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Miocene Calcareous Nannofossils of the Bihoku Group in the Shobara Area, Hiroshima Prefecture, Southwest Japan

YAMAMOTO Yasuo[1] and SATO Tokiyuki[2]

1 Department of Geosciences, Faculty of Science, Osaka City University, Osaka 558-8585, Japan.
2 Institute of Applied Earth Sciences, Department of Geosciences, Mining Engineering and Materials Processing, Mining College, Akita University, Akita 010-0852, Japan.

Abstract

Calcareous nannofossil flora and its biostratigraphic correlation of the Miocene Bihoku Group are investigated, in the Shobara area, Hiroshima Prefecture, SW Japan.

Eleven genera 23 species of calcareous nannofossils are identified from the Korematsu Formation and the lower part of the Itabashi Formation. Floras of these samples are characterized by the relative frequency changes of *C. pelagicus* versus *S. heteromorphus* and the smaller *Reticulofenestra* coccolith.

Based on the occurrence of *S. heteromorphus*, *H. ampliaperta*, *H. scissura*, *H. euphratis*, *D. deflandrei*, *D. exilis*, *C. macityrei*,and the lack of occurrence of *S. belemnos*, the Korematsu Formation and the lowermost part of the Itabashi Formation can be correlated with the upper part of biozone NN4 of Martini (1971). The biohorizon of the top acme of *D. deflandrei* was recognized around the lithostratigraphic horizon of the Mitsukaichi tuff bed (s Member) in the Itabashi Formation.

This biostratigraphic result is most fundamental and provides valuable data for interpretation of the Early to Middle Miocene transgression in the Southwest Japan.

Key words: calcareous nannofossil, Shobara, Bihoku Group, Miocene, biostratigraphic correlation

Introduction

Marine Tertiary deposits are sporadically distributed in the mountainside of the Chugoku Province, southwest Japan. These were considered to be the Miocene age, based on the study of benthic fossils primarily, and called as "the Setouchi Miocene Series".

There has been discussion that the transgression in related to the global sea level rise and/or tectonic activities relating to the development of the back-arc basin (Ueda and Takayasu, 1992; Nomura, 1992 and other authors). To solve this problem, we have few fundamental data about the geologic age of the Setouchi Miocene Series. Plankton biostratigraphic data are necessary for the stratigraphic correlation and age determination in marine strata. Previously, few planktonic microfossil data were reported from the Setouchi Miocene Series (Saito, 1963; Yoshimoto, 1979; Tai et al., 1979; Okamoto, 1992; Watanabe et al., 1999).

The calcareous nannofossils are one of the most useful microfossils for biostratigraphic correlation of shallow marine formations, numerous specimens of which could be determined from a few samples only, by simple preparation; many biostratigraphic investigations have been reported from a world-wide region. Sato et al. (1992) studied the Miocene calcareous nannofossil biostratigraphy in the back-arc region of central to northeast Japan. Miocene calcareous nannofossil biostratigraphic correlation between the western part of the Chugoku Province and the back-arc region is significant for an interpretation about transgression in southwest Japan. However, only Yoshimoto (1979) and Huang and Okamoto (1980) reported these from the Miocene of the Chugoku Province.

The Shobara area, which is located in the northeastern part of the Hiroshima prefecture, was well known as one of an archetypal and representative marine Miocene basin in the western part of the Setouchi province, Southwest Japan. The purpose of this study is to investigate the Miocene calcareous nannofossil flora on the margin of the Paleo-Japan Sea.

Geologic settings

The marine Miocene formations are spread sporadically over the Cretaceous volcanics basement in the Northern part of Hiroshima Prefecture. Imamura et al. (1953) called these formations the "Bihoku Group". Ueda (1986, 1989) revised the Bihoku Group in the Miyoshi-Shobara area, based on lithostratigraphic study.

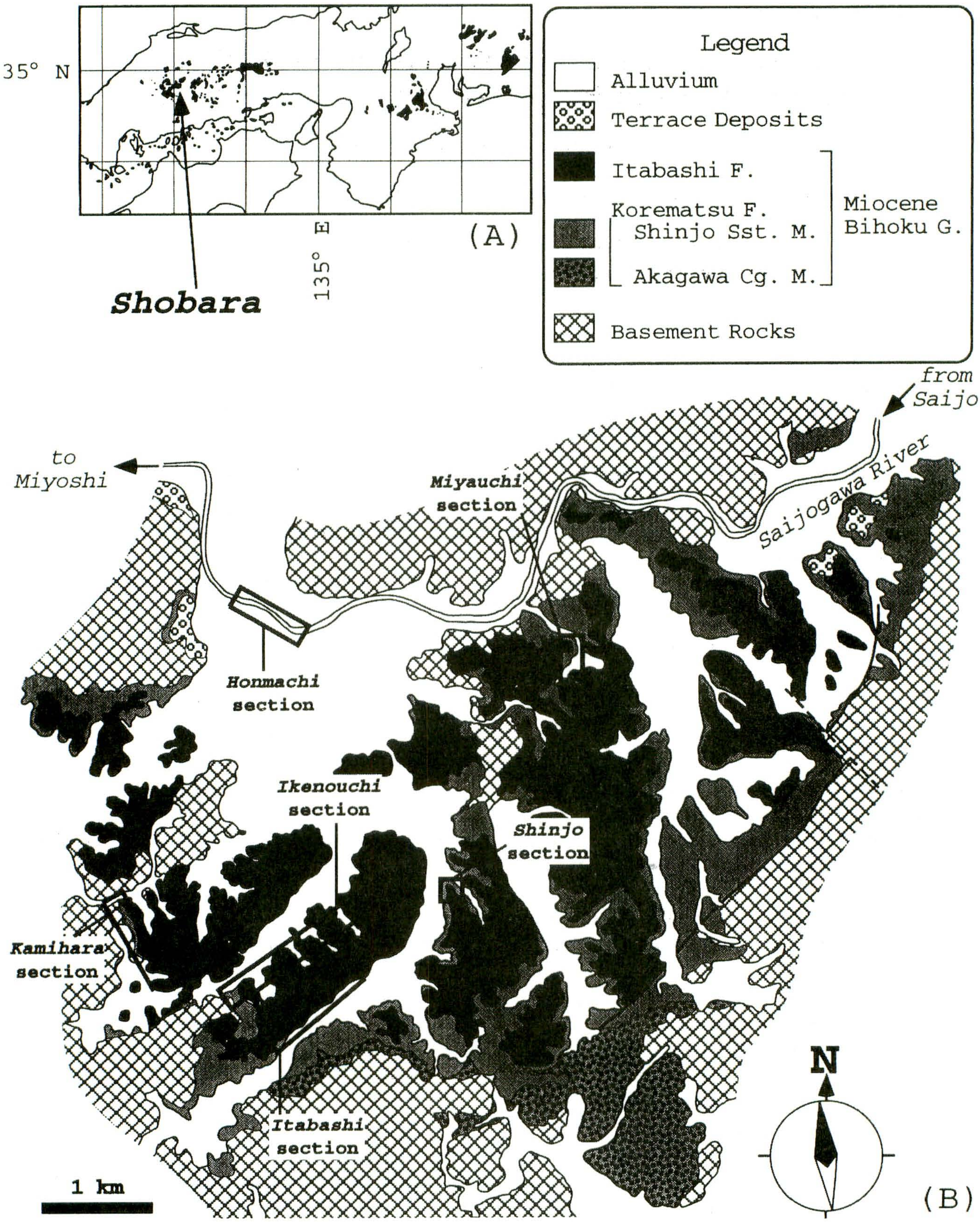

Fig. 1 (A) Distribution of the 1st Setouchi Supergroup. (B) Location of the sampled sections showed in the geologic map of Shobara basin (modified after Ueda, 1986).

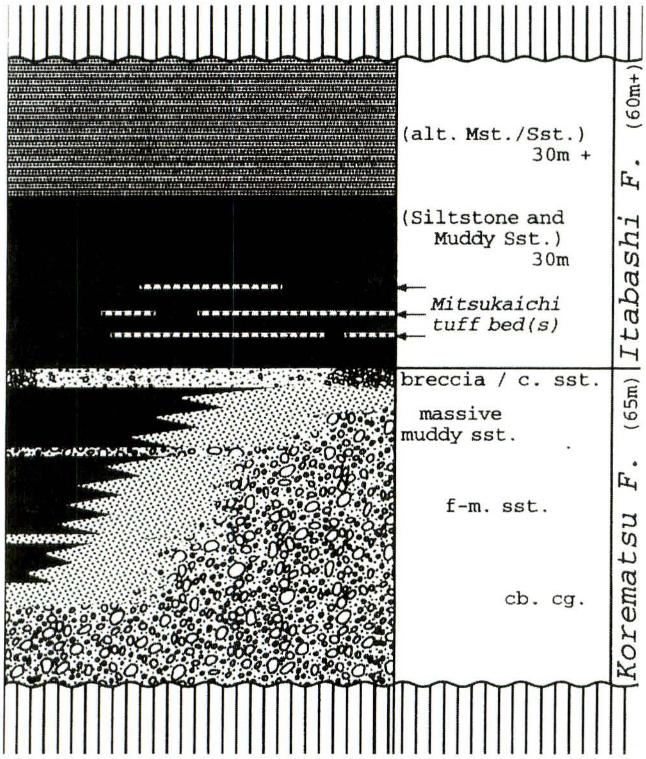

Fig. 2 Generalized lithologic sequence of the Miocene Bihoku Group in the Shobara area (modified after Ueda, 1989).

The Korematsu Formation, the total thickness of which is ca. 65 m, consists of conglomerates, sandstones and muddy sandstones, which were deposited in a shallow marine environment. The Itabashi Formation, the total thickness of which is over 60 m, consists of muddy sandstones, siltstones and siltstones/sandstones alternations. The Shiomachi Formation, consists of non-marine conglomerates, sandstones and siltstones, which underlies the marine formations in the Miyoshi area, is not distributed in the Shobara area. A generalized lithologic sequence of the Miocene Bihoku Group in the Shobara area is shown in Fig. 2.

Section measurement and sample collection

Samples were collected from the six main sections in the Shobara area. The lithofacies of all collected samples are massive, muddy sandstone or siltstone. Accurate sampling was was carried out to cover as many stratigraphic horizons as possible, in a meter-order interval from each section. However, nannofossils could not be identified from the middle to the upper part of the Itabashi Formation. The localities of the samples are shown in Fig. 3.

Fine tuff layers in the lower part of the Itabashi Formation were correlated with the Mitsukaichi Tuff Bed (s member) of Ueda (1986, 1989). The type locality of the tuff bed (s member) is designated in the Mitsukaichi outcrop between the Kamihara and Honmachi. Ueda (1986, 1989) described the tuff bed (s member) as sometimes being separated into two or three layers. In this study, more thin tuff layers are observed around the horizon of Ueda's (1986, 1989) Mitsukaichi Tuff Bed (s member). Correlation of these tuff layers is too difficult because thiness of the layers (less than 1 cm) and the volcanic materials showing complete weathering. However, the lithostratigraphic interval of these tuff layers could be correlated between sections (Fig. 4).

1. Kamihara section

In the western part of the Shobara basin, the national park of "Bihoku Kuryo Koen" was constructed in the early 1990's. During this construction, the uppermost part of the Korematsu Formation and almost of the Itabashi Formation were well exposed, but these exposures have not reminded. The route around the small valley which is situated in the west of the park was visible in April, 1998, and Ueda (1986) also showed the columnar section of the same route.

Around this area, horizons of the uppermost part of the Korematsu Formation to the middle part of Itabashi Formation rest directly on the Cretaceous basement, with an angular unconformity between. The bedding planes of the Bihoku Group are almost horizontal or slightly dipping to the southeast (0 to 5 degrees). Hermatypic coral bioherm and *Operculina complanata japonica* (large foraminifera) indicating the "Mid-Neogene Climatic Optimum" of Tsuchi (1992), were recognized in the uppermost part of the Korematsu Formation.

Kam-01 and 02 were collected from the route of the small valley, and Kam-03 and 04 come from the construction outcrops. Two relatively thick (10 to 30 cm) fine tuff layers are recognized in the lower part of the Itabashi Formation in each route. The columnar section shown in Fig. 4 is a composite of two sections, compiled by correlation of the tuff layers.

2. Ikenouchi section

This section was measured along the northwestern side of the hill passing to the southwest from the Shobara interchange of the Chugoku expressway, in the southwestern part of the Shobara basin. Several small outcrops appear and disappear around this route.

The bedding planes of the Bihoku Group are gently dipping to the north (2 to 10 degrees). Slumping and/or landslide structures were often observed in the Itabashi Formation. Many thin, tuff layers are recognized in the lower part of Itabashi Formation. The sections of each of the small outcrops were compiled by the correlation of the tuff layers mentioned above. The samples collected at two outcrops are shown in Fig. 3.

3. Itabashi section

This section located in the southeastern side of the hills which is similar to the Ikenouchi section. Ueda (1986 and 1989) designated here as the type section of the Itabashi Formation Around this route, the bedding planes of the Bihoku Group are almost horizontal or slightly dipping to the north (0 to 5 degrees).

Samples collected from the two outcrops along this route are shown in Fig. 3. The three, fine tuff layers, correlating to the "Mitsukaichi Tuff Beds" of Ueda (1986; 1989) are recognized in the horizons between Ita-01 and Ita-04. The two relatively thick (ca. 50 cm and 10 cm) tuff layers are indicated as bold lines in Fig. 4. Both outcrops were visible in April, 1998.

4. Shinjo section

The southern part of Shobara basin, along the route of National road no. 432 from Korematsu-cho to Shinjo-cho, was designated as the type section of the Korematsu Formation (Ueda, 1986 and 1989). On the western hills of this route, horizon of the Itabashi Formation were exposed by major construction in the late 1980's. In these exposures, the Foram. Sharp Line (Nomura, 1992) was recognized by Okamoto (1992). Occurrence of the Pteropod fossils was reported by Okamoto (1992) from the horizon below the FSL. However, these exposure have not survived. The upper part of column in Fig. 4 was proposed by Okamoto (1992).

In this study, the samples were collected from the western side of the hills where exposed by other minor construction, but this outcrop has also disappeared. Bedding planes of the Bihoku Group are almost horizontal. A thin tuff layer was recognized in the uppermost part of this outcrop.

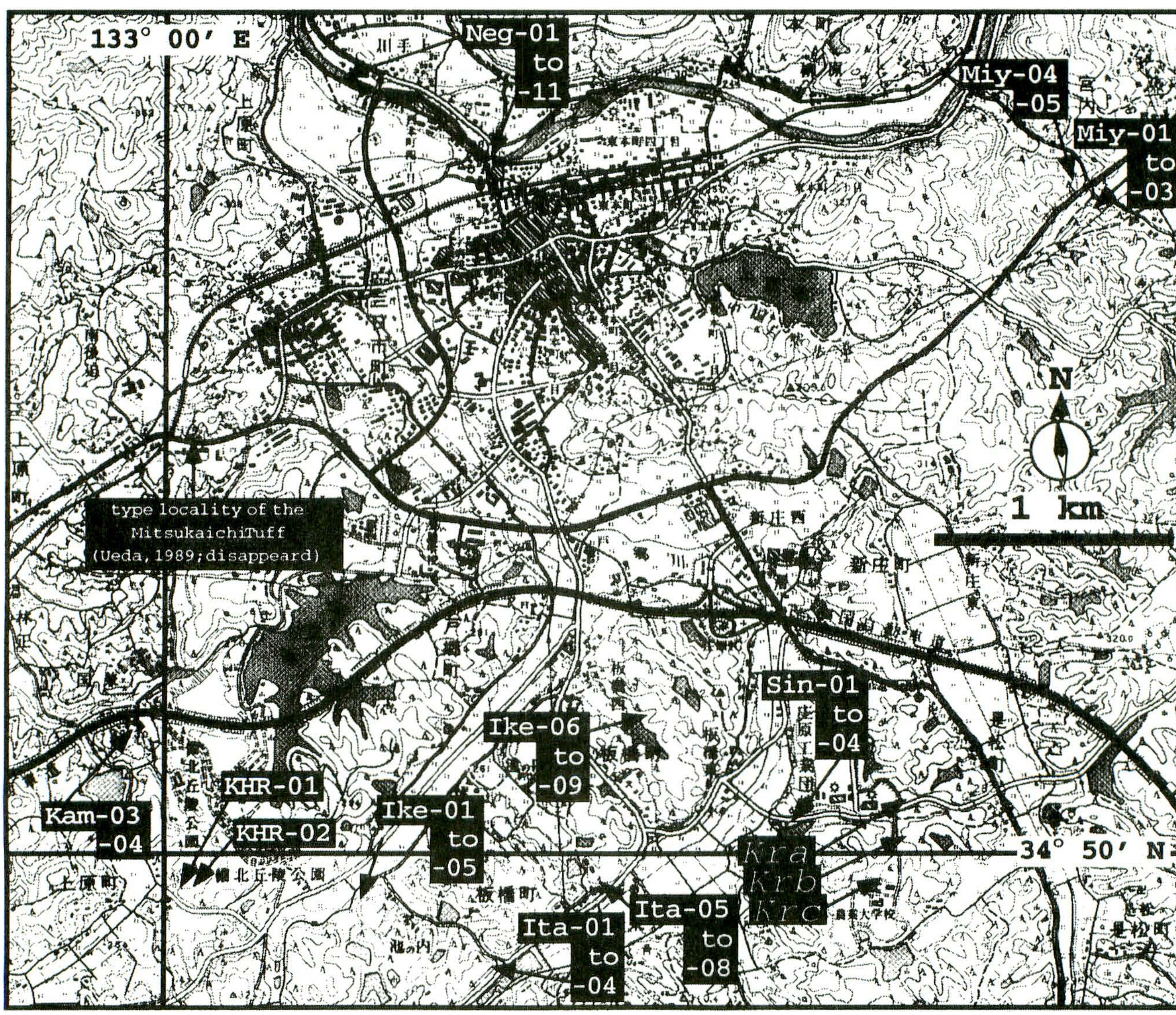

Fig. 3 Location of the sampled outcrops showed in the 1 : 25,000 geomorphologic map "Shobara" "Inakusa" "Nagata" and "Mirasaka" published by Geographical Survey of Japan. Localities of the *Kra*, *Krb* and *Krc* after Okamoto (1992).

5. Honmachi section

On the river bed of the Saijogawa river, which flows westward in the northern part of the basin, the Korematsu Formation (50 m) and the lower part of the Itabashi Formation (10 m) are exposed continuously. The Bihoku Group overlies the Cretaceous basement, and bedding planes are dipping to the southeast or south at 5 to 10 degrees.

Two layers of *Operculina complanata japonica* were recognized in the lower part of Korematsu Formation. The two thin tuff layers were recognized in the uppermost part of this section. The molluscan fossil assemblages (Okamoto et al., 1990; Ueda, 1991), benthic foraminifera fossil assemblages (Nomura, 1988) and Decapod crustacean fossil assemblages (Sakumoto, 1996) were reported from the similar section. Yamamoto (1999) has described the lithofacies distribution and discussed the paleoenvironmental changes around these outcrops. These excellent natural outcrops are visible whenever.

The calcareous nannofossil flora in this section are reported in Yamamoto (1999). The same data used for more detailed biostratigraphic investigation in the present study.

6. Miyauchi section

Many molluscan fossils indicating a tropical, brackish, shallow marine (mangrove swamp and related) paleoenvironment, were reported from the northeastern part of the basin (Okamoto and Terachi, 1974). Planktonic foraminifera indicating Blow's (1969) biozone N7 to N9, have been reported from the lower part of the "Upper Shale Formation of the Bihoku Group" (approximately similar to the

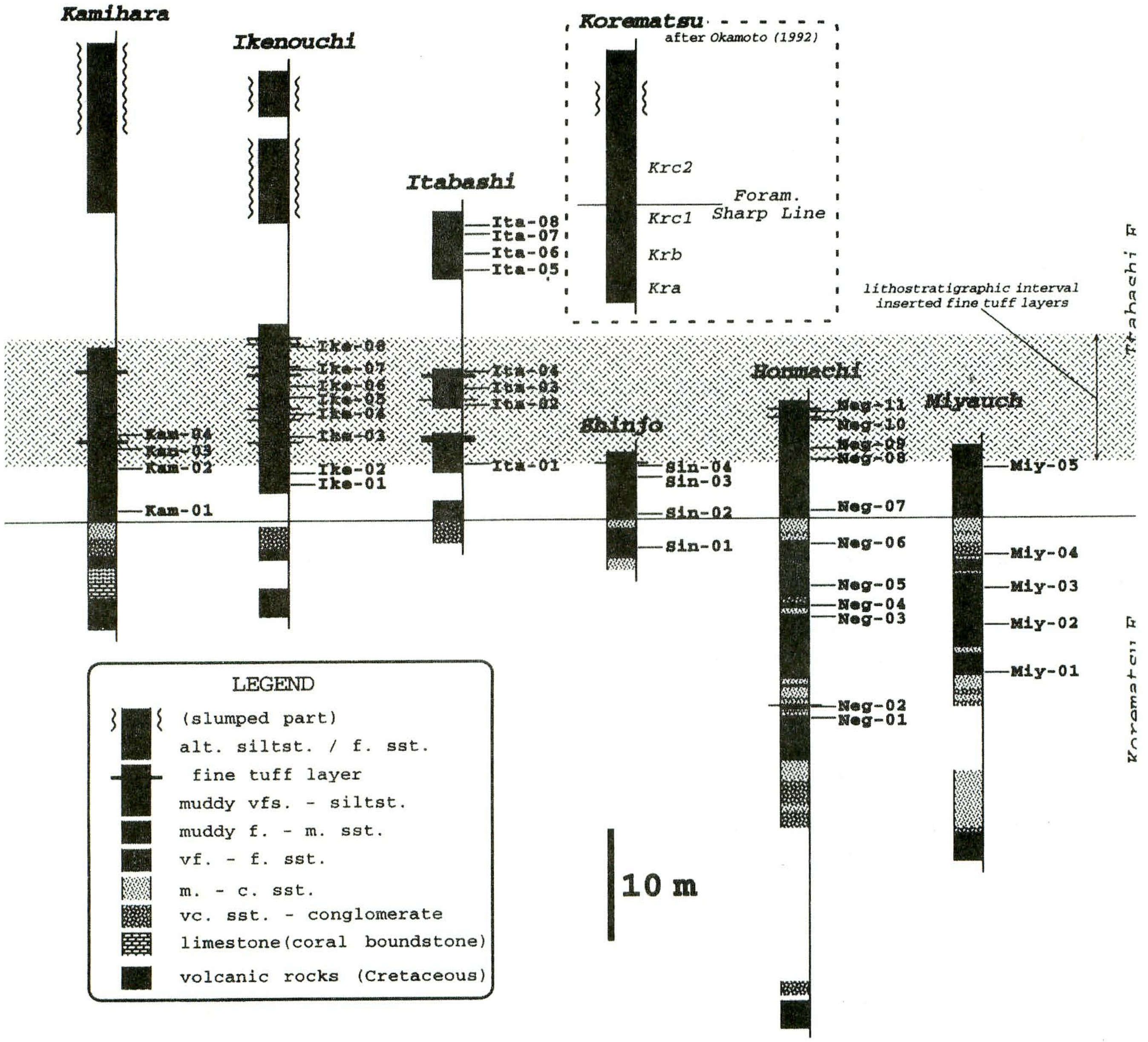

Fig. 4 Correlation of columnar sections in the studied area. Column of the "*Korematsu*" section by Okamoto (1992).

Itabashi Formation) in this area (Okamoto, 1992).

Miy-04 and 05 were collected from the outcrop on the western side of the "Kaisekidani-bashi" bridge. This outcrop existed in April, 1998. Miy-01, 02, 03 were collected from the disappeared outcrop on the southern side of same bridge which was exposed by the construction work in 1995. Bedding planes of the Bihoku Group are almost horizontal around the bridge. *Vicarya* was identified from the lower part of Korematsu Formation in the southern outcrop.

Table. 1 Identified taxa in this study.

Braarudosphaera Deflandre (1947)
- *Braarudosphaera bigelowii* (Gran and Braarud 1935) Deflandre (1947)

Calcidiscus Kamptner (1950)
- *Calcidiscus leptoporus* (Murray and Blackman 1898) Loeblich and Tappan (1978)
- *Calcidiscus premacintyrei* Theodoridis (1984)
- *Calcidiscus macintyrei* (Bukry and Bramlette 1969) Loeblich and Tappan (1978)

Coccolithus Schwarz (1894)
- *Coccolithus miopelagicus* Bukry (1971)
- *Coccolithus pelagicus* (Wallich 1877) Schiller (1930)

Coronocyclus Hay, Mohler and Wade (1966)
- *Coronocyclus nitescens* (Kamptner 1963) Bramlette and Wilcoxon (1967)

Cyclicargolithus Bukry (1971)
- *Cyclicargolithus floridanus* (Roth and Hay in Hay et al. 1967) Bukry (1971)

Dictyococcites Black (1967)
- *Dictyococcites antarcticus* Haq (1976)
- *Dictyococcites productus* (Kamptner 1963) Backman (1980)

Discoaster Tan(1927)
- *Discoaster deflandrei* Bramlette and Riedel (1954)
- *Discoaster exilis* Martini and Bramlette (1963)
- *Discoaster variabilis* Martini and Bramlette (1963)
- *Discoaster* spp.

Helicosphaera Kamptner (1954)
- *Helicosphaera ampliaperta* Bramlette and Wilcoxon (1967)
- *Helicosphaera cartrei* (Wallich 1877) Kamptner (1954)
- *Helicosphaera euphratis* Haq (1966)
- *Helicosphaera granulata* Bukry and Percival (1971)
- *Helicosphaera intermedia* Martini (1965)
- *Helicosphaera scissura* Miller (1981)
- *Helicosphaera* spp.

Pontosphaera Lohmann (1902)
- *Pontosphaera multipora* (Kamptner 1948) Roth (1970)
- *Pontosphaera* spp.

Reticulofenestra Hay, Mohler and Wade (1966)
- *Reticulofenestra* spp. (small)
- *Reticulofenestra* spp. (large)

Sphenolithus Deflandre in Grassé (1952)
- *Sphenolithus abies* Deflandre in Deflandre and Fert (1954)
- *Sphenolithus heteromorphus* Deflandre (1953)
- *Sphenolithus moriformis* (Brönnimann and Stradner 1960) Bramlette and Wilcoxon (1967)

Miscellaneous

Methods

Powdered samples were smeared over 18 x 18 mm cover glasses, and enclosed on slide glasses by photocuring adhesive. Calcareous nannofossils were observed in these smear slides by standard polarized light microscopy techniques (0 to 90 degree cross-polarized light at x800 to x1500 magnification). More than 200 specimens of the coccoliths were identified taxa in each sample. After this examination, the slides were continuously scanned for the presence of other species. Furthermore, 50 *Discoaster* specimens were identified in the each selected 15 samples. Sequential changes of relative occurrence ratio of the *D. deflandrei* in total number of the *Discoaster* specimens were showed in Fig. 5.

In this study, *Reticulofenestra* -type placoliths were counted as *Reticulofenestra* (large) and (small), dividing then on a long axis diameter of five micrometers. These placolith were not identified in species order. Some uncertain forms of *Discoaster* specimens (aff. *D. formosus*, *D. musicus*, and so forth) were also not identified, and were counted as "*Discoaster* spp.". Other taxonomy followed after Perch-Nielsen (1985), except *Calcidiscus premacintyrei* Theodoridis (1984).

Results

Eleven genera and 23 species of the calcareous nannofossils are identified from 24 samples. Determined taxa are listed in Tables 1 and 2. Relative frequencies of the taxa and their stratigraphic changes on the composite section are presented in Fig. 5. In six samples (Neg-01, 02, 03, 04 and 06, 07), the nannofossils were scarcely preserved and numbered less than 200 specimens in a slide. About these samples, only the qualitive data of taxa occurrences are pre-

Table 2 Occurrence of the calcareous nannofossils in the six sections. "+" indicate coccolith encountered after the routine count or occurrence of taxa in poorly preserved nannoflora.

sample code	*B. bigelowii*	*C. leptoporus*	*C. macintyrei*	*C. premacintyrei*	*C. miopelagicus*	*C. pelagicus*	*C. nitescens*	*C. floridanus*	*D. antarcticus*	*D. productus*	*D. deflandrei*	*D. exilis*	*D. variabilis*	*Discoaster* spp.	*H. ampliaperta*	*H. cartrei*	*H. euphratis*	*H. granulata*	*H. intermedia*	*H. scissura*	*Helicosphaera* spp.	*P. multipora*	*Pontospohaera* spp.	*Reticulofenestra* (S)	*Reticulofenestra* (L)	*S. abies*	*S. heteromorphus*	*S. moriformis*	miscellaneous	total
Kam-04		1	0	2	4	121	2	0	1	2	3	0	1	2		13					1	1	2	72	27	5	64	9		333
Kam-03		0			5	78	2	2	1	1	5		0	3		5				1		1	1	63	15	5	50	7		245
Kam-02	1	0		1	8	124	3	4	1	7	3		1	2		18		1		1		1	1	37	25	0	31	5		275
Kam-01	1	0		1	2	65					21	1	1	5		25		1					1	61	10	1	15	7		218
Ike-08																														barren
Ike-07																														barren
Ike-06																														barren
Ike-05																														barren
Ike-04																														barren
Ike-03																														barren
Ike-02		1			6	100	1	1	2	15	4	1	2	1		29	1			2	3			58	6	2	14	2		251
Ike-01																														barren
Ita-08																														barren
Ita-07																														barren
Ita-06																														barren
Ita-05																														barren
Ita-04		0		1	3	37	2	2	3	7	4		2	1	1	8				1	4	0		49	25	9	54	8		221
Ita-03	0		1		2	77	3	2		4	3		0	1		11		1			1	1	2	88	16	5	29	6	2	255
Ita-02	0			0	5	58	1	1		4	4		2	1	1	2				1	1	1		89	23	5	24	4	1	228
Ita-01																														barren
Sin-04																														barren
Sin-03					3	102	1	5	1	3	4		2		1	23				2	1			55	10	2	47	4		266
Sin-02		1		3		91	2	9	5	5	7	2	1		1	24				1	4			49	7	6	47	7	1	273
Sin-01					4	93	1	1	2	2	2		0			14				1				42	13	8	79	8	1	271
Neg-11		1	1	1	4	70	1	2		3	5	2	6	8	1	10					2	1	1	59	19	6	18	4	1	226
Neg-10			1		2	105	2	2	2	1	2	2	5	5		13						1		63	7	1	6	4	1	225
Neg-09					4	117	2	3	1	3	3			1		32				1	4			28	6	1	5	2	2	215
Neg-08		1		1	2	125	1	1	2	7	2			0	2	17	1	2	1	2	4	1	1	40	17	5	8	7	0	250
Neg-07			+			+		+	+	+	+			+		+				+	+			+	+	+	+	+	+	87
Neg-06				+		+		+	+	+	+		+	+		+				+	+			+	+	+	+	+	+	105
Neg-05		1			2	76	1	2	2	5	5		3	3		29		1			1			32	6	5	22	5		201
Neg-04					+	+			+	+	+			+		+				+	+			+	+	+	+			130
Neg-03	+				+	+				+	+				+	+		+			+			+		+	+	+		129
Neg-02	+				+	+		+			+				+	+				+	+			+	+	+	+	+		71
Neg-01	+					+					+		+			+								+	+	+	+	+		69
Miy-05					3	85		2	5	5	6		2	3	2	41			1	5	2			53	7	3	57	4	3	289
Miy-04					4	151	1	1		1	4	1	4	2	6	25			1	4	6			4	4	1	8	3	1	232
Miy-03																														barren
Miy-02																														barren
Miy-01																														barren

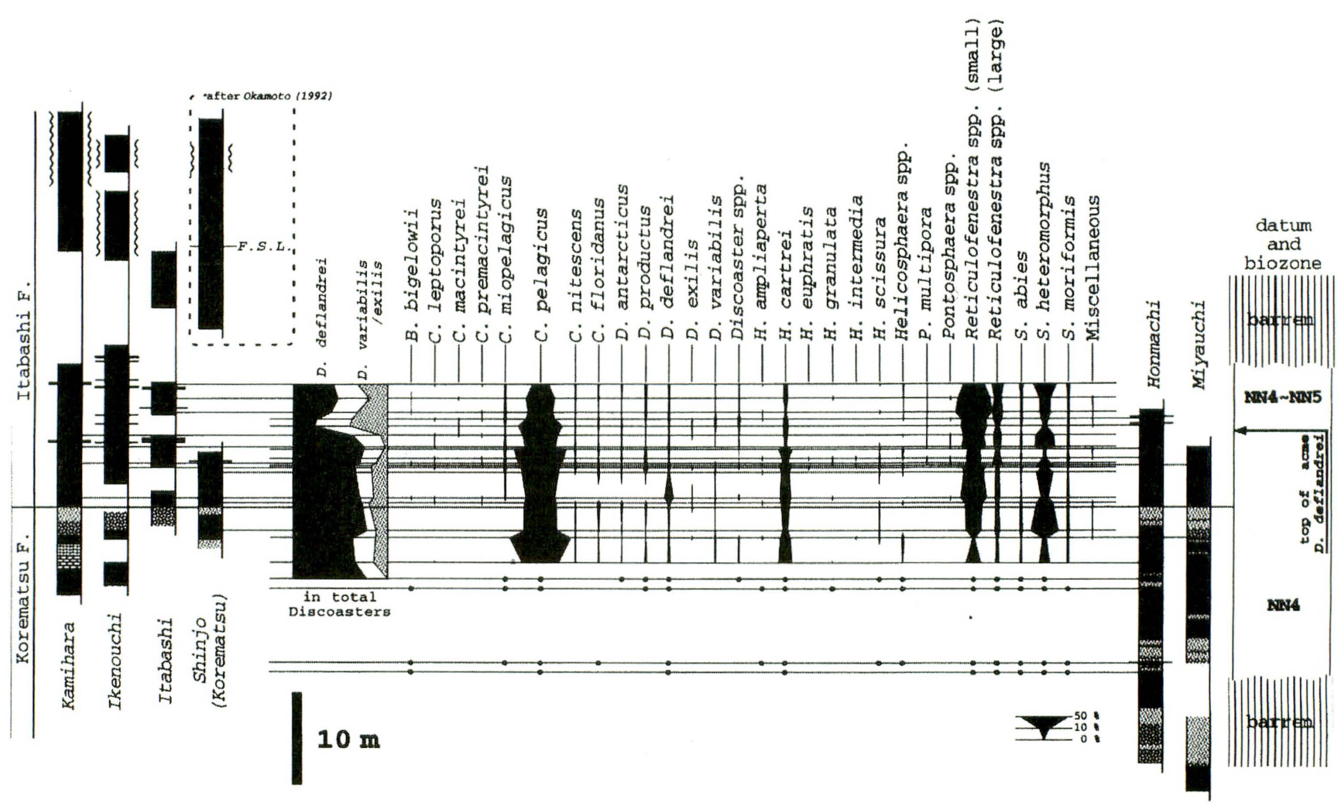

Fig. 5 Relative frequencies of the calcareous nannofossil taxa and their sequential changes on the composite section. Dots on the sample horizons indicate occurrence of taxa in poorly preserved nannoflora. Biozone after Martini (1971).

sented in Table 2 and Fig. 5.

In 15 samples, *C. pelagicus* is most predominant. Frequency of *C. pelagicus* changes from 17 (Ita-04) to 65 (Miy-04) percent of the flora. *S. heteromorphus* is numerically superior than *C. pelagicus* in Ita-04, and the smaller *Reticulofenestra* coccolith is superior in Ita-02 and Ita-03. The floras of these samples are characterized by the relative frequency changes of genus *Coccolithus* versus genus *Sphenolithus* and the smaller *Reticulofenestra* coccolith. The frequency of the genus *Sphenolithus* is relatively higher than other regions of the same age around the Japan Islands (e.g., Sato et al., 1992). The occurrence of the *H. cartrei*, *D. deflandrei*, *C. miopelagicus*, *C. floridanus* and the larger *Reticulofenestra* coccolith are common in the most samples. *B. bigelowii* is detected from seven samples (Kam-01, Kam-02, Ita-02, Ita-03, Neg-01, Neg-02 and Neg-03).

For biostratigrapically important taxa, the occurrence of *S. heteromorphus* and *D. deflandrei* are recognized from all the samples' flora, except *Sphenolithus belemnos*. *C. miopelagicus* and *C. floridanus* also recoginized from most samples. The occurrence of *H. ampliaperta*, *H. scissura*, *H. euphratis*, *D. exilis*, *C. macityrei* were recognized sporadically.

Biostratigraphic correlation

Results of the biostratigraphic study are shown in the Fig. 5. The occurrence of *S. heteromorphus* and lack of *S. belemnos* in all floras indicate that the Korematsu Formation and the lower part of the Itabashi Formation could be correlated to Martini's (1971) standard biozone NN4 and NN5.

The top of the biozone NN4 is defined as the horizon of highest occurrence of *H. ampliaperta*. However in some regions, the occurrence of *H. ampliaperta* is very rare or absent; thus, the biozones NN4 and NN5 often cannot be distinguished (Perch-Nielsen, 1985). Miller (1981) pointed that the highest occurrence of *H. ampliaperta* and *H. scissura* were in the same horizon. For instance, Martini (1980) used the lowest occurrence of *D. exilis* as the approximate NN4/NN5 boundary. According to Bukry (1973, 1975), the top of acme of *D. deflandrei*, the highest occurrence of *H. ampliaperta*, and the lowest occurrence of *C. macintyrei* are found in the same horizon. This biohorizon indicates the CN3/CN4 boundary of the Okada and Bukry's (1980) low-latitude biostratigraphic zonation. Perch-Nielsen (1985) pointed out that *H. euphratis* becomes rare and often disappears in the upper part of the biozone NN4.

In this study, *H. ampliaperta* is identified from the ten samples (Ita-04, 02, Sin-03, 02, Neg-11, 08, 03, 02, Miy-05,

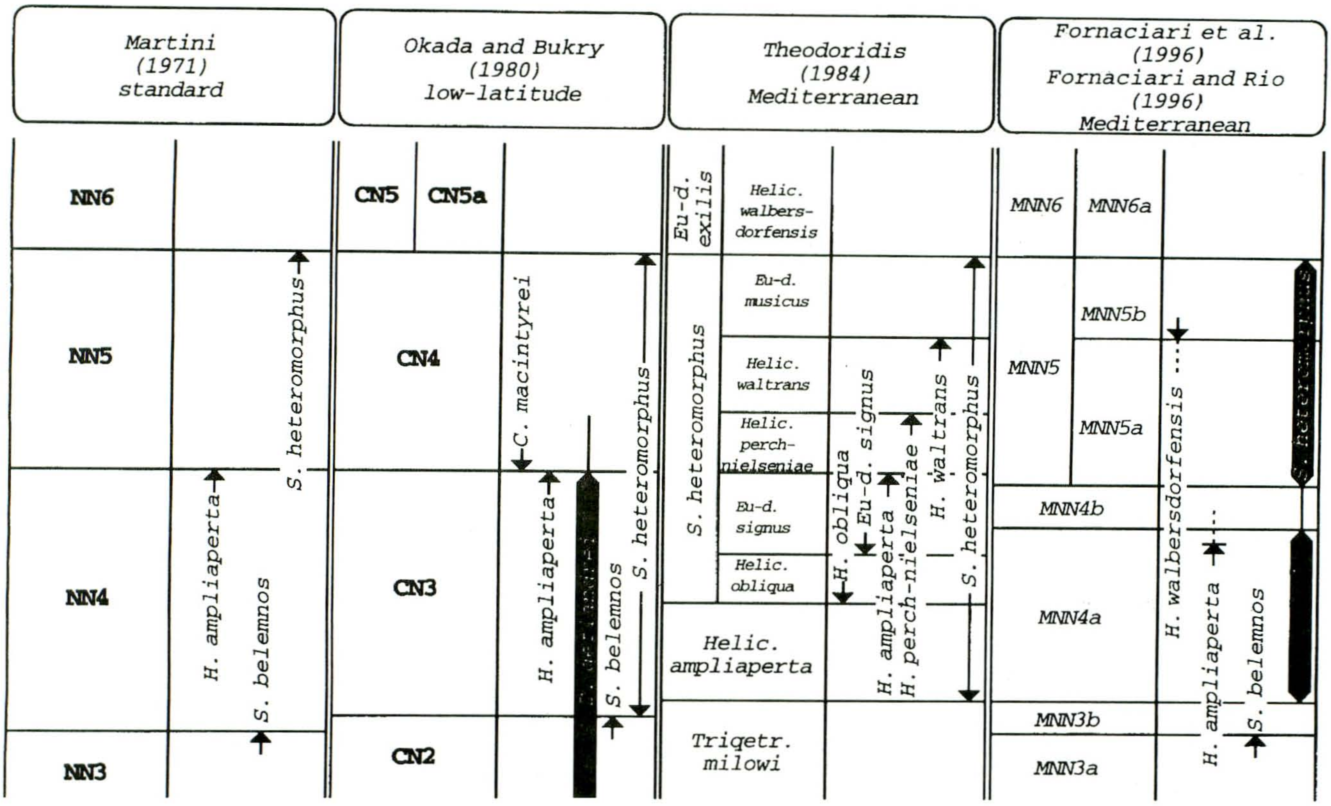

Fig. 6 Comparison of the Early to Middle Miocene calcareous nannofossil biostratigraphic zonation.

04). But recognizing the highest occurrence horizon of *H. ampliaperta* is difficult to find in the sections of the Shobara area, only six samples (Kam-04, 01, Ita-03, Neg-10, 05, 01) being devoid of *H. ampliaperta* and *H. succisura*. The relative frequency distribution of *D. deflandrei* in the total *Discoaster* specimens was reduced rapidly around the horizon of the Mitsukaichi tuff bed (s Member) in the lower part of the Itabashi Formation. During the study, the Korematsu Formation and lowermost part of the Itabashi Formation could be correlated with the upper part of Martini's NN4 and Bukry's CN3; and the biohorizon of the top of acme *D. defrandrei* was recognized around the horizon of the Mitsukaichi tuff bed (s Member) in the Itabashi Formation. Sporadic occurrences of *D. exilis*, *C. macintyrei* and *H. euphratis* confirm this correlation.

Theodoridis (1984) and Fornacciari et al. (1996) proposed the calcareous nannofossil biozonation in the Mediterranean region. Theodoridis (1984) defined the zonation by the lowest occurrence of *Helicosphaera obliqua*, *Eu-discoaster signus* and the highest occurrence of *Helicosphaera perch-nielseniae*. Sections of the Shobara area could not be correlated with this zonation because these species were unidentified. Fornacciari et al. (1996) used the paraacme interval of *S. heteromorphus*. The number of specimens of genus *Sphenolithus* in this study are enough for quantitative analysis. Based on quantitative analysis, the genus *Sphenolithus* may be used for biostratigraphic zonation in the Paleo-Japan sea region.

Sato et al. (1992) recognized the same biohorizon (top of acme of *D. deflandrei*) in the back-arc basins of central and northeast Japan, and considered that the first transgression occurred in the age of NN4. The present study indicates that the Miocene transgression to the mountainside of the Chugoku province occurred in the same period as the back-arc region.

Summary

The Miocene calcareous nannofossil flora of the Bihoku Group in the Shobara area are characterized by the relative frequency distribution changes of genus *Coccolithus* versus genus *Sphenolithus* and the smaller *Reticulofenestra* coccolith. The frequency of the genus *Sphenolithus* is relatively higher than other regions of the same age around the Japan Islands.

Based on the occurrence of *S. heteromorphus*, *H. ampliaperta*, *H. scissura*, *H. euphratis*, *D. deflandrei*, *D. exilis*, *C. macityrei*,and the lack of occurrence of *S. belemnos*, the Korematsu Formation and the lowermost part of the Itabashi Formation can be correlated with the upper part of biozone NN4 of Martini (1971). Based on the sequential changes of relative occurrence ratio of the *D. deflandrei* in the total number of *Discoaster* specimens, the biohorizon of the top of acme *D. deflandrei*, was recognized around the lithostratigraphic horizon of the Mitsukaichi tuff bed (s Member) in the Itabashi Formation.

This biostratigraphic result is most fundamental and provides valuable data for interpretation of the Early to Middle Miocene transgression in Southwest Japan.

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* : in Japanese with English abstract
** : in Japanese

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Locality name in Japanese Kanji charactor

Shobara	庄原
Bihoku	備北
Kamihara	上原
Ikenouchi	池の内
Itabashi	板橋
Shinjo	新庄
Koremats	是松
Honmach	本町
Miyauchi	宮内
Mitsukaichi	三日市

Explanation of Plate

all figures are same maginification, scale bar = 10 μm .

1. *Braarudosphaera bigelowii* Deflandre
   Kam-01, cross-polarized transmission light

2. *Coccolithus miopelagicus* Bukry
   Sin-03, cross-polarized transmission light

3. *Coccolithus pelagicus* (Wallich) Schiler
   Sin-03, cross-polarized transmission light

4. *Coronocyclus nitescens* (Kampter) Bramlette and WilCoxon
   Sin-03, cross-polarized transmission light

5. *Cyclicargolithus floridanus* (Roth and Hay *in* Hay*et al.*) Bukry
   Kam-02, cross-polarized transmission light

6. *Discoaster deflandrei* Bramlette and Riede
   Sin-03, normal transmission light

7. *Discoaster exilis* Martini and Bramlette
   Neg-10, normal transmission light

8. *Discoaster variabilis* Martini and Bramlette
   Kam-01, normal transmission light

9. *Pontosphaera multipora* (Kamptner) Roth
   Sin-03, cross-polarized transmission light

10. *Helicosphaera ampliaperta* Bramlette and Wilcoxon
    Neg-08, cross-polarized transmission light

11. *Helicosphaera cartrei* (Wallich) Kamptner
    Neg-08, cross-polarized transmission light

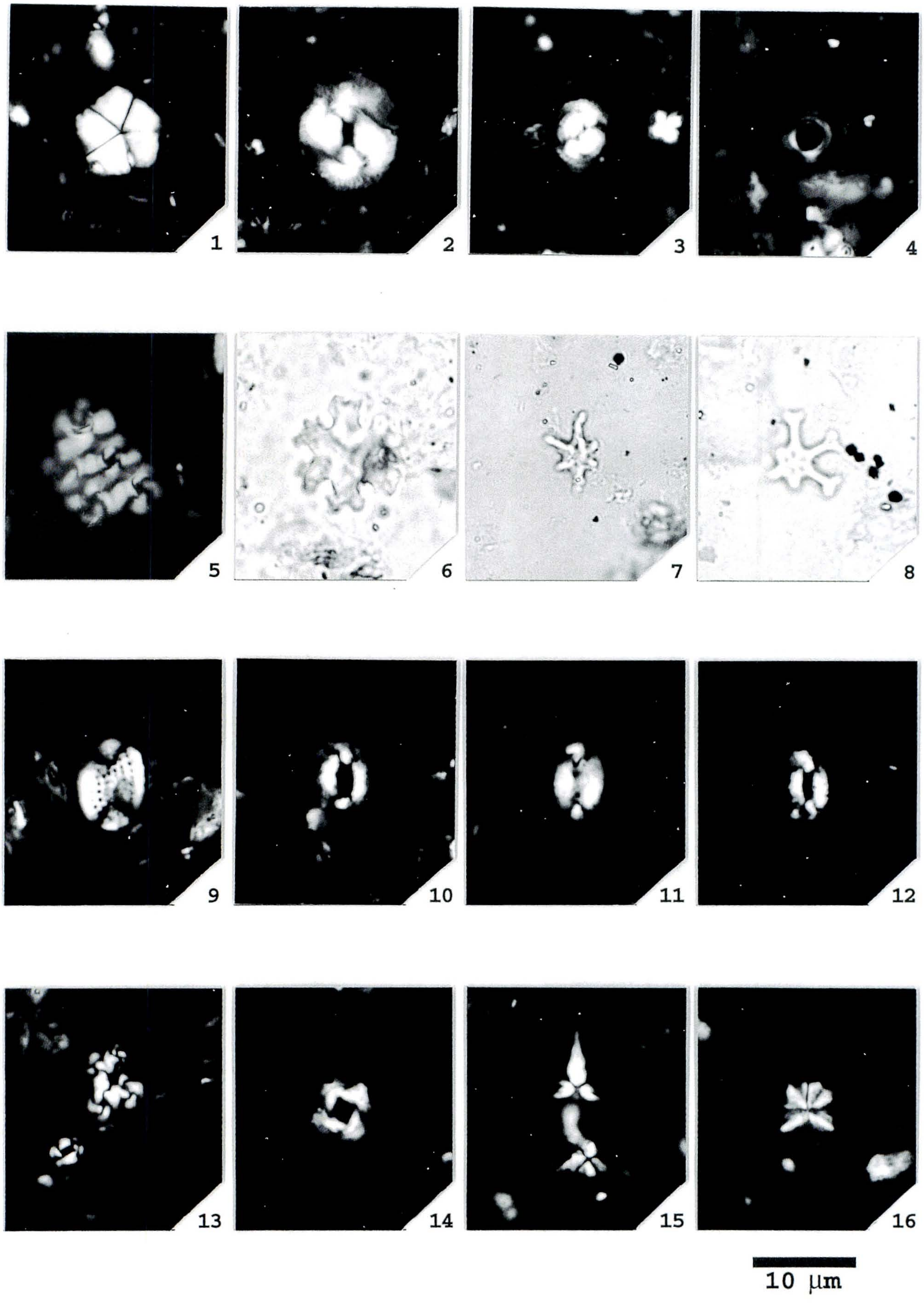
12. *Helicosphaera scissura* Mller
    Neg-08, cross-polarized transmission light

13. *Reticulofenestra* spp. (small)
    Kam-01, cross-polarized transmission light

14. *Reticulofenestra* sp. (large)
    Sin-03, cross-polarized transmission light

15. *Sphenolithus heteromorphus* Deflandre
    Sin-03, cross-polarized transmission light

13. *Sphenolithus moriformis* (Brönimann and Stradner) Bramlette and Willcoxon
    Kam-04, cross-polarized transmission light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