.P. (above the core interval of 300 cm), considering the increase of some warm-water benthic species *Lenticulina* spp., *H. balthica* and *A. pauciloculata*. However, it might be still cold until 9500 yr B.P. because the cold-water benthic species *Buccella frigida* (Wang *et al.*, 1988) shows a relatively high percentage at the core interval of 300–190 cm (about 14000–9500 yr B.P.), and the water mass dominating this area was mostly similar to the modern Yellow Sea cold water. After 9500 yr B.P., the water temperature becomes warmer (it may be the warmest since the last glacial), which was reflected by the lowest percentage of cold water species (*Buccella frigida*) and the highest percentages of warm water species (*Lenticulina* spp., *Hyalina balthica* and *Ammonia pauciloculata*).

The planktonic species *Pulleniatina obliquiloculata*, an indicator of Kuroshio Current, has often been regarded as a characteristic species of warm and high-salinity water (Thompson, 1981; Wang *et al.*, 1985c; Chinzei *et al.*, 1987; Oda and Takemoto, 1992; Li *et al.*, 1997). Its abundance increases apparently above the core depth of 300 cm, especially above 200 cm, which implies that a certain warm water mass existed (such as the Yellow Sea Warm Current or the outer-shelf water of the East China Sea) and affected this area strongly after 9500 yr B.P. (above the core depth of 190 cm), though it had begun to get warm since approximately 14000 yr B.P. (at the core depth of 300 cm).

It is thought that the warm current began to strongly influence the study area by the post-glacial westward shift of the Kuroshio Current. Jian *et al.* (1998) suggested that the Kuroshio Current entered the Okinawa Trough thoroughly at about 7000 yr B.P.. For further comparison of the changes of currents of the East China Sea, we need the detailed AMS ^{14}C dates of Core 97-02.

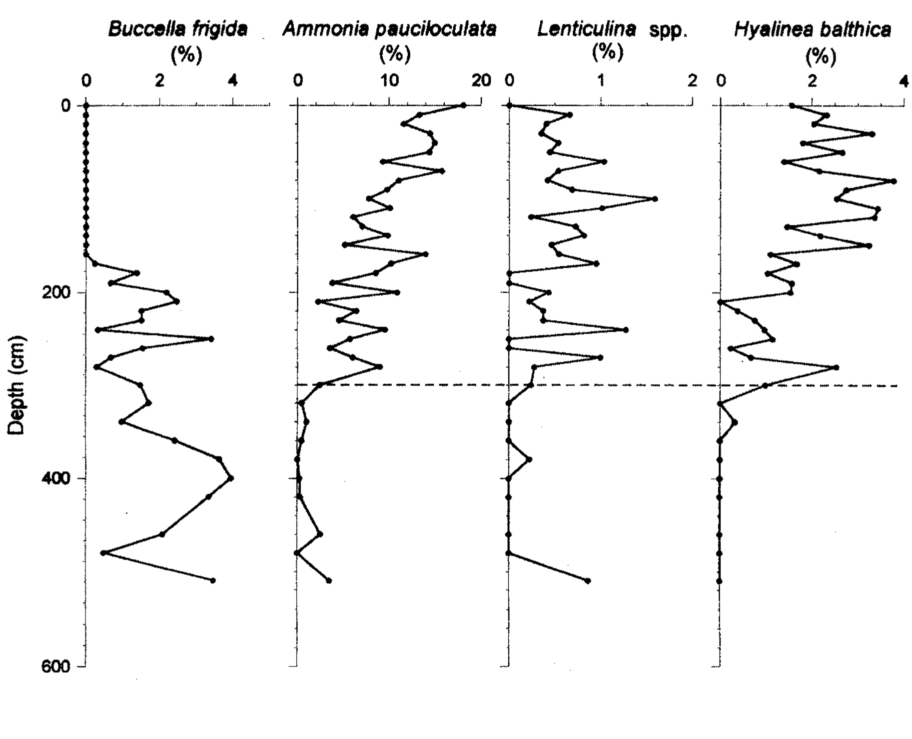


Fig. 6. Down-core variations of water temperature-indicated species.

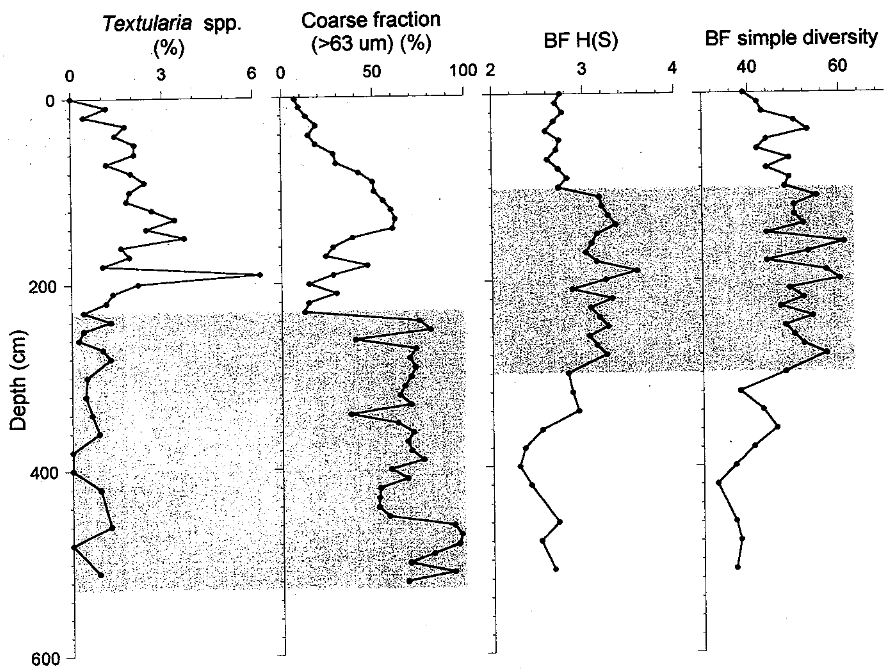


Fig. 7. Down-core variations of benthic foraminifera species diversity, *Textularia* spp. and coarse fraction (>63 μm) in Core 97-02.

The variation of species diversity of benthic foraminifera is shown in Fig. 7. The relatively higher diversity [H(S)] for benthic foraminifera is shown at the core interval of 300 to 100 cm. This coincides with the high simple species diversity at this interval, which reflects their adaptation to the environmental change from the deeper inner to middle shelf.

An increase of the agglutinated group and *Textularia* spp. above the core depth of 200 cm may indicate the high-energy coastal environment in the lower part of the core. Since the formation and preservation of agglutinated tests are prevented in high-energy environments. This is also supported by the high coarse fractions and by the severe abrasion of large foraminifera specimens or mollusca shells at this interval (Fig. 7).

CONCLUSIONS

Core 97-02 of the northern East China Sea may disclose the strata since the last glacial maximum and give hints for the paleoceanographic changes. The foraminifera assemblages reflect that the water depths were 0–20, 20–50 and 50–100 m at the core depths of 510–300, 300–150 and 150–0 cm, respectively. At the same time, the absolute abundances of both planktonic and benthic foraminifera increase rapidly from a few to several thousands. The planktonic ratio in total foraminiferal fauna also increases from a few to 40%.

Characteristic species of both benthic and planktonic foraminifera show that the water temperature has increased since the last glacial on account of the enhancement of warm water mass (such as the Yellow Sea Warm Current), and the weakening of both the Yellow Sea Cold Water and the coastal water in this area. The Yellow Sea Warm Current might finally dominated this area very strongly after 9500 yr B.P. (above the core depth of 190 cm) though it had come to affect this area since 14000 yrs B.P. (above the core depth of 300 cm), with the post-glacial westward shift of the Kuroshio Current.

Temperature-indicative species also shows that the water temperature began to increase after 14000 yr B.P. and to reach the highest after 9500 yr B.P., which may reflect the thorough entering of the Kuroshio Current into the East China Sea at that time.

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Appendix 1. Benthic foraminifera (larger than 0.063 mm) percentages in Core 97-02

Species depth (cm)	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190
Gaudryina haeringensis					0.2			0.4		0.3	0.2	0.2	1.2	0.5			0.5			
Proteonia spp.		0.2	0.1																	
Texularia spp.		1.2	0.4	1.8	1.4	2.1	2.1	1.2	2.0	2.4	1.9	1.8	2.6	3.4	2.5	3.7	1.6	1.9	1.0	6.2
Tritaxia donghaiensis			0.1							0.2	0.3									
Verneuilina sp.			0.7	1.1	0.8	0.1		0.2	0.6		1.1	0.6	0.2			0.5				
Ammomassilina spp.	0.3	1.0	2.0	0.9	0.4	0.1	0.3	0.2		0.3	0.2		0.2		0.3					
Edentostomina cultrata					0.1															
Miliammina spp.	0.3	0.3	0.1	0.1	1.2	0.9	0.3	1.2	2.0	0.7	0.8	1.4	0.5	1.2	1.1	2.3	0.9	0.7	0.3	0.7
Pyrgo elongata													0.5		0.3					
Quinquelocolina contorta												0.6				1.4		0.5	0.7	0.9
Quinqueloculina lamarckiana																0.5				
Quinqueloculina rotunda												0.4		1.2	0.5		0.2			2.0
Quinqueloculina sabulosa	0.6	0.5	1.2	0.7	1.0	0.4	1.6	0.7	1.8	1.0	0.6	1.6	3.1	2.9	4.4	1.9	2.7	0.5		1.3
Quinqueloculina seminula								0.2				0.4			0.5		0.2			
Quinqueloculina seminulangula					0.1		0.2	0.3			0.5	0.6	1.2	1.5	1.4			0.2	2.1	
Quinqueloculina tikutoensis																	0.2		0.3	
Quinqueloculina vulgaris												0.2	0.2	1.2	1.1	1.9	1.3	9.3	5.1	2.9
Quinqueloculina spp.							0.2						0.2	0.2						
Sigmoilina tenuis		0.5	0.4	0.2	0.4	0.4		0.1		0.3	0.3	0.4			0.3	0.5	0.2	0.2		0.2
Sigmoilina spp.																	0.4			
Sigmoilopsis asperula	0.6	0.7	1.1	0.8	0.3	1.3	1.4	1.2	2.0	2.1	2.4	2.6	1.7	2.4	1.6	0.5	2.2	1.7	1.0	2.4
Spioroloculata communis		0.2								0.3			0.2	0.2						0.4
Spioroloculina laevigata																	0.4		0.3	
Triloculina tricarinata																				
Triloculina trigonula					0.2		0.5	0.1	0.1			0.2	0.2				0.2			
Triloculina spp.																	0.2			
Amphicoryna sublineata		0.2					0.2										0.2			
Amphicoryna sp.																		0.2		
Botuloides sp.																	0.2			
Dentalina cf. basiplanata				0.2					0.1											
Dentalina communis				0.1						0.2										
Dentalina decepta														0.2						
Dentalina extensa										0.2										
Dentalina sp.																				0.2
Esosyrinx sp.																				0.2
Fissurina spp.	1.2	1.0	1.1	0.4	0.5	0.6	0.7	0.6	0.7	0.9	0.8	0.4	1.0	2.2	1.1	0.5	0.9	0.7	2.1	2.0
Lagena spp.	0.6		0.4		0.1	0.4		0.2		0.5	0.3	0.6	0.7	1.2	0.5	0.9		0.2		0.9
Lenticulina calcar										0.2	0.5	0.4				0.5	0.2			
Lenticulina costata											0.2									
Lenticulina iotus		0.5	0.1	0.4	0.2	0.1	0.7	0.2	0.1	0.3	0.6	0.2		0.2	0.5		0.4	0.5		
Lenticulina tumida														0.2	0.3					
Lenticulina sp.		0.2	0.3		0.4	0.3	0.3	0.3	0.3	0.2	0.3	0.4	0.2	0.2				0.5		
Polymorphina sp.																				
Saracenaria italica		0.2									0.2									
Sigmomorphina sp.																				
Bifarina sp.																				0.2
Bolivina robusta	22.7	27.6	30.9	33.0	32.5	29.8	36.1	33.1	35.7	34.5	34.4	23.6	19.7	21.3	15.0	20.8	24.3	22.6	19.2	10.0
Brizalina seminuda	3.4	1.3	1.1	0.5	0.2	1.2	0.5	1.1	0.7	0.3	1.3	0.8	1.7	1.0	0.1	0.5	0.4	0.7	0.7	0.2
Brizalina striatula	0.3								0.1	0.2	0.2	0.4	0.2	1.2	0.3	0.5	0.7	0.2	0.7	
Brizalina spp.				0.1	0.2	0.9	0.3	0.1	0.7	0.2		0.4	1.0	0.7			0.9			0.2
Bulimina marginata	7.2	5.3	6.7	5.1	6.5	7.4	5.0	5.8	6.2	5.3	3.3	3.4	4.8	2.2	3.6	1.9	2.7	4.0	2.7	0.7
Cassidulina carinata	7.8	4.8	4.1	4.5	4.8	3.6	5.4	3.8	0.8	2.6	1.3	1.6	4.6	1.5	3.8	0.9	1.8	4.7	0.7	1.3
Fursenkoina pauciloculata												0.6		0.2	0.3					
Fursenkoina schreibersiana				0.1	0.1	0.1	0.2	0.1	0.3		0.2						0.2	0.2		
Globobulimina notovata		0.2														0.5		0.2		
Globocassidulina subglobasa	1.2	1.7	0.3	0.7	0.9	0.7	0.5	1.0	0.6	0.9	0.5	1.2	1.2	1.5	0.8	1.4	1.3			1.3
Guembelitria vivans			0.1	0.2		0.4	0.2		0.7						1.1					
Hopkinsina pacifica	0.3	0.2		0.4					0.1	0.5			0.2		0.3	0.5	0.2		0.3	0.2
Islandiella islandica																	0.4	0.5	2.4	4.6
Rectobolivina bifrons striatula																				
Siphouvigerina porrecta	0.3																			
Stainforthia complanata	0.3	0.2	0.3	0.7	0.1			0.2									0.2			
Trifarina angulosa			0.3	0.4	0.2	0.7		0.2		0.5		0.2	0.2	0.2	0.3	0.9			0.3	0.4
Trifarina bradyi						0.1														
Uvigerina canariensis	2.5	4.0	3.4	2.5	2.6	3.0	2.9	2.5	2.1	1.9	2.7	1.4	1.7	1.2	1.9	2.8	2.2	2.6	1.0	0.4

Appendix 1. Continued

Species depth (cm)	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190
Uvigerina dirupta														0.2						
Virgulopsis orientalis	0.3	0.3	0.4	0.1	0.3	0.3	0.3	0.7	0.4	0.7	0.5	0.4	1.9	0.2	1.1		0.4	0.2	0.3	0.4
Astrononion tasmanensis	2.8	3.7	2.6	4.3	4.2	2.1	3.8	3.8	3.8	3.1	4.6	3.0	1.2	3.6	4.6	2.3	4.0	1.7	3.1	1.5
Cribrononion incertum																				
Cribrononion porisuturalis																				
Cribrononion subincertum						0.1												0.2	0.3	0.2
Cribrononion sp.																				
Elphidiella Kiangsuensis																				
Elphidium advenum	1.2	1.3	2.7	2.2	2.1	3.0	3.8	3.0	3.5	2.2	4.9	3.0	5.3	4.1	4.6	4.2	3.8	4.8	5.8	4.9
Elphidium crispum																				
Elphidium magellanicum																3.2	4.2	8.6	15.4	6.0
Florilus decorus	1.6	0.5	1.4	1.3	0.4	1.3	1.6	0.8	1.3	2.2	1.0	1.2	2.2	3.6	2.2	9.7	2.2	1.0	1.0	3.3
Melonis sp.																				
Nonion akitaense														1.7		0.5		1.0		
Nonion stella																				
Nonion sp.																				
Nonionella jacksonensis	2.2	0.3	1.6	0.6	0.5	0.7		0.2	0.6	0.9	0.2	0.2		1.0	0.8		0.4	1.4		0.9
Nonionella magnalingua	0.3	0.5		0.1	0.1												0.2			
Nonionella sp.	1.9	1.2	0.1	0.7	0.3			0.2	0.6	0.5	0.2	1.2		1.9						1.3
Protelphidium compressum																		0.2	0.7	0.7
Pseudononionella sp.																				
Pullenia bulloides																				
Pullenia quinqueloba	0.3	0.2	0.5	0.1	0.1	0.1		0.2	0.6		0.3	0.4	0.2		0.5	0.9				1.1
Spirilina sp.			0.1																	
Stomoloculina multangula																				
Ammonia annectens																				
Ammonia compressiuscula			1.5	0.8	2.2	1.3	4.8	1.8	2.1	2.7	4.9	5.1	2.9	3.4	1.9	1.9	2.5	2.6	2.1	2.2
Ammonia confertitesta																				
Ammonia convexdorsa																	0.7	1.2		1.8
Ammonia ketienziensis angulata	5.3	12.0	6.3	7.6	9.1	8.2	5.0	6.3	3.9	5.8	7.0	6.9	5.5	6.8	7.7	5.1	5.4	4.0	2.7	2.7
Ammonia limbatobeccarii	0.3		0.3	0.1			0.7	0.4	0.3		0.2	0.2	0.5				0.5	0.2	1.0	1.3
Ammonia multicella																		0.2		
Ammonia pauciloculata	18.1	13.3	11.6	14.4	15.0	14.4	9.3	15.8	11.0	9.8	7.8	10.1	6.0	7.0	9.8	5.1	13.9	10.2	8.6	3.8
Ammonia tepida																		0.2	2.7	1.3
Buccella frigida																		0.2	1.4	0.7
Cancris auriculus	0.3				0.5	0.1	0.2	0.3	0.7	0.2		0.2	1.2	1.2			0.5	0.2	0.3	0.9
Cibicides lobatulus	0.3	0.2		0.2			0.2					0.4	0.5	0.2	0.5		0.2	0.7	1.0	0.2
Cibicides pseudoungerianus	1.2	0.2	0.4	0.6	0.7	0.4	0.5	0.6	0.7	0.5	0.8	1.2	1.9	1.2	0.5	0.9	0.7	1.4	1.0	2.7
Cibicides sp.								0.2				0.2	0.2		0.3	0.5	0.2	0.2	0.7	0.9
Cibicidina sp.																				
Discorbinella bertheloti																				
Epistominella naraensis	6.9	4.2	2.5	1.9	2.2	2.4	0.7	1.8	2.0	2.7	1.1	2.6	6.0	3.4	4.4	4.6	3.4	1.0	3.1	7.7
Eponides repandus						0.3							0.2				0.2			
Eponides sp.																				
Gavelinopsis sp.	1.6	3.7	3.7	0.8	0.9	1.9	1.6	2.8	2.8	2.7	2.5	3.8	5.0	1.9	2.5	4.6	2.7	1.0	1.0	1.5
Geminospira simaensis																				0.2
Gyroidina nipponica	2.2	3.0	5.3	3.1	2.2	2.4	2.6	2.8	1.4	1.4	0.3	1.0	0.2	0.2	0.8	0.5	1.1	1.4	1.0	0.4
Gyroidina sp.																			0.3	
Hanzawaia nipponica	0.9	1.0	0.3	1.2	0.7	0.4	1.2	0.4	0.4	1.0	2.1	1.8	3.1	3.1	3.3	3.2	0.5	1.0		4.2
Heterolepa dutemplei	0.3	0.2	0.8	0.7	0.9	1.0	1.9	0.9	2.0	1.4	2.7	3.4	1.7	1.5	3.3	0.5	0.5	0.7		
Hyalinea balthica	0.6	1.0	0.7	1.7	1.3	1.3	0.9	0.6	3.1	2.2	2.1	2.6	2.2	1.0	1.6	1.4	0.9	0.7	0.7	
Hyalinea sp.	0.9	1.3	1.4	1.7	0.4	1.3	0.5	1.5	0.7	0.5	0.5	0.8	1.2	0.5	0.5	1.9	0.2	1.0	0.3	1.5
Lamarkina scabra																				0.2
Neoeponides procera																				
Pararotalia nipponica															0.3	1.9	1.1	1.7	3.4	1.1
Pseudoeponides japonica	0.3	0.5	0.5	0.2	0.4	0.3	0.2	0.1	0.6	0.9	0.3	1.2	0.2		1.1	0.9	0.5	0.2	0.3	0.7
Pseudogyroidina sinensis											0.8	1.4	0.7	0.7	1.1	0.9	0.2			
Pseudorotalia indopacifica										0.2	0.3	0.2								
Pulsiphonina sp.	0.3			0.1	0.2	0.4	0.3	0.2	0.1	0.5	0.2	0.2	0.2		0.3		0.2			
Rosalina bradyi				0.1								0.2								1.8
Rosalina australis				0.1	0.3		0.3	0.1		0.5				0.7	0.8		0.5	1.0	0.3	1.5
Rotalia sp.																				
Sphaeroidina bulloides				0.1										0.2	0.3					
Seabrookea sp.				0.1						0.2				0.2	0.3					0.2
Total benthic foram counted	321	602	734	845	1114	674	579	1294	715	582	630	495	416	413	366	216	552	421	292	452

Appendix 1. Continued

Species depth (cm)	200	210	220	230	240	250	260	270	280	300	320	340	360	380	400	420	460	480	510
Gaudryina haeringensis										0.2	0.4	0.3				0.6			0.9
Protenoia spp.																			
Texularia spp.	2.2	1.3	1.1	0.4	1.3	0.4	0.2	1.0	1.3	0.5	0.4	0.6	0.9			0.9	1.3		0.9
Tritaxia donghaiensis				0.4															
Verneuilina sp.	0.4			0.8		0.8	0.2		0.1										
Ammomassilina spp.																			
Edentostomina cultrata	0.2			0.4															
Miliammina spp.	0.4	0.4	0.4	0.4	0.3	0.4	0.2			0.2				0.2				0.5	
Pyrgo elongata				0.4														0.5	
Quinqueloculina contorta		0.7				0.4		0.3	0.3	0.2	0.4		0.4						
Quinqueloculina lamarckiana	0.4										0.4								0.9
Quinqueloculina rotunda	0.7	0.7			1.3		0.2	1.3	2.1	2.7	2.6	1.0	0.4		0.5			0.5	
Quinqueloculina sabulosa	1.3	0.4	0.8	0.4				0.3	0.3	0.2									
Quinqueloculina seminula						0.4							0.2						
Quinqueloculina seminulangula	0.4		0.4		0.3	0.4		1.0		0.2								0.5	
Quinqueloculina tikutoensis							0.4		0.3										
Quinqueloculina vulgaris	2.8	13.4	2.3	7.5	8.6	2.7	1.1	1.3	1.1	1.2	2.1	0.3	1.8	0.9	2.1	0.6	3.3	5.2	5.2
Quinqueloculina spp.		2.7	1.5	1.1	0.6		1.5	1.0		0.7		3.5	1.5	1.6	1.6	0.6	1.3	1.9	1.7
Sigmoilina tenuis		0.7	0.4																
Sigmoilina spp.	0.9	0.7	0.4			1.5	0.9	0.3		2.4	1.7	0.6	1.3	0.2	1.4	1.2	1.7	1.4	0.9
Sigmoilopsis asperula	0.7	0.4	0.8	0.8		0.8	0.4	1.0	0.7	0.2									
Spioroloculata communis						1.5	0.4		0.1										
Spioroloculina laevigata	0.2							0.3			0.4								
Triloculina tricarinata	0.2																		
Triloculina trigonula					0.3									0.2			0.4		
Triloculina spp.																			
Amphicoryna sublineata	0.2													0.2					
Amphicoryna sp.																			
Botuloides sp.																			
Dentalina cf. basiplanata																			
Dentalina communis																			
Dentalina decepta																			
Dentalina extensa																			
Dentalina sp.																			
Esosyrinx sp.	0.2																		
Fissurina spp.	2.2	1.3	3.0	2.6	2.9	2.3	1.3	2.0	1.1	1.0		1.9	1.1	2.3	1.2	2.1	1.7	0.9	0.9
Lagena spp.	0.4			0.8	0.3							0.3	0.4	0.2		0.3		0.5	
Lenticulina calcar		0.2												0.2					
Lenticulina costata																			
Lenticulina iotus			0.4	0.4	0.3			0.7	0.3	0.2									
Lenticulina tumida																			
Lenticulina sp.	0.4				1.0			0.3											0.9
Polymorphina sp.														0.2					
Saracenaria italica	0.2																		
Sigmomorphina sp.					0.3		0.2					0.3							
Bifarina sp.																			
Bolivina robusta	21.8	5.1	12.4	11.3	11.1	11.7	9.6	10.3	16.7	5.4	2.1	1.9	0.2			0.3	4.6	0.9	0.9
Brizalina seminuda	0.4	0.7	0.4			0.4			0.6	0.2	0.4		0.2		0.2				
Brizalina striatuda	0.0	0.4	2.3	0.8	1.0		1.3	1.0	0.6	2.2	1.3	1.0	1.3	1.6	0.2	1.5	0.8	0.9	
Brizalina spp.	0.4	0.7	0.8		0.6	0.4	0.2	0.3	1.1	0.2			1.1	0.7	0.2	0.3		0.5	0.9
Bulimina marginata	2.6	1.6	0.8	1.1	3.2	2.3	2.6	1.7	2.9	2.0	0.9	0.3	0.4	0.2			0.8	1.4	0.9
Cassidulina carinata	1.1	0.2	1.9	0.8	0.6		0.9	0.3	2.4	0.5							0.4	0.5	
Fursenkoina pauciloculata					0.3				0.3										
Fursenkoina schreibersiana			0.4																
Globobulimina notovata	0.2			0.4															0.9
Globocassidulina subglobasa	0.7			0.8	1.3	1.1	0.4	0.7	1.1	1.2		1.0	1.1	1.8	0.9	0.9	0.4	0.9	1.7
Guembelitria vivans	0.2				0.3		0.2												
Hopkinsina pacifica			0.4																
Islandiella islandica	0.4	0.4	0.4		0.3	0.4		0.7	0.1	1.0		1.0	0.9			0.3		0.9	0.9
Rectobolivina bifrons striatula																		0.5	
Siphouvigerina porrecta																			
Stainforthia complanata																			
Trifarina angulosa	0.9	0.2	0.4			0.4													
Trifarina bradyi																	0.4		
Uvigerina canariensis	2.4	0.2	1.9	0.4	0.6	1.5	1.1	1.3	2.7	0.5	0.4		0.2		0.2			0.5	

Appendix 1. Continued

Species depth (cm)	200	210	220	230	240	250	260	270	280	300	320	340	360	380	400	420	460	480	510
Uvigerina dirupta																			
Virgulopsis orientalis									0.4	0.2							0.4		
Astrononion tasmanensis	2.0	2.7	1.1		2.5	1.9	2.4	2.7	2.7	0.5	3.4	0.3	0.4	0.2	0.2	0.6	1.3		
Cribronion incertum					0.3		0.4	0.3								2.4			
Cribronion porisuturalis		0.7										1.3			0.7		0.4	0.5	
Cribronion subincertum	0.2	2.9	0.4	3.0	1.0	0.1	2.2	1.0	0.6	1.2	6.0	2.6	2.4	4.3	2.6	2.7	1.3	1.9	2.6
Cribronion sp.					0.6					0.5		0.6	0.4	0.5			0.4		
Elphidiella Kiabgsuensis				0.4		0.4	0.2			1.0		0.6	0.9		0.7				
Elphidium advenum	6.8	4.7	6.8	5.6	5.4	8.7	7.2	12.0	5.1	6.4	6.4	8.7	9.2	7.5	8.2	10.3	13.8	12.3	8.7
Elphidium crispum																			1.7
Elphidium magellanicum	4.1	30.4	15.4	24.1	17.8	8.0	20.2	8.7	9.8	24.2	20.9	24.8	35.5	43.2	39.6	39.8	31.3	37.0	29.6
Florilus decorus	1.1	1.1	1.1	1.1	1.9	1.9	0.7	1.3	1.1	1.2	0.4	1.3	1.1	1.6	2.1	2.1	2.9	3.3	1.7
Melonis sp.														0.2					
Nonion akitaense						1.1	1.3	0.3		0.2		0.3							
Nonion stella				0.4		0.8	0.2	0.3											
Nonion sp.																	0.4		
Nonionella jacksonensis	1.1	0.2	0.4		0.3				0.6										
Nonionella magnalingua																			
Nonionella sp.	0.2	0.4			0.3			0.3	0.1			0.3							
Protelphidium compressum		0.4			0.3	1.1		0.3	0.4	1.2	0.9	0.6	1.5	0.9		0.6	0.4		
Pseudononionella sp.												1.3	0.2	0.2					
Pullenia bulloides											0.4								
Pullenia quinqueloba			0.8		0.3		0.2		0.1				0.2		0.2				
Spirilina sp.																			
Stomoloculina multangula				0.8								0.3			0.2		0.4	0.5	0.9
Ammonia annectens									0.1										
Ammonia compressiuscula	2.6	1.8	1.9	0.8	2.9	1.5	2.6	1.7	3.2	0.5	4.7	1.3	0.4	1.6	0.2	0.3	0.8	0.9	0.9
Ammonia confertitesta		3.4	4.1		0.3	15.2	14.3	16.7	6.6	17.8	15.0	16.1	15.1	15.0	14.0	10.6	4.6	6.6	6.1
Ammonia convexdorsa	0.9	2.0		2.6	0.6	0.8	1.5	0.3	0.1	0.7	2.1	2.3	1.1	0.5	0.7	0.9	0.4	1.4	2.6
Ammonia ketienzziensis angulata	3.1	1.3	1.5	2.3	2.5	0.8	2.0	3.3	4.4	1.0	1.3	1.0			0.2		1.7		1.7
Ammonia limbatobeccarii	0.7	1.1	0.8	0.4	0.3	2.3		0.7			2.1		0.4	0.2	0.2	0.3			
Ammonia multicella									0.3										
Ammonia pauciloculata	10.9	2.2	6.4	4.5	9.6	5.7	3.5	6.7	9.0	2.4	0.4	1.0	0.4		0.2	0.3	2.5		3.5
Ammonia tepida	0.2		1.5	1.9	1.0	0.4					0.4	1.3							
Buccella frigida	2.2	2.5	1.5	1.5	0.3	3.4	1.5	0.7	0.3	1.5	1.7	1.0	2.4	3.6	4.0	3.3	2.1	0.5	3.5
Cancris auriculus	0.7	0.4						0.7	0.1		0.9			0.2					
Cibicides lobatulus	0.4		0.8		0.3		0.7						1.5						
Cibicides pseudoungerianus	0.9	0.4	0.8	1.9	0.6	0.4	0.7	0.3	0.3	1.2	0.4	1.0	0.2	0.5	0.9	0.3	0.4	0.5	
Cibicides sp.		0.7	1.9			1.5	1.3	1.0	2.2	1.2	2.1	3.5	1.1	1.1	3.7	3.3	4.6	2.8	1.7
Cibicidina sp.				0.4	1.0														
Discorbinella bertheloti																		0.5	
Epistominella naraensis	2.2	0.9	5.6	4.1	3.5	2.7	2.9	1.3	2.8	1.7	0.9	1.9	0.7	0.2	0.5	1.2		0.5	1.7
Eponides repandus		0.2											0.7	0.2					
Eponides sp.																			
Gavelinopsis sp.	1.7	1.1	1.5	2.3	0.3	1.1	0.4	1.0	1.7	0.5	0.4		1.3	0.7	0.7	0.3			0.9
Geminospira simaensis				0.4															
Gyroidina nipponica	2.6	0.4	1.5	1.9	1.6	0.8	0.7	0.3	2.1						0.2		2.1		0.9
Gyroidina sp.																			
Hazawaia nipponica	2.0	0.7	0.8	1.5		0.8	1.3		1.5	1.0	2.1	1.9	1.1	0.5	0.9	2.4	0.4	0.5	0.9
Heterolepa dutemplei	1.7		2.3	2.3	1.0	0.4	0.7	1.3	1.4	1.5	0.9	0.3	1.1	0.5	0.5	0.9			
Hyalinea balthica	1.5		0.4	0.8	1.0	1.1	0.2	0.7	2.0	1.0		0.3							
Hyalinea sp.									0.6										
Lamarkina scabra		0.2																	
Neoeponides procera	0.2					0.4	0.4		0.1						0.2				
Pararotalia nipponica	2.0	3.1	3.8	1.5	2.5	5.3	5.0	7.0	2.1	7.1	10.3	7.4	4.4	3.6	7.5	7.0	7.5	5.2	4.3
Pseudoeponides japonica	0.7				0.3	0.4			0.1			0.3	0.2			0.3	0.4		0.9
Pseudogyroidina sinensis	0.4	0.2	0.8	0.4		0.4	0.4	0.7	0.7		1.3	1.3	0.2	0.9	0.7			0.9	
Pseudorotalia indopacifica					0.3			0.3									0.8	3.3	2.6
Pulsiphonina sp.	0.4		0.4					0.3	0.1					0.2					1.7
Rosalina bradyi			2.6	1.5	1.9	1.5	1.1	0.7	0.4	0.5			1.1	0.5			1.7	0.9	
Rosalina australis	0.7	0.9	0.4	0.4	0.3				0.3	0.2	0.9	0.6	0.9	0.7	1.4			0.9	1.7
Rotalia sp.																			0.9
Sphaeroidina bulloides																			
Seabrookea sp.	0.2								0.1										
Total benthic foram counted	459	447	266	266	314	264	456	300	712	409	234	310	456	440	429	329	240	211	115

Appendix 2. Planktonic foraminifera (larger than 0.125 mm) percentages in Core 97-02

Species Depth (cm)	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190
Globigerinoides conglubatus		1.5	1.3	0.4	0.5	0.6		0.2	1.0	1.0	1.1	1.3	1.4	0.4						
Globigerinoides ruber	11.3	15.9	15.2	19.8	26.5	22.4	15.1	18.0	21.9	17.3	15.7	14.0	4.1	18.0	7.1	28.6	10.0	16.7	14.3	9.4
Globigerinoides tenellus	7.9	3.5	3.9	5.0	1.4	1.7	3.4	2.2	2.6	3.0	1.1	2.2		0.9	2.0	2.9				4.7
Gs. sacculifer "with sac"					1.4			0.7	1.0		0.7	0.4		0.4				8.3		1.6
Gs. sacculifer "without sac"	5.3	3.5	3.5	1.5	1.4	1.7	10.1	3.7	3.6	3.6	3.3	2.6	4.1	1.8	7.1					
Globigerinella aequilaterals		0.5				1.1		1.0							2.0					
Globigerina calida	23.8	32.3	27.0	24.0	27.4	21.3	10.1	18.7	18.2	13.7	23.0	9.6	26.9	23.2	24.2	14.3	30.0	33.3		29.7
Globigerina bulloides	15.9	10.0	11.7	13.4	12.6	17.8	11.8	15.5	14.1	13.2	6.6	10.0	10.3	13.2	9.1	11.4	10.0			10.9
Globigerina falconensis				0.4							0.4			1.3	1.0					
Bella digitata	2.0	2.5	1.3	0.8	0.5			0.5	0.5	0.5	0.7									
Globigerina ruberscens	2.0	1.5	4.3	1.1	0.9	1.1	1.7	0.7	1.0	3.0	2.2	1.3	3.4	1.3		8.6			28.6	3.1
Neogloboquadrina pachyderma L			1.3			1.1	2.5	0.7	3.1	5.1	1.1	5.2	6.9	1.8	6.1					3.1
Neogloboquadrina pachyderma R	0.7		0.9	0.8	1.9	2.3	1.7	1.2	1.0	1.5	1.5	1.7	2.8	1.8	1.0				14.3	
Pulleniatina obliquiloculata	1.3	2.5	4.3	5.7	4.7	2.9	4.2	4.7	3.6	1.5	4.7	10.0	1.4	4.8	4.0	14.3	5.0	8.3	14.3	9.4
Globorotalia inflata					0.5		0.8													
Globorotalia crassaformis		0.5		0.4		0.6														1.6
Globorotalia menardii												0.4				2.9				
Globigerinita glutinata	18.5	12.9	14.8	13.4	8.8	14.9	23.5	21.2	14.1	20.3	22.3	24.5	26.9	21.9	23.2	8.6	30.0	16.7		12.5
Neogloboquadrina dutertrei	9.3	10.4	9.6	12.2	11.2	9.8	13.4	8.2	14.1	10.2	13.1	16.2	10.3	9.2	11.1	8.6	15.0	16.7	28.6	12.5
Globigerina quinqueloba	2.0	2.5	0.9	1.1	0.5	0.6	1.7	2.5		2.0	2.6	0.4	1.4		2.0					
Total Plankton foram counted	151	201	230	262	215	174	119	401	192	197	274	229	145	228	99	35	20	12	7	64

Species Depth (cm)	200	210	220	230	240	250	260	270	280	300	320	340	360	380	400	420	460	480	510
Globigerinoides conglubatus			10.0																
Globigerinoides ruber	9.1	4.5			12.5		5.3	23.1	11.6			50.0	16.7					33.3	
Globigerinoides tenellus		4.5			12.5				4.7										
Gs. sacculifer "with sac"					6.3														
Gs. sacculifer "without sac"		4.5				5.3		7.7								7.1	5.9		
Globigerinella aequilaterals												50.0							
Globigerina calida	36.4	36.4	50.0	50.0	18.8	21.1	47.4	15.4	27.9	52.9			16.7		100	35.7	17.6		
Globigerina bulloides	27.3	4.5				10.5	5.3	7.7	14.0					50.0		14.3	17.6		
Globigerina falconensis																			
Bella digitata										5.9									
Globigerina ruberscens						10.5				5.9									
Neogloboquadrina pachyderma L		4.5			6.3				2.3	5.9						14.3	5.9		
Neogloboquadrina pachyderma R					6.3					5.9			16.7				5.9		
Pulleniatina obliquiloculata						5.3			4.7										
Globorotalia inflata										5.9									
Globorotalia crassaformis																			
Globorotalia menardii																			
Globigerinita glutinata	9.1	18.2	10.0	50.0	18.8	31.6	21.1	7.7	18.6	5.9	33.3		33.3	50.0			23.5	33.3	100
Neogloboquadrina dutertrei	18.2	22.7	30.0		18.8	15.8	21.1	38.5	16.3	11.8	66.7		16.7			28.6	23.5	33.3	
Globigerina quinqueloba																			
Total Plankton foram counted	11	22	10	2	16	19	19	13	43	17	3	2	6	2	3	14	17	3	1

Appendix 3. PF/(BF+PF) ratio, foraminiferal abundance, BF diversity[S, H(S)], BF assemblages and coarse fraction (CF, >0.063 mm) in the sediment

Depth (cm)	PF/(PF+BF) (%)	PF Abundance per gram	BF Abundance per gram	S	BF H(S)	Agulitinated (%)	Porcelaneous (%)	Lagenids (%)	Serial (%)	Planispiral (%)	Trochospiral (%)	CF (%)
0	43.49	7904	10272	39	2.75	0.0	1.9	1.9	46.4	10.3	39.6	7.2
10	36.09	10880	19264	42	2.70	1.3	3.2	2.0	45.5	7.6	40.4	9.2
20	30.69	5200	11744	43	2.78	1.4	4.9	1.9	47.5	9.1	35.1	13.0
30	24.47	5120	13520	50	2.68	2.8	2.8	1.1	48.3	9.3	35.5	18.4
40	28.13	6976	17824	53	2.59	2.4	3.5	1.2	48.3	7.6	37.0	14.4
50	29.72	4560	10784	44	2.74	2.2	3.3	1.5	48.4	7.4	37.2	18.3
60	26.15	1640	4632	42	2.71	2.1	4.5	1.9	51.5	9.2	30.9	28.1
70	24.94	2293	6901	49	2.62	1.8	3.9	1.3	48.5	8.2	36.4	29.5
80	23.53	2347	7627	44	2.73	2.5	5.9	1.3	48.4	10.2	31.7	41.9
90	30.71	2752	6208	49	2.83	2.9	4.8	2.4	47.6	8.9	33.2	49.8
100	28.73	1355	3360	48	2.73	3.5	4.8	2.9	44.3	11.1	33.5	50.4
110	36.54	1520	2640	55	3.18	2.6	8.5	2.0	34.1	9.1	43.6	55.4
120	41.41	784	1109	50	3.20	4.1	8.2	1.9	37.3	8.9	39.7	59.6
130	40.66	755	1101	50	3.27	3.9	10.9	4.4	31.5	16.0	33.2	61.9
140	39.00	624	976	52	3.36	2.5	11.5	2.5	29.5	12.8	41.0	60.4
150	29.41	120	288	44	3.15	4.2	8.8	1.9	30.6	20.8	33.8	38.4
160	12.66	32	221	61	3.09	2.2	8.9	1.8	35.5	14.7	37.0	27.7
170	11.55	22	168	53	3.03	1.9	13.1	2.1	33.0	18.8	31.1	23.7
180	17.05	24	117	44	3.15	1.0	9.9	2.1	28.4	26.4	32.2	46.7
190	44.74	293	362	57	3.59	6.2	10.8	3.3	20.1	19.9	39.4	27.8
200	37.72	111	184	60	3.25	2.6	8.3	3.7	31.2	15.5	38.6	14.5
210	14.53	30	179	49	2.88	1.3	20.1	1.6	9.6	43.6	23.7	29.6
220	13.36	16	106	52	3.31	1.1	6.8	3.4	21.8	25.9	41.0	14.2
230	9.83	12	106	47	3.08	1.5	10.9	3.8	15.4	35.3	33.1	12.0
240	21.11	34	126	54	3.17	1.3	11.5	4.8	19.4	30.9	32.2	74.7
250	20.00	17	66	48	3.27	1.1	8.0	2.3	18.2	23.9	46.6	81.0
260	18.43	26	114	50	3.06	0.4	5.3	1.5	16.4	35.1	41.2	39.6
270	15.49	14	75	51	3.14	1.1	7.7	3.3	17.9	20.4	49.6	72.8
280	22.69	52	178	57	3.25	1.4	4.9	1.4	28.9	20.5	42.7	69.5
300	10.11	12	102	48	2.83	0.7	8.3	1.2	13.4	36.4	39.9	70.2
320	3.70	1	29	38	2.87	0.9	7.7	0.0	5.1	38.5	47.9	64.0
340	8.28	4	39	43	2.94	1.0	5.5	2.6	5.2	43.2	42.6	37.0
360	11.11	7	57	46	2.54	0.9	5.7	1.5	5.5	52.0	34.4	71.2
380	11.82	7	55	41	2.35	0.0	3.2	3.2	4.3	58.6	30.7	70.3
400	10.06	6	54	37	2.29	0.0	5.6	1.2	1.9	54.5	36.8	58.9
420	6.53	6	82	33	2.42	1.5	2.4	2.4	3.3	58.7	31.6	52.9
460	11.76	3	20	37	2.72	1.3	6.7	1.7	7.9	52.5	30.0	93.5
480	3.65	1	18	38	2.52	0.0	10.4	1.4	7.1	55.5	25.6	96.1
510	8.73	1	10	37	2.67	1.7	8.7	1.7	6.1	45.2	36.5	93.6