05SMC13AD15 FR02

Foraminiferal packstone. It is massive and sedimentary structure is not observed. Abundant planktonic foraminifera is included. Irregular patches of muddy sediments filling cavities formed by bioturbation are scattered. The fringes of the sediments are outline by Mn oxides. Foraminiferal packstone with abundant planktonic foramifera occur at the center of the patch located in the center of thin section, while marginal part of the patch, similar to the sediments of other irregular shaped patches, is occupied by sediments with poor planktonic foraminifera.

5-7-4 Identification of Microfossils

(1). Sample Preparation and Method of Fossil Identification

1). Calcareous Nannoplanktons

The sample preparation was conducted by precipitation method. At first, a fresh part of each sample was pulverized and was put into a beaker with water. After stirring, top of the water was taken by straw and was dropped to a cover glass. The cover glass was dried at low temperature of 40 ℃ on hotplate. Sealing agent was dropped on a slide glass and, then the dried cover glass, facing the sample attached side down, was placed on the slide glass. After that, this was put into Ultraviolet Box for 15 second irradiation to fix the sample.

For identification of calcareous nannoplanktons, polarization-microscope, BX-P by Olympus Corp., was used at magnification of 1,500X. Species of randomly selected 200 individuals were identified for each sample. After that, the identification work continued to confirm the occurrences of other species not included in 200 individuals.

2) Foraminifera

After washing surface and cross sections of samples and dying, fossil identification was conducted using microscope. Further, thin sections were prepared and fossil identification was conducted using biological microscope.

(2). Results of Microfossil Identification

Among the ten limestone samples of fossil identification, calcareous nannoplanktons were identified from 5 samples and planktonic foraminifera were identified from seven samples.

1). Calcareous Nannoplankton

a. Fossil Zones and Datum Planes

For international correlation of calcareous nannoplankton of the Neogene and the Quaternary, the fossil zones of Martini(1971) and Okada & Burkry (1980) and the datum planes established by Takayama & Sato (1987) and Sato et al. (1999) are commonly used. For Paleogene, the fossils zones were established by Martini (1971) with code number of NP and by Okada & Burkry (1980) (Figures 5-7-2 and 5-7-3). In this study the calcareous nannoplankton zones of Martini, which has been commonly used in Ocean Drilling Project (ODP), is used.

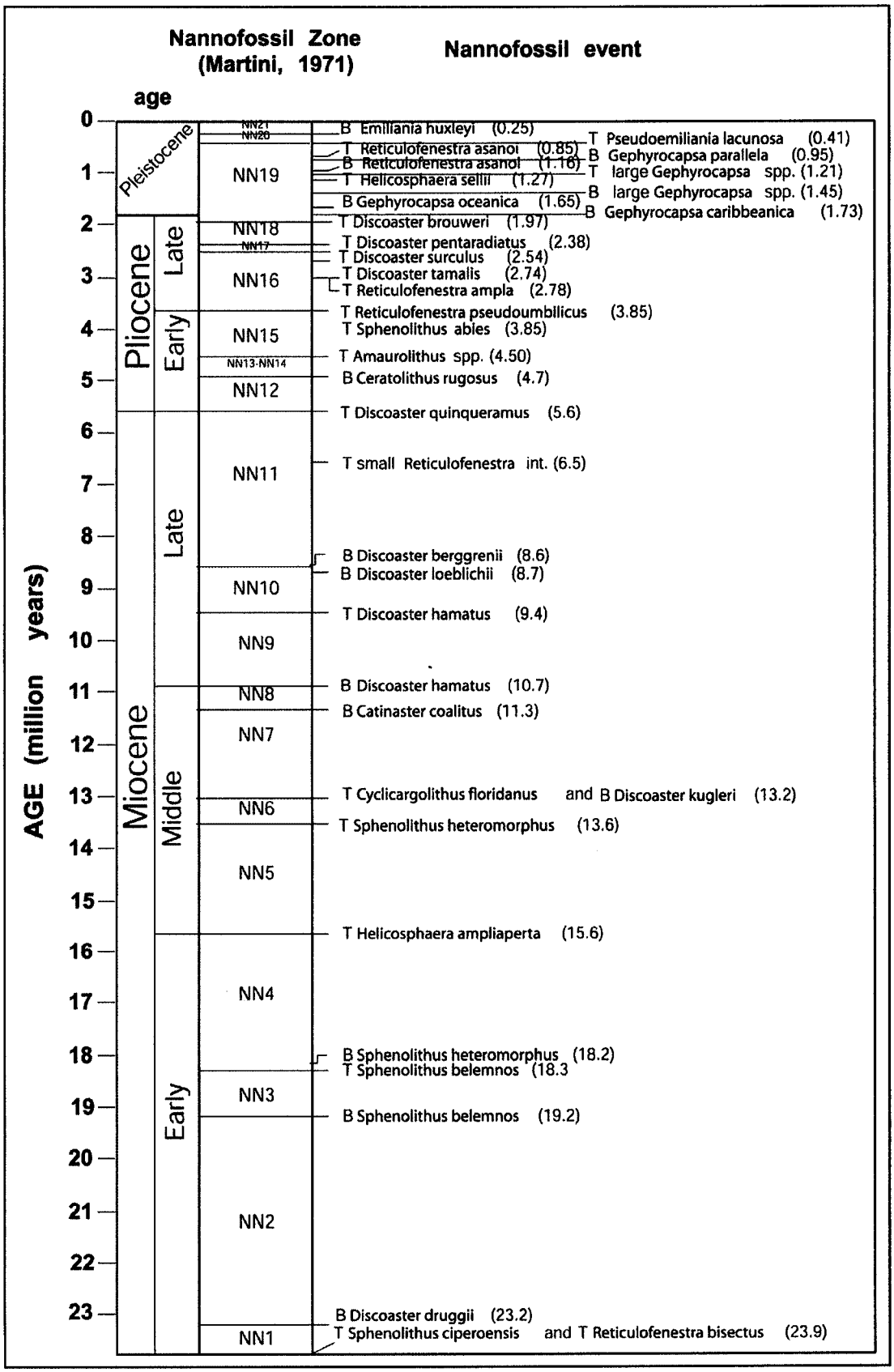


Figure 5-7-2 The Fossile Zones of Neogene to Quaternary Calcareous Nonnoplanktons by Martini (1971) and Datum Plane and Age (After Sato, 2000)

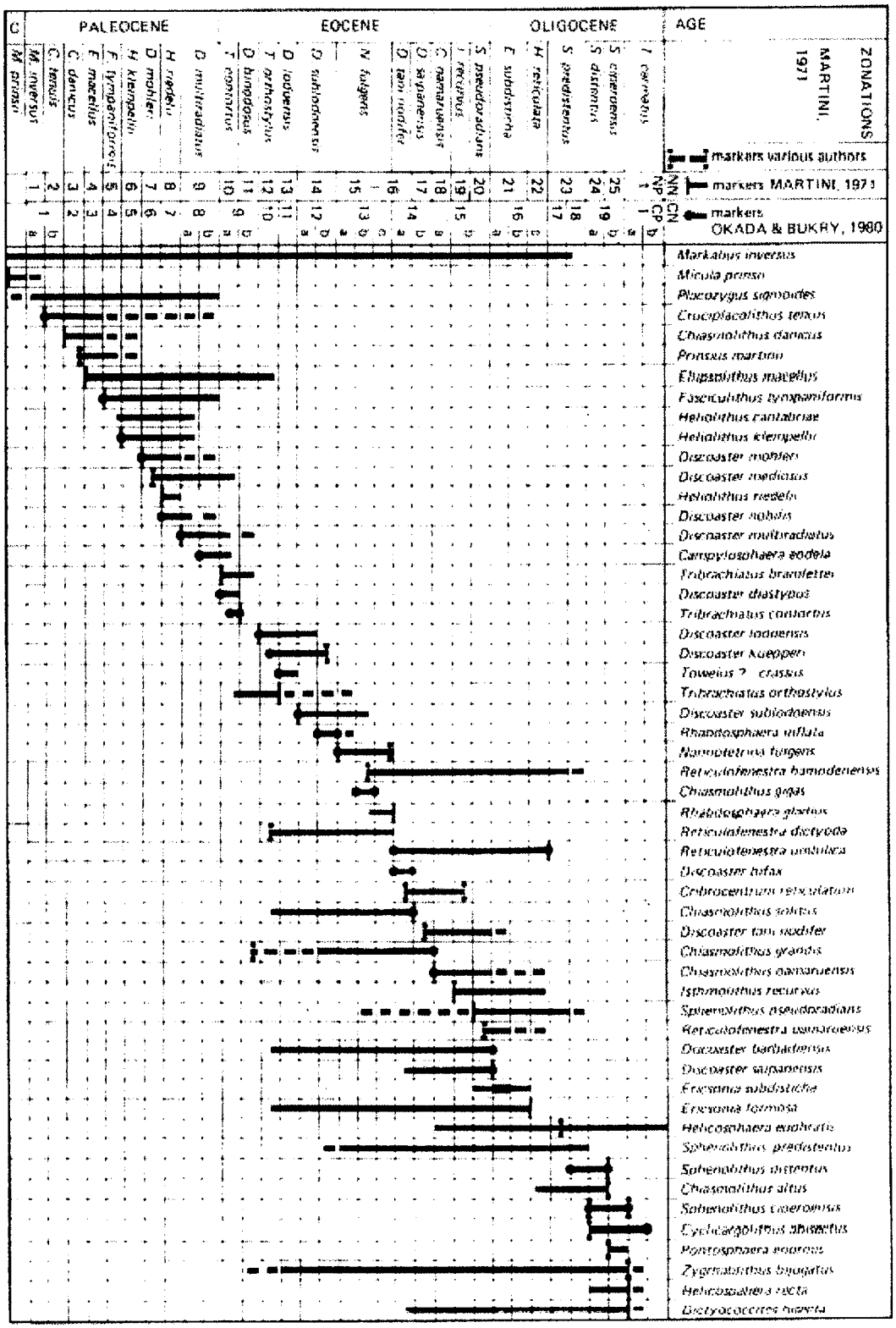


Figure 5-7-3 The fossil zones of the Paleogene Calcareous Nnnoplanktons and Datum Plane (After Perch-Nielsen, 1985)

b. Results of Calcareous Nannoplankton Identification

Among five samples studied, fossils of calcareous nannoplankton were found from five samples. The list of the identified calcareous nannoplanktons is given on Table 5-7-2.

Table 5-7-2 List of Identified Calcareous Nannoplanktons

Age(Nannofossil Zone:Martini,1971)	(Barren)	l.Eoc.-e.Olg. (NP17-23)	early Mio. (NN1)	Miocene or older	(Barren)	mixed	(Barren)	Eocene (NP12-17)
Sample	12AD15FR01	12AD20FR01	12AD25FR01	12AD29FR01	12AD29FR02	12AD29FR03	13AD15FR01	13AD15FR02
Calcidiscus formosus						+		+
Calcidiscus leptoporus								
Calcidiscus macintyrei								
Ceratolithus cristatus								
Chiasmolithus grandis								+
Coccolithus eopelagicus								+
Coccolithus pelagicus		18	20	+				+
Coccolithus miopelagicus			+					
Cyclicargolithus abisectus								
Cyclicargolithus floridanus		57	55					+
Discoaster barbadiensis								+
Dsicoaster calculosus			+					
Discoaster deflandrei			12	+				
Discoaster pentaradiatus								
Dsicoaster variabilis			2					
Discoaster spp.								
Discolithina japonica								
Discosphaera tubifera								
Eiffelithus eximius						+		
Emiliania huxleyi								
Gephyrocapsa oceanica								
Gephyrocapsa parallela								
Gephyrocapsa spp. (small)						+		
Helicosphaera carteri								
Helicosphaera granulata			+					
Helicosphaera hyalina								
Helicosphaera sellii								
Helicosphaera wallichi								
Pseudoemiliania lacunosa								
Reticulofenestra spp. (small)		14				+		
Rhabdosphaera clavigera								
Scapholithus fossilis								
Sphenolithus moriformis		10	11			+		
Sphenolithus predistentus		1						
Sphenolithus radians								+
Syracosphaera pulchra								
Tiquetrorhabdulus carinatus			+					
Umbilicosphaera sibogae						+		
Total No. (%)	B	100	100		B		B	

+': present (not counted), B: Barren, r: reworked

The characteristics of each sample are given below.

05SMC12AD20FR01

The most predominant species is *Cyclicargolithus floridanus*, accounting 57% of the total and cold current species of *Coccolithus pelagicus* is common with 18%. *Sphenolithus predistentus* rarely occur.

05SMC12AD25FR01

Same as above, *Cyclicargolithus floridanus* is the most predominant species accounting 55%. The cold current species of *Coccolithus pelagicus* occupies 20% of total, and *Discoaster calculosus* and *Triqutrorhabdulus carinatus* are rarely observed.

05SMC12AD29FR01

Only a small number of calcareous nannoplanktons were identified. *Discoaster deflandrei* rarely occurs.

05SMC12AD29FR03

The occurrences of calcareous nannoplankton is very rare, however, *Gephyrocapsa spp.* (small), *Umbilicosphaera sibogae*、*Calcidiscus formosus* and *Eiffelithus eximius* were identified.

05SMC13AD15FR02

Calcareous nannoplankton rarely occurs, however, species such as *Calcidiscus formosus*、*Discoaster barbadiensis* and *Chiasmolithus grandis* were identified.

05SMC12AD15FR01、05SMC12AD29FR02、05SMC13AD15FR01

Calcareous nannoplankton was not found in these samples.

2) Foraminifera

a. Fossil Zones and Datum Planes

The geologic age was determined by fossil zones of Blow (1969), and datum plane and time scale were based on the international time scale developed by Berggren et al. (1995) (Figures 5-7-4 to 5-7-7). Their datum planes were established on the foraminifera of the lower latitudes, and, consequently, their datum plains are directly applicable to this study. The micrographs of foraminifera are shown on Plate VI.

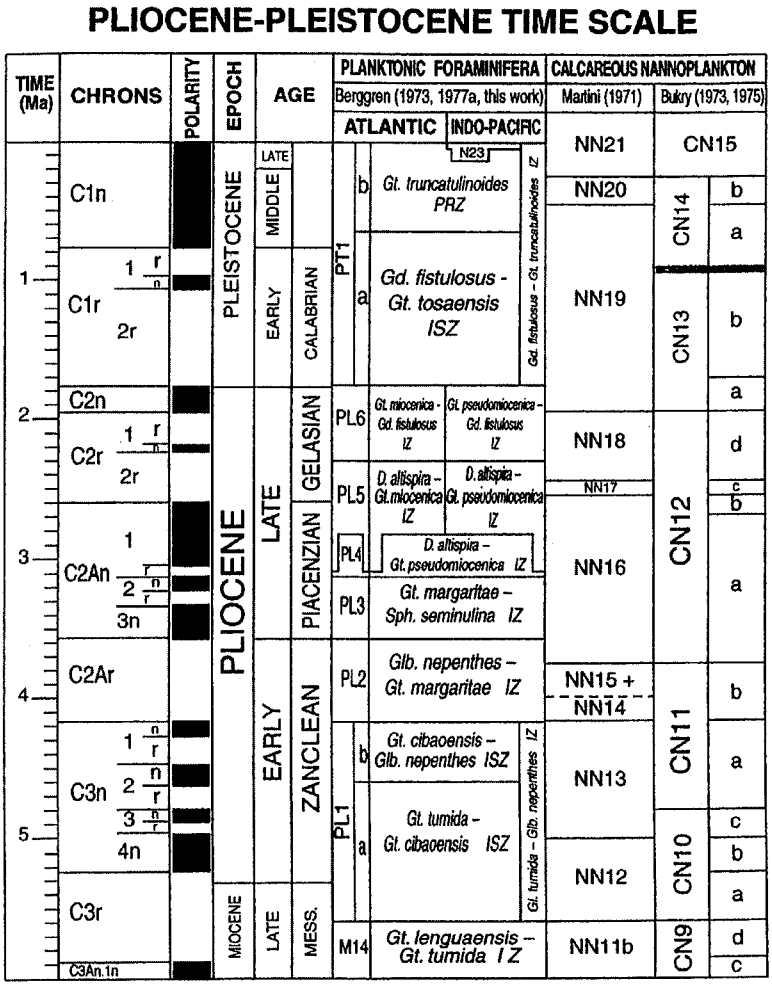


Figure 5-7-4 The Fossil Zones of Calcareous Planktonic Fossils and Time Scale (Pliocene-Pleistocene)

(After Berggren et al., 1995)

EARLY MIOCENE TIME SCALE

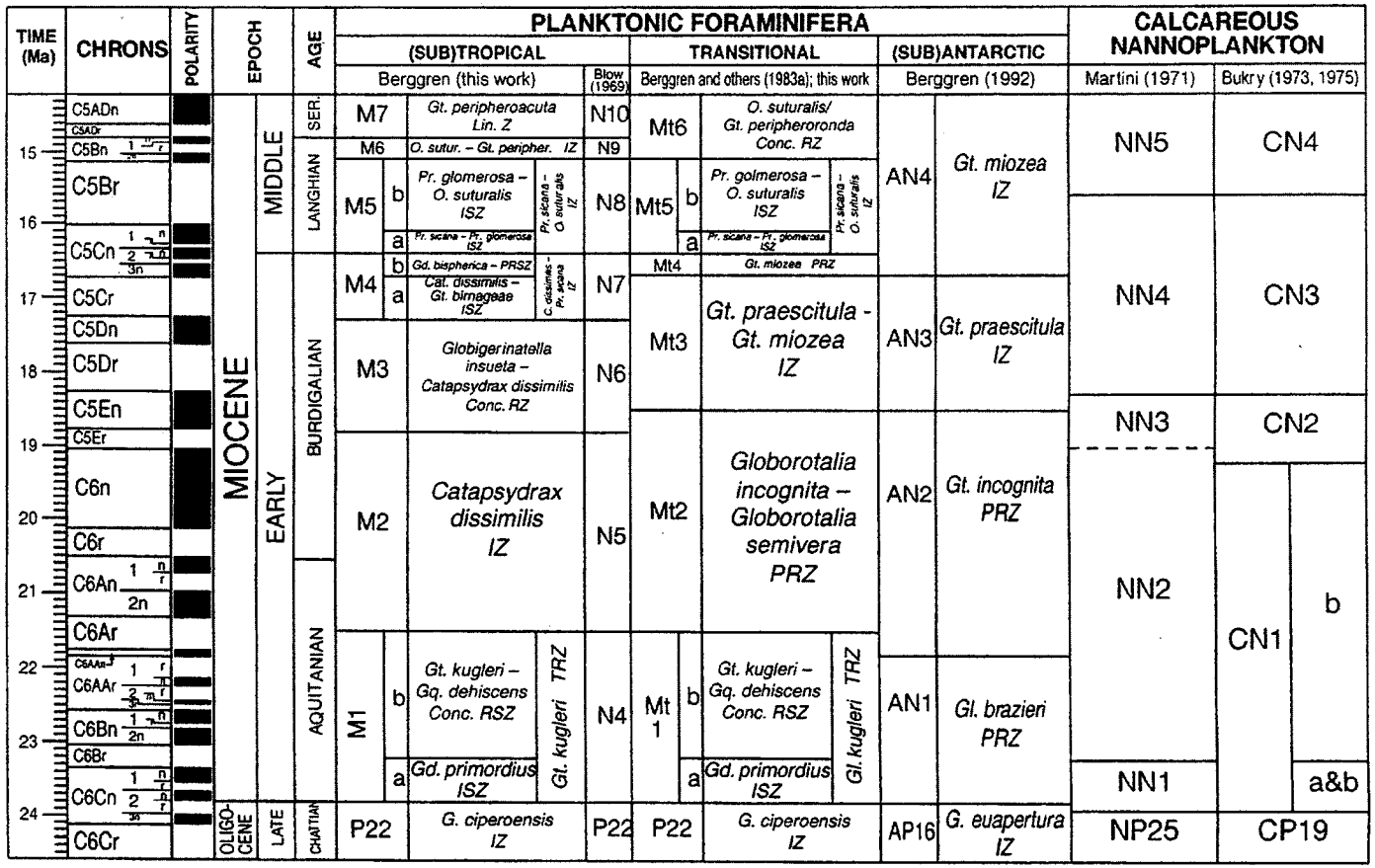


Figure 5-7-5 The Fossil Zones of Calcareous Planktonic Foraminifera and Time Scale (Early Miocene)

(After Berggren et al., 1995)

OLIGOCENE TIME SCALE

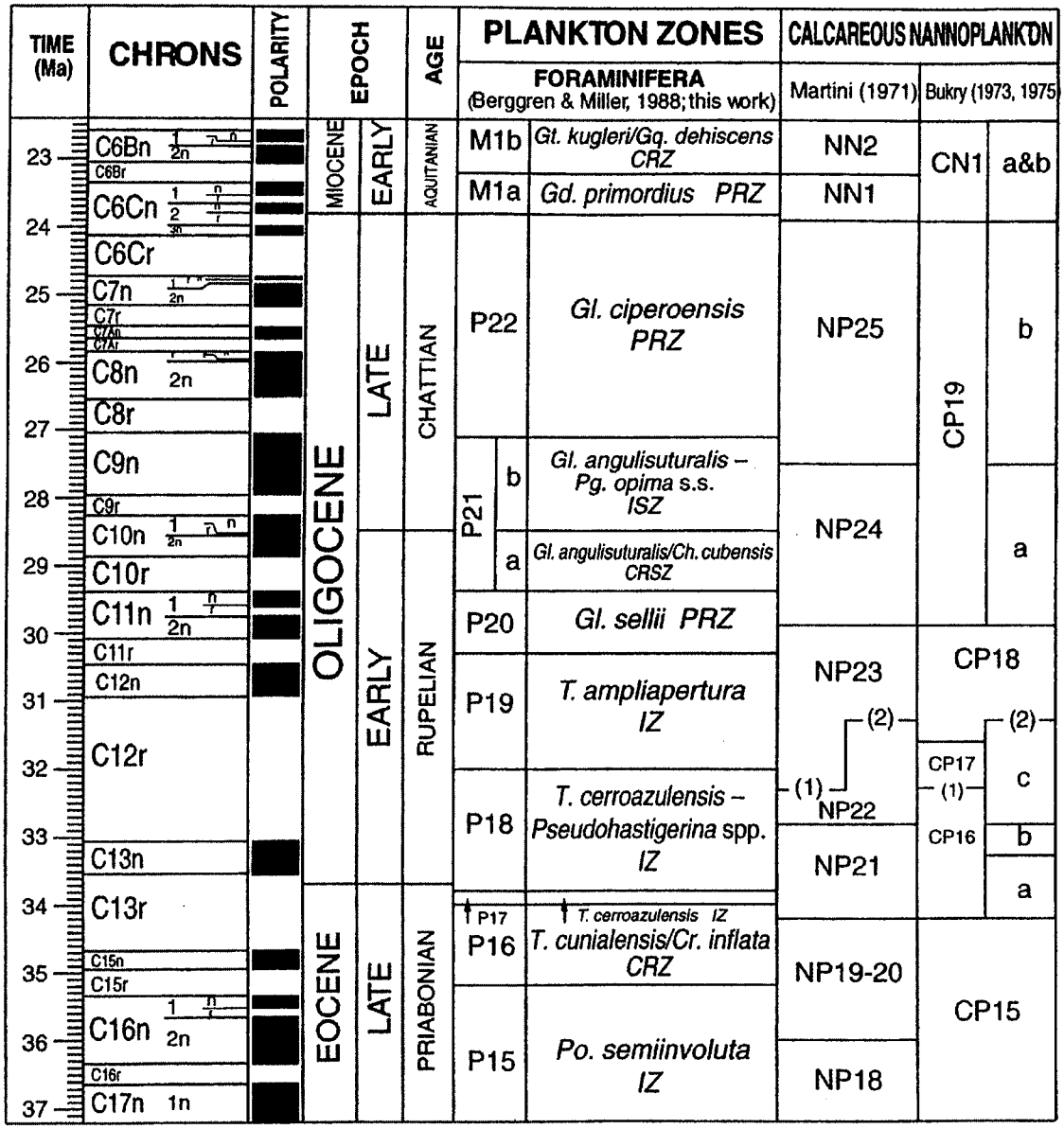


Figure 5-7-6 The Fossil Zones of Calcareous Planktonic Foraminifera and Time Scale (Oligocene)

(Berggren et al., 1995)

EOCENE TIME SCALE

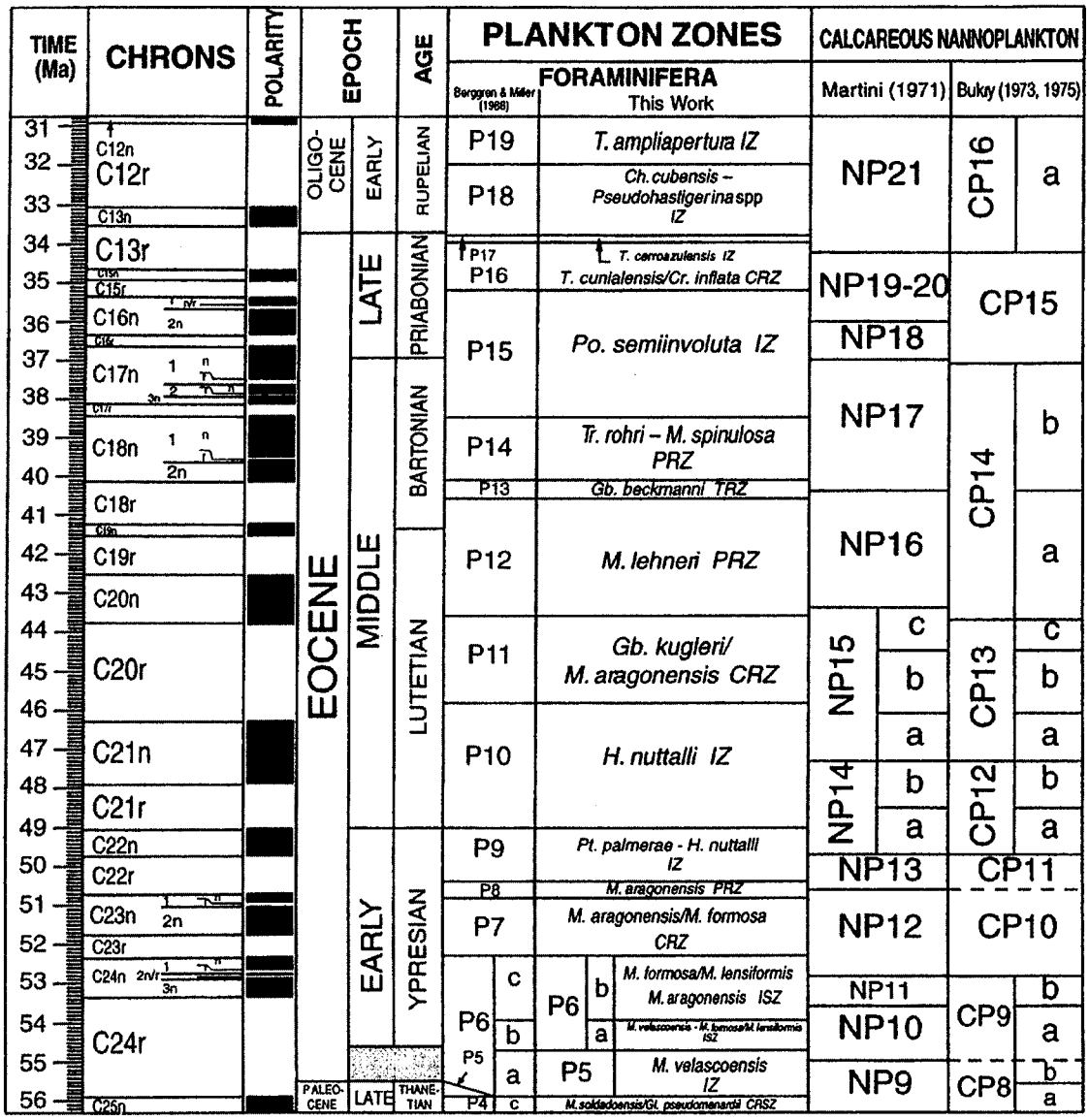


Figure 5-7-7 The Fossil Zones of Calcareous Planktonic Fossils and Time Scale (Eocene)

(Berggren et al., 1995)

b. Results of Planktonic Foraminifera Identification

Among studied eight samples, planktonic foraminifera were identified from seven samples. The results of fossil identification are given on Table 5-7-3

Table 5-7-3 List of Planktonic Foraminifera found in Calcareous Rocks

Sea Mountain	MC12							MC13
Sample No.	05SMC12AD15 FR01	05SMC12AD20 FRC01	05SMC12AD25 FR01	05SMC12AD29 FR01	05SMC12AD29 FR02	05SMC12AD29 FR02	05SMC13AD15 FR01	05SMC13AD15 FR02
Abundance	VR	VR	VR	VR	VR	non	VR	VR
Preservation	VP	VP	VP	VP	VP		M	VP
species								
Globigerina cf. binaiensis Koch			+					
Globigerina aff. eocaena Guembel	+							
Globigerina aff. ampliapertura Bolli	+							
Globigerina cf. praebulloides Blow				+				
Globigerina rubescens Hofker							+	
Globigerina spp.				+				
Globigerinoides conglobatus (Brady)			+				+	
Globigerinoides ruber (d'Orbigny)		+					+	
Globigerinoides sacculifer (Brady)		+	+				+	
Globigerinoides sp.		+						
Globigerinatheka cf. subconglobata (Shutskaya)								+
Globigerinatheka spp.					+			
Globoquadrina venezuela (Hedberg)		+						
Globorotalia menardii (Parker ,Jones and Brady)		+	+					
Globorotalia tumida (Brady)		+						
Morozovella sp.								+
Orbulina universa d'Orbigny			+					
Pulleniatina obliquiloculata (Parker and Jones)			+					
Sphaeroidinella dehiscens (Parker and Jones)		+	+				+	

Preservation M:Medium, VP:very poor

Red: Found in fillings of cavity

The characteristics of each sample are given below.

05SMC12AD15FR01

Preservation of planktonic foraminifera is this sample is poor and it was difficult to identify species. The species included in this sample seem to be *Globigerina aff. Eocaena* and *Globigerina aff. Ampliapertura.*

05SMC12AD20FR01

Because of poor preservation of planktonic foraminifera in this sample, it is difficult to

identify species, however, genera such as *Globoquadrina cf, venezuelana* and *Globigerinoides* were identified. Relatively well preserved recent species were identified in unconsolidated, pale grayish brown clay filling cavities.

05SMC12AD25FR01

Preservation of palnktonic foraminifera in this sample is poor, however, *Globigerina cf. binaiensis* was identified. Relatively well preserved recent species were found in the sediments filling cavities formed by bioturbation.

05SMC12AD29FR01

Preservation of planktonic foraminifera is poor, and only *Globigerina sp* was identified from this sample.

05SMC12AD29FR02

Preservation of planktonic foraminifera is poor, and only *Globigerinatheka sp.* was identified from this sample.

05SMC12AD29FR03

Planktonic foraminifera was not observed in this sample.

05SMC13AD15FR02

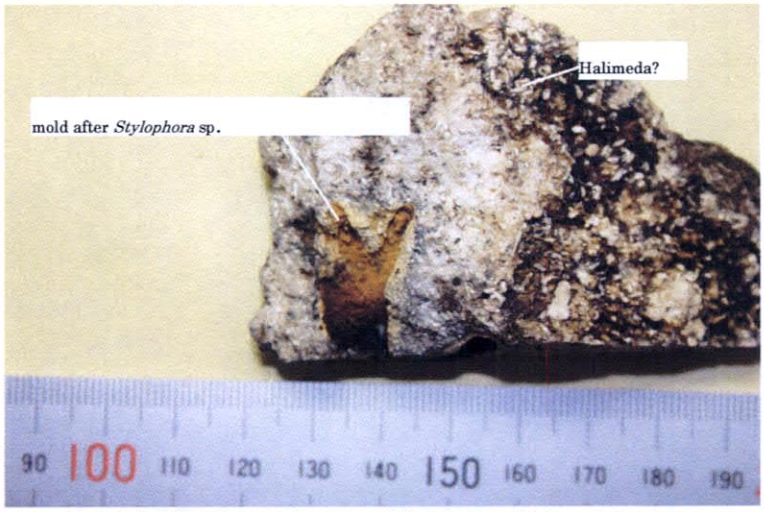
Preservation of planktonic foraminifera was poor because of recrystalization. Among identified foraminifera, only *Glonigerinatheka cf.subconglobata* and *Morozovella sp.* are index fossils.

3) Fossils

The results of studied five samples are given below. Among the five samples geologic time was obtained only from two samples; 05SMC12AD18 FRC01and 05SMC12AD20 FRC02.

05SMC12AD18 FRC01

Fragments of reef coral, *Stylophora sp.* was included, and they are partly leached forming mold. Other large fossils identified are benthic foraminifera, coralline algae and Halimeda (?), however, it is impossible to identify genus and species of them by naked eye.



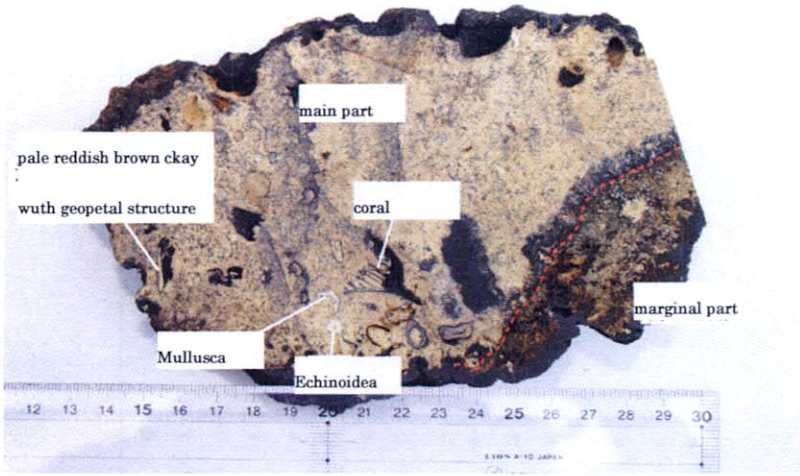
* *Stylophora sp.*

- Sessile coral of dendritic shape,
- Small size coral of approximately 1.5mm across, characterized by regular arrangements of acicular pillars and six to twelve septum
- Widely distributed in middle to western part of Indian Ocean and Pacific Ocean, commonly observed in various environments in Japan from Ryukyu Islands to southwestern part of Japan.
- It is found from Paleocene to present.

<u>05SMC12AD20 FRC01</u>

This limestone consists of two different parts: main and marginal parts.

In the main part, fragments of coral, Mullusca, *Echinoidea* are observed, however it was impossible to identify their genera and species. Fossil was not found in the marginal part.



05SMC12AD20 FRC02

Thin platy reef coral, *Porites* (?) sp. was observed. Only fragments of the reef coral occur and it seen to be allochthonous fossil. Other than this, Halimeda was observed, but it was impossible to identify its genus and species.

**Porites* sp.

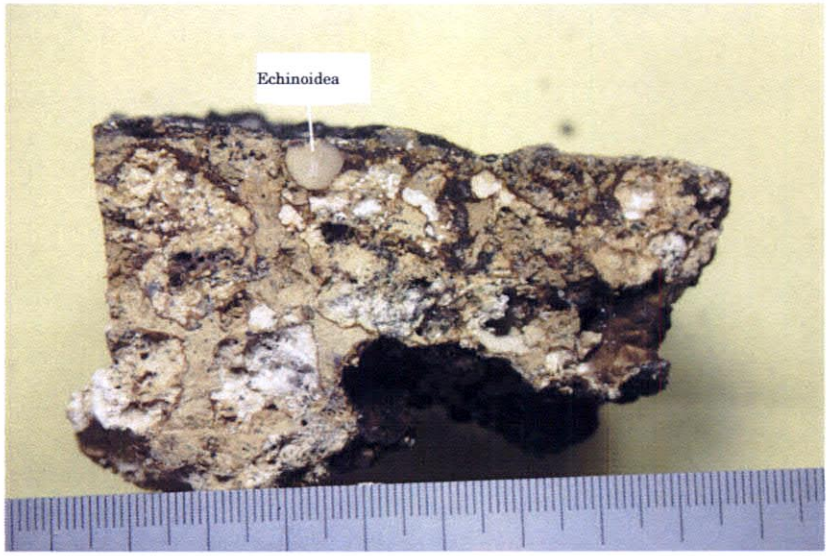
- Sessile coral and it shows variable colony shape such as massive, dendritic and foliated.
- Individual coral is less than 2mm across and it shows characteristic arrangement of septum.
- It is widely distributed in the Indian, Pacific and Atlantic Oceans, and it is found in

various environments, including coral and non-coral areas, in Japan.

- It is found from Eocene to present.

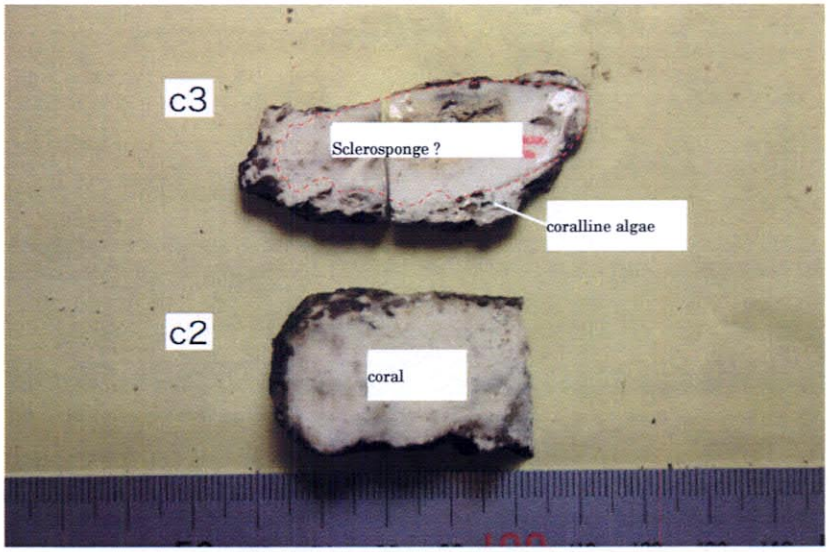
05SMC12AD25 FRC01

This calcareous conglomerate includes large bioclasts such as coralline algae and *Echinoidea*, however because of strong alteration it was impossible to identify their genera and species. Large bioclasts were not found in the matrix.



05SMC12AD29 FRC01

C2 is a milky white fragment of coral and genus and species are unknown. C3 is a fragment of sclerosponge covered by coralline algae and genus and species of them could not be identified.



5-7-5 Considerations

(1). Calcareous Nannoplankton

Based on the results of calcareous nannoplankton studies, the ages of the limestone were considered. The results of fossil studies are given on Table 5-7-4.

In the sample 05SSMC12AD20FR01, the predominant species is *Cyclicargolithus floridanus*, which has range of Palaeogene to middle of the middle Miocene. Despite poor occurrences of fossils that can be used for geological age determination, a small number of *Sphenolithus predistentus*, which has range of late Eocene to early Oligocene corresponding to fossil zones of NP17 to 23, were observed. Therefore, this sample is correlated to the age between late Eocene to early Oligocene corresponding to Martini's (1971) fossil range of NP17 to 23.

Similar to 05SMC12AD20FR01, the sample 05SMC12AD25FR01 has *Cyclicargolithus floridanus* (Palaeogene to middle of the middle Miocene) as the predominant species and then cold current type of *Coccolithus pelagicus* comes second. While, small amount of NP25 to NN1 zone species (top of late Oligocene to the bottom of early Miocene) *Discoaster calculosus*, and NN1-2 zone (bottom of early Miocene) species *Triqutrorhabdulus carinatus* are included. From these evidences, this sample is correlated to Martini's (1971) fossils zone of NN1 corresponding to the top of early Miocene.

The number of individual fossils and species are less in sample 05SMC12AD29FR01, but *Discoaster deflandrei* ranging form Paleogene to middle Miocene was observed. Uncertainty remains, however, this sample is correlated to the geological age of Paleogene to Miocene.

In spite of the rare occurrences of nannoplanktons in sample 05SMC12AD29FR03, a wide variety of species, such as common Quaternary species of *Gephyrocapsa* spp. (small) and *Umbilicosphaera sibogae*, NP12-21 zone (Paleogene and Miocene to Oligocene) species of *Calcidiscus formosus* and late Cretaceous index fossil of *Eiffelithus eximius*, are included. The sample seems to be composed of a mixture of Cretaceous, Paleogene and Quaternary materials.

The sample 05SMC13AD15FR02 collected in the MC13 area has less amount of nannoplanktons, however, Paleogene species were identified. They are NP12-21 zone (Eocene to early Oligocene) species of *Calcidiscus formosus*, NP12-21 zone (Eocene to early Oligocene) species of *Discoaster barbadiensis* and NP11-17 zone (Eocene) species of *Chiasmolithus grandis*. From these occurrences of nannoplanktons,

this sample is correlated to fossil zone NP12- 17 (Eocene).

The index fossils of Eocene, Oligocene, Neogene and Quaternary were identified by the identification of nannoplankton from six samples of MC12 area and two samples of MC13 area. The sample correlated to Quaternary has the nannoplanktons of lower horizon by resedimentation (e.g. 05SMC12MC01FS01), however, the amount of this is very limited. Therefore, limestones of the MC12 were suggested to be formed during Eocene to Miocene. Only the exception is sample 05SMC12AD29FR03 which has index fossils of Cretaceous, Paleogene and Quaternary ages. This suggests that some of samples has episode of resedimentation and mixing of older and younger materials took place.

(2) Planktonic Foraminifera

The identification of planktonic foraminifera was conducted for considering the age of calcareous rocks. The results of identification are given in Table 5-7-4.

The planktonic foraminifera included in the sample 05SMC12AD15FR01seem to be *Globigerina* aff. *Eocaena* and *Globigerina* aff. *Ampliapertura*, suggesting the formation of this sample during Oligocene. The genera of *Globoquadrina cf*、*venezuelana* and *Globigerinoides* were identified in the samples of 05SMC12AD20FR01 and this sample, possibly, was formed during Miocene. Relatively well preserved foraminofera of recent species were observed from the unconsolidated, pale grayish brown clay filling the pores of this sample.

The occurrences of *Globigerina* cf. *binaiensis* in the sample 05SMC12AD25FR01 suggest the age of this sample to be late Oligocene to early Miocene. Relatively well preserved foraminifera of recent species were identified from the sediments filling the cavity formed by bioturbation. Preservation of planktonic foraminifera in sample 05SMC12AD29FR01 is poor and only *Globigerina* sp. was identified. It was impossible to determine the age of this sample.

The occurrence of *Globigerinatheka* sp. suggests formation of the sample 05SMC12AD29FR02 to be middle Eocene. The preservation of foraminifera in the sample 05SMC13AD15FR02 is very poor because of recrystallization and *Glonigerinatheka* cf.*subconglobata* and *Morozovella* sp. were scarcely identified. Occurrences of these foraminifera suggest that this sample is correlated to fossil zone of P.11-12 (middle Eocene) by Berggren et al. (1995).

The foraminifera of Eocene, Oligocene and Miocene were identified from this study of foraminifera, however, preservation of foraminifera is poor in most of the

samples. Especially, the sample 05SMC13ADFR02 shows the poorest preservation because of recrystallization.

(3) Fossils

Among the five samples studied, geological ages could be estimated only from two samples; 05SMC12AD18FRC01 (reef coral, *Stylophora* sp.) and 05SMC12AD20FRC02 (reef coral, *Porites* (?) sp.). Each of them is respectively correlated to Paleocene to recent and Eocene to recent.

Table 5-7-4 Results of Fossil Studies Carbonate Rocks

Ser. No.	Sea Mt.	Sample No.	Depth (m)	Piece No. of sample	Lithology	Microfossils		Geological Age (based on large fossils)	Remarks
						Geological Age (based on Calcareous nonnoplanktons)	Geological Age (based on foraminifera)		
1	MC12	05SMC12AD15_FR01	2,437	c3	Calcareous clay (Pale yellowish brown~pale reddish brown clay)	not found	Oligocene?	–	Consisting of Mn oxides and pale yellowish brown to pale reddish brown clay.
2		05SMC12AD18_FRC01	1,368	c3	bioclastic grainstone (foraminiferal pack-/ wackestone)	–	–	Oligocene to present	Benthic and planktonic foraminifera, fragments (partly leached) of reef coral (*Stylophora* sp.), coralline algae and Halimeda (?) were observed.
3		05SMC12AD20_FR01	1,562	a1	bioclastic grainstone	Late Eocene to early Oligocene (NP17~23)	Miocene?	–	Consisting of main and marginal parts, Mn oxides occur at the contact of two parts
		05SMC12AD20_FRC01				–	–	impossible to determine	Consisting of main and marginal parts. Flame of coral, Mollusca and Echinoidea were observed, but it was impossible to determine their geneda and species.
4		05SMC12AD20_FRC02		c1	coral framestone/ coral rudstone	–	–	Eocene to present	Pores (possibly mold by leaching of bioclasts) of 2cm across at the maximum partly occur in the sample.
5		05SMC12AD25_FR01	2,221	c1	Calcareous conglomerate (pores are filled by foraminiferal pack-/ wackestone)	lower early Miocene (NN1)	late Oligocene to early Miocene	–	The sample is coated by Mn oxides and gray, unconsolidated clay with abundant planktonic foraminifera is attached on Mn oxides.
		05SMC12AD25_FRC01				–	–	impossible to determine	Large bioclasts such as Coralline algae and Echinoidea were included as pebbles, however, because of alteration it was impossible to determine their genera and species.
6		05SMC12AD29_FR01	2,385	a1	Coarse sandstone (pyroclastic origin)	Paleogene to Miocene?	impossible to determine	–	Calcareous part and non-calcareous part with darker color mixed together.
7		05SMC12AD29_FR02		c2, c3	c2: flame of coral c3: fragments of sclerosponge	not found	middle Eocene	–	The surface is coated by Mn oxides.
		05SMC12AD29_FRC01				–	–	impossible to determine	c2 is flame of milky white coral and c3 is a fragment of sclerosponge covered by coralline algae. It was impossible to determine their geneda and species.
8		05SMC12AD29_FR03		c4	bioclastic packstone (foraminiferal pack-/ wackestone)	mixture of Cretaceous to Quaternary species	not found	–	Irregular pores of bioclastic origin are observed. Some of them are filled by pale yellow sediments (muddy sediments with acicular plagioclase)
9	MC13	05SMC13AD15_FR01	1,724	a1	Fine sandstone (pyroclastic origin)	not found	present	–	Pores of unknown origin occur filled by foraminifera and mud pellet mixed with Mn oxides.
10		05SMC13AD15_FR02			bioclastic wakestone (forminiferal packstone)	Eocene (NP12-17)	middle Eocene (P.11-12?)	–	Massive, consolidated and without sedimentary structure. Molds formed by leaching of Mollusca were observed.

5-8 Fossil Identification of Unconsolidated Sediments

5-8-1 Samples

The identification of unconsolidated sediments was conducted for four samples collected from MC12 and MC13 Sea Mountains (Table 5-8-1).

The fossil studies were conducted by following scientists.

Calcareous nannoplankton studies : Dr. T. Sato, Faculty of Technology, Akita University

Planktonic foraminifera studies : Dr. M. Oda, Graduate Studies of Science. Toohoku University

Table 5-8-1 Samples for Fossil Identification (Unconsolidated Sediments)

Ser. No.	Sea Mt.	Sample No.	Water Depth (m)	Sampling Location (m)	Type of Sediments
1	MC12	05SMC12MC01FS01	3,315	0.10~0.11	Calcareous Sand
2		05SMC12MC02FS01	2,481	0.10~0.11	Calcareous Sand
3	MC13	05SMC13MC01FS01	2,358	0.10~0.11	Calcareous Sand
4		05SMC13MC02FS01	3,163	0.10~0.11	Calcareous Sand

5-8-2. Identification of Fossils

(1) Sample Preparation and Method of Fossil Identification

1) Calcareous Nannoplanktons

Samples were prepared following the same procedure as calcareous rock samples.

The sample preparation was conducted by precipitation method. At first, a fresh part of each sample was pulverized and was put into a beaker with water. After stirring, top of the water was taken by straw and was dropped to a cover glass. The cover glass was dried at low temperature of 40 ℃ on hotplate. Sealing agent was dropped on a slide glass and, then the dried cover glass, facing the sample attached side down, was placed on the slide glass. After that, this was put into Ultraviolet Box for 15 second irradiation to fix the sample.

For identification of calcareous nannoplanktons, polarization-microscope, BX-P by Olympus Corp., was used at magnification of 1,500X. Species of randomly selected 200 individuals were identified for each sample. After that, the identification work continued to confirm the occurrences of other species not included in 200 individuals.

2) Planktonic Foraminifera

For collection of foraminifera fossils each of unconsolidated sediments sample was directly rinsed by water using 250 mesh sheave (Oda, 1978). The collected foraminifera sample was dried and split using splitter for quantitative analysis of taxonomic composition. From the split sample, more than 100 individuals of foraminifera of more than 0.15mm across were collected using 100 mesh sheave, and then these foraminifera were studied by binocular microscope for identification of species.

3). Benthic Foraminifera

Each of unconsolidated sediments sample was directly rinsed by water using 250 mesh sheave, and then collected sample was dried at 35 ℃ using electric oven. The dried sample was split using splitter for quantitative analysis of taxonomic composition. Foraminifera of more than 0.125mm across were selected from the split sample and studied by binocular microscope for identification of species.

(2) Results of Fossil studies

Calcareous nannoplankton, palnktonic and benthic foraminifera were found from all of the examined samples.

1) Fossil Zones and Datum Planes

The fossil zones and datum planes mentioned in the chapter 5-7 were used for calcareous nannoplanlton of unconsolidated sediments.

2) Results of Calcareous Nannoplankton Identification

Calcareous nannoplankton was found in all of the studied samples. The occurrences of calcareous nannoplankton and micrograph of typical calcareous nannoplankton are given, respectively, in Table 5-8-2 and Plate VII.

All of the four samples yield calcareous nannoplankton. It was possible to identify 200 individuals of calcareous nannoplankton for 3 samples except 05SMC13MC01FS01, which has poor occurrence of calcareous nannoplankton. Preservation of calcareous nannoplankton is generally good and abundant well preserved calcareous nannoplankton occur in samples 05SMC12MC01FS01 and 05SMC13MC01FS01.

The characteristic features of each sample are given below.

Table 5-8-2 List of Calcareous Nannoplankton (Unconsolidated Sediments)

Age (Nannofossil Zone:Martini,1971)	Quaternary (NN21)	Quaternary (NN21)	Quaternary (NN21)	Quaternary (NN21)
Sample	12MC01FS01	12MC02FS01	13MC01FS01	13MC02FS01
Calcidiscus formosus				
Calcidiscus leptoporus	5	4		2
Calcidiscus macintyrei	r			
Ceratolithus cristatus	+	2		1
Chiasmolithus grandis				
Coccolithus eopelagicus				
Coccolithus pelagicus	+		+	
Coccolithus miopelagicus				
Cyclicargolithus abisectus				r
Cyclicargolithus floridanus				r
Discoaster barbadiensis				
Dsicoaster calculosus				
Discoaster deflandrei				
Discoaster pentaradiatus	r			r
Dsicoaster variabilis				
Discoaster spp.	r			
Discolithina japonica		+		+
Discosphaera tubifera			+	
Eiffelithus eximius				
Emiliania huxleyi	16	8	+	16
Gephyrocapsa oceanica	11	19	+	10
Gephyrocapsa parallela	30	21	+	18
Gephyrocapsa spp. (small)	10	23		23
Helicosphaera carteri	4	1	+	5
Helicosphaera granulata				
Helicosphaera hyalina				1
Helicosphaera sellii				r
Helicosphaera wallichi			+	2
Pseudoemiliania lacunosa				r
Reticulofenestra spp. (small)				
Rhabdosphaera clavigera	1	1	+	3
Scapholithus fossilis	4	4		1
Sphenolithus moriformis				
Sphenolithus predistentus				
Sphenolithus radians				
Syracosphaera pulchra	9	3	+	8
Tiquetrorhabdulus carinatus				
Umbilicosphaera sibogae	10	14	+	10
Total No. (%)	100	100		100

+': present (not counted), B: Barren, r: reworked

05SMC12MC01FS01

The sample yields abundant, well preserved calcareous nonnoplanktons of Quaternary index fossils, such as *Gephyrocapsa oceanica* and *G. parallela.* Among them, 16% of the total is Emiliania huxleyi, characterizing NN21 zone of late Quaternary. This sample is correlated to NN21 zone of late Quaternary.

05SMC12MC02FS01

Same as 05SMC12MC01FS01, this sample is, also, characterized by calcareous nannoplankton of late Quaternary. Particularly, *Emiliania huxleyi*, characterizing NN21 zone of late Quaternary, occurs at 8% of the total, and this sample is correlated to NN21 zone of late Quaternary.

05SMC13MC01FS01

Despite of poor occurrences of calcareous nannopalnkton, Quaternary index fossils of *G. oceanica* and *G. parallea* were identified. Further, occurrence of *Emiliania huxleyi* (NN21 zone of late Quarternary) suggests this sample being correlated to NN21 zone of late Quaternary.

05SMC13MC02FS01

Abundant, well preserved calcareous nannoplankton are observed in this sample. Among them, Quaternary index fossils of *G. oceanica* and *G. parallea* and *Emiliania huxleyi*, characterizing NN21 zone of late Quaternary, were found. This sample is correlated to NN21 zone of late quaternary.

3) Foraminifera

a. Fossil Zones and Datum Planes

The geologic age of the samples was determined based on the fossil zones of Blow (1969), datum planes and time scales of Berggren et al. (1985, 1995) (Figure 5-8-1). All of the four samples are sediments deposited after Pliocene, and they are dominated by four species of planktonic foraminifera, *Globigerinoides conglobatus , Gds. sacculifer ,Globorotalia tumida* and *Sphaeroidinella dehiscens*, accounting approximately 60% of the total. These species belong to tropic and sub-tropic geographic province (Be, 1977). The datum planes mentioned above are based on foraminifera of low latitude, consequently these datum planes are applicable to this studies.

The datum planes and ages of after Pliocene given below were used in this study.

1) Appearance of *Globigerinella calida calida* : 0.3 Ma
2) Extinction of *Globorotalia tosaensis* :0.6 Ma
3) Appearance of *Globorotalia truncatulinoides* :2.0Ma
4) Extinction of *Dentoglobigerina altispira* :3.09Ma
5) Appearance of *Globorotalia tosaensis* : 3.35Ma
6) Extinction of *Globigerina nepenthes* :4.18Ma
7) Appearance of *Sphaeroidinella dehiscens* :5.2Ma
8) Appearance of *Globorotalia tumida* :5.6Ma

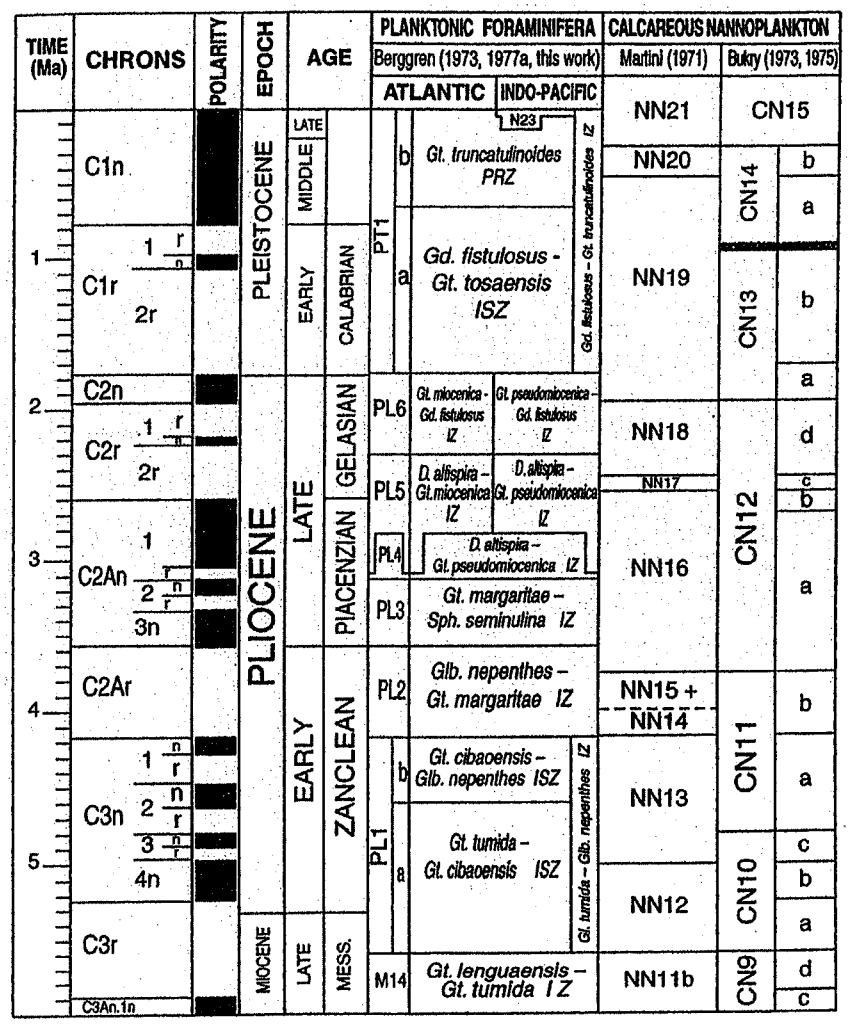


Figure 5-8-1 Zones and Time scale of Pliocene Planktonic Foraminifera of Low Latitudes

(after Berggren et al., 1995)

b. Results of Planktonic Foraminifera Identification

All of studied four samples yield planktonic foraminifera and a total of 11 genera and 19 species were identified (Table 5-8-3). The preservation of planktonic foraminifera is relatively good.

Characteristic features of each sample are given below.

05SMC12MC01FS01

Abundant, well preserved planktonic foraminifera are found in this sample. The most dominant species are *Globigerinoides rubber* and *Gds. Sacculif*, and other than these *Globorotalia tumida* and *Sphaeroidinella dehiscens* dominantly occur. The occurrences of *Globorotalia truncatulinoides* and *Glogigerinella calida* and the absence of *Globorotalia tosaensis* suggest this samples to be sediments of upper Pleistocene.

05SMC12MC02FS01

Abundant, well preserved planktonic foraminifera occur in this sample. The most dominant species are *Globigerinoides rubber* and *Gds. Sacculif.* Because of the occurrences of *Globorotalia tumida*、*Sphaeroidinella dehiscen* and *Globorotalia truncatulinoides* and the abusence of *Globorotalia tosaensis*, this sample is correlated to upper Pleistocene.

05SMC13MC01FS01

Abundant, relatively well preserved palnktonic foraminifera are found in this sample. The dominant species are *Globigerinoides ruber*、*Gds. sacculifer*、*Globorotalia tumida* and *Sphaeroidinella dehiscens.* The occurrence of *Dentoglobigerina altispira* and the absence of *Globigerina nepenthes*, *Globorotalia truncatulinoides* and *Globorotalia tosaensis* suggest that this sample is correlated to late Pliocene.

05SMC13MC02FS01

Similar to 05SMC13MC01FS01, abundant, relatively well preserved planktonic foraminifera are found in this sample. The dominant species are *Globigerinoides ruber*、*Gds. Sacculifer* and *Sphaeroidinella dehiscens.* Considering the occurrences of *Globorotalia tumida* and *Dentoglobigerina altispira* and the absence of *Globigerina nepenthes*, *Globorotalia truncatulinoides* and *Globorotalia tosaensis*, this sample is correlated to late Pliocene.

Table 5-8-3 List of Planktonic Foraminifera (Unconsolidated Sediments)

	MC12 Sea Mountain		MC13 Sea Mountain	
Sample No.	05SMC12MC01 FS01	05SMC12MC02FS01	05SMC13MC01FS01	05SMC13MC02FS02
Species	10-11cm	10-11cm	10-11cm	10-11cm
Candeina nitida d'Orbigny	VR	VR		
Globigerina bulloides d'Orbigny	VR	VR	VR	R
Globigerina rubescens Hofker		VR		
Dentoglobigerina altispira (Cushman and Jarvis)			C	R
Globigerinella aequilateralis (Brady)	R	R		
Globigerinella calida (Parker)	R			
Globigerinoides conglobatus (Brady)	F	C	C	F
Globigerinoides ruber (d'Orbigny)	C	C		R
Globigerinoides sacculifer (Brady)	C	C	C	F
Globoquadrina venezuelana (Hedberg)			R	R
Globorotalia crassaformis (Galloway and Wissler)	R	F	R	R
Globorotalia menardii (Parker ,Jones and Brady)	R	R	R	
Globorotalia scitula (Brady)	VR	R		
Globorotalia truncatulinoides (d'Orbigny)	R	R		
Globorotalia tumida (Brady)	C	C	C	C
Neogloboquadrina dutertrei (d'Orbigny)	R	R		
Orbulina universa d'Orbigny	R	R	F	R
Pulleniatina obliquiloculata (Parker and Jones)	R	R	R	R
Sphaeroidinella dehiscens (Parker and Jones)	C	C	C	C

A>30%

30%>C>10%

10%>F>3%

R<3%

c. Results of Benthic Foraminifera Identification

As shown on Table 5-8-4, benthic foraminifera occur in all of the examined samples. Foraminifera are relatively well preserved and agglutinated species are not found.

The characteristic features of each sample are given below.

05SMC12MC01FS01

Abundant occurrences of *Evolvocassidukina brevis* (Aoki)、*Gavelinopsis praegeri* (Heron-Allen and Earland)、*Oridorsalis umbonatus* (Reuss) and *Pseudoparrella exigua* (Brady) are observed.

05SMC12MC02FS01

This sample is characterized by the occurrences of *G. praegeri* and *Pullenia bulloides* (d'Orbigny).

05SMC13MC01FS01

The occurrences of benthic foramionifera in this sample are poor and only the foraminifera with more than 0.355mm across were observed. Among them, *Globocassidulina subglobosa* (Brady), *Laticarinina holophora* (Stache) and *Uvigerina proboscidea Schwager* are frequently observed.

05SMC13MC02FS01

This sample is characterized by abundant occurrences of *G. subglobosa, O. umbonatus* and *P. exigua*

Table 5-8-4 List of Identified Benthic Foraminifera

Locality	MC12		MC13	
Sample No.	05SMC12MC01	05SMC12MC02	05SMC13MC01	05SMC13MC02
Water depth (m)	3,315	2,481	2,358	3,163
Presevation	G	G	G	G
A/T ratio (%)	0	0	0	0
Benthic foraminiferal no. (/g)	----	----	----	----
Calcareous foraminifers				
Aragonia aragonensis (nuttall)		1		
Anomalinoides sp.			1	4
Astrononion sp.			1	3
Bulimina aculeata d'Orbigny		2		1
Bulimina rostrata Brady		1		
Cassidulina sp.			1	2
Cibicides wuellerstorfi (Schwager)		3		2
Cibicides spp.	4	3		1
Discorbinella convexa (Takayanagi)			1	
Ehrenbergina hystrix Brady				1
Ehrenbergina pacifica Cushman	1		1	
Evolvocassidukina brevis (Aoki)	7			2
Fissurina spp.	5	2	1	3
Gavelinopsis praegeri (Heron-Allen and Earland)	6	15		7
Globocassidulina cressa (d'Orbigny)	2	1		2
Globocassidulina moluccensis (Germeraad)		1		
Globocassidulina mucronata Nomura				1
Globocassidulina parviapertura Nomura	3	2	1	
Globocassidulina subglobosa (Brady)	3	6	4	10
Globocassidulina sp.	1	5	2	
Gyroidina altiformis (R.E. and K.C. Stewart)		1		
Gyroidina orbicularis d'Orbigny	2	1	1	4
Gyroidina soldanii d'Orbigny	1			1
Gyroidinoides nipponicus (Ishizaki)		1		2
Lagena spp.	2	1		
Laticarinina holophora (Stache)			4	
Lenticulina sp.		1		
Lernella sp.				1
Melonis barleeanus (Williamson)	1			
Melonis sphaeroides Voloshinova				1
Nodosaria longiscata d'Orbigny		1	1	1
Nuttallides umbonifera (Cushman)	2	3	2	1
Oolina sp.	1	1		2
Oridorsalis umbonatus (Reuss)	6	2	1	11
Osangularia culter (Parker and Jones)		2		1
Paracassidulina quasicarinata Nomura				4
Paracassidulina sulcata (Belford)	1	2	2	
Parafissurina sp.	1			
Pleurostomella sp.			1	
Pseudononion sp.				1
Pseudoparrella exigua (Brady)	13		1	12
Pullenia bulloides (d'Orbigny)	5	7		5
Pullenia quinqueloba (Reuss)	2			2
Pullenia salisburyi R.E. and R.C. Stewart	1	1		
Pyrgo murrhina (Schwager)	2		2	
Quinqueloculin sp.	1		2	
Rosalina sp.			1	
Rupertia stabilis Wallich	1			
Sphaeroidina compacta Cushman and Todd	1			
Stilostomella spp.				1
Tosaia hanzawai Takayanagi	1	1		1
Uvigerina proboscidea Schwager	2	4	6	2
Miscellaneous calcareous foraminifera	7	3	2	4
Total number of benthic foraminifera	85	74	39	96

5-8-3. Considerations

Calcareous nannoplankton, planktonic and benthic foraminifera were observed from all of the examined four samples. The geologic age estimated from calcareous nannoplankton and planktonic foraminifera and the environment of sedimentation estimated from benyhic foraminifera are summarized in Table 5-8-5.

Table 5-8-5 Results of Fossil Identification (Unconsolidated sediments)

Ser. No.	Sea Mt.	Sample No.	Water Depth (m)	Samplin g depth	Type of Sediments	Geologic Age (based on calcareous nannoplankton)	Geologic Age (based on planktonic foraminifera)	Environment of Sedimentation (based on benthic foraminifera)
1	MC12	05SMC12MC01FS01	3,315	0.10~0.11	Calcareous Sand	late Quaternary (NN21)	upper Pleistocene	lower bathyal zone
2		05SMC12MC02FS01	2,481		Calcareous Sand	late Quaternary (NN21)	upper Pleistocene	unknown
3	MC13	05SMC13MC01FS01	2,358		Calcareous Sand	late Quaternary (NN21)	late Pliocene	unknown
4		05SMC13MC02FS01	3,163		Calcareous Sand	late Quaternary (NN21)	late Pliocene	lower bathyal zone

The paleobathymetry was estimated based on vertical distribution of present benthic foraminifera in the warm current area of the northwest Pacific (Akimoto,1990, Akinoto 1999, Akimoto and Torii, 1996, Akimoto et al.,2002, Inoue,1989, Kaiho & Nishimura, 1992) and in the equatorial area (Akimoto ,1994).

The genera such as *Globocassidulina subglobosa* and *Globocassidulina* tend to occur in summit area of sea mountain (Akimoto, 1994). *Gavelinopsis praegeri*, *Oridorsalis umbonatus* and *Pseudoparrella exigua* mainly occur in respective zones of upper bathyal, middle bathyal and lower bathyal.

The sample 05SMC12MC02 collected at 2,481m of MC12 area yield a small amount of lower bathyal zone type *Nuttallides umbonifera* (Cushman), in addition to upper bathyal zone type *G. praegeri*, suggesting that the sample has an episode of re-sedimentation. This coincide with the evidence of sorting in sample 05SMC13MC01 collected at 2,358m of MC13 area. Because of these mixing of foraminifera fossils in these samples, it is difficult to determine paleobathymetry. Since the sampling depths of these samples agree with the distribution depth of *N. umbonifera*, the sedimentation of these samples took place, probably, in lower bathyal zone.

Abundant *Pseudoparrella exigua* observed in the samples collected at more than 3,000m deep (05SMC12MC01 and 05SMC13MC02) suggest that sedimentation of

these samples took place in lower bathyal zone.

Based on the fossil studies of unconsolidated sediments, the sedimentation of the unconsolidated sediments covering MC12 area took place in Quaternary and that covering MC13 area in late Pliocene to Quaternary, and all of these were formed in lower bathyal environment.