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Planktonic foraminiferal biostratigraphy of the upper Miocene Kubota Formation in the eastern Tanagura area, Northeast Japan

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Abstract: A planktonic foraminiferal fauna consisting of 39 species was obtained from the upper Miocene Kubota Formation in the eastern Tanagura area, Northeast Japan. The general composition of the foraminiferal fauna indicates that the Kubota Formation was deposited under an open sea environment influenced by a warm current. The presence of *Neogloboquadrina acostaensis*, absence of *Globorotalia plesiotumida*, and the first occurrence of *Globorotalia merotumida* in the middle part of the Kubota Formation enable a correlation with Zone N.16 of Blow (1969). This foraminiferal zonal assignment is consistent with such stratigraphic data as radiometric, calcareous nannofossil, radiolarian, and diatom ages. We recognize four biohorizons defined by the first occurrences of *N. acostaensis*, *Globorotaloides falconarae*, and *G. merotumida* and the last occurrence of *Neogloboquadrina* cf. *mayeri*. These biohorizons will be useful for determining the age of Zone N.16 in Japan.

Keywords: biostratigraphy, paleoclimate, planktonic foraminifera, upper Miocene, Kubota Formation, Northeast Japan.

1. Introduction

The "late Miocene" Period has been recognized as a transitional interval from the warmer subtropical middle Miocene to cooler temperate Pliocene in and around the Japanese Islands based on molluscan fauna (Chinzei, 1986; Ogasawara, 1994). Thus, this period could be important for understanding the evolution of Japanese marine climate. We have used faunal evolution of planktonic foraminifera as an indicator of climatic changes and geological ages. However, only few data of planktonic foraminiferal fauna in the Japanese upper Miocene have been reported. Especially, there is no detailed report on Zone N.16 of Blow (1969) on Northeast Japan.

The upper Miocene Kubota Formation distributed in the eastern Tanagura area, Northeast Japan (Fig. 1) is well known as a typical unit yielding the Shiobara-type molluscan fauna (Iwasaki, 1970), which flourished in the middle to late Miocene time. This formation abundantly yields marine microfossils including planktonic foraminifers (Aita, 1988; Shimamoto *et al.*, 1998). Therefore, this formation is in an important position to facilitate our understanding of the characteristics of the upper Miocene planktonic foraminiferal fauna in Northeast Japan. Although the planktonic foraminiferal biostratigraphy was examined by Aita (1988) and Shimamoto *et al.* (1998) for this sequence, details of the relative abundance of various species of the fauna have not yet been reported. Furthermore, the planktonic foraminiferal ages are still controversial: Aita (1988) assigned this formation to Zone N.17, while Shimamoto *et al.* (1998) assigned it to Zone N.16.

The purpose of this study was to examine the upper Miocene planktonic foraminiferal fauna from the Kubota Formation for their geological ages.

2. Geological setting

Neogene marine sequences in the eastern Tanagura area were formed in a half-basin which opens toward

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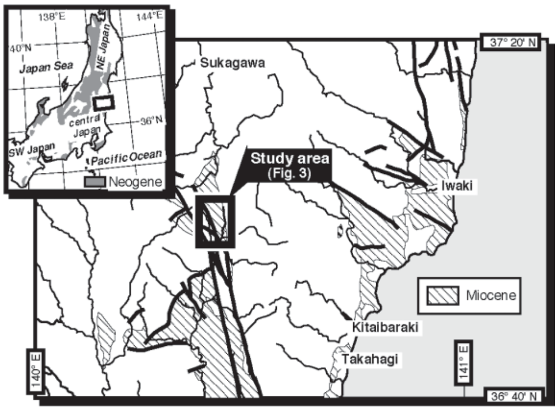

Fig. 1 Index map of the eastern Tanagura area, Northeast Japan.

the north. The Miocene sequence unconformably overlies the pre-Tertiary granitic and metamorphic rocks and is divided into the Akasaka and Kubota Formations in ascending order (Shimamoto *et al*., 1998) (Fig. 2). The Akasaka Formation consists mainly of medium- to coarse-grained sandstone with a basal conglomerate layer. The thickness of this formation is about 200 meters. The Kubota Formation conformably overlies the Akasaka Formation and is mainly composed of fine- to coarse-grained sandstone. The Kubota Formation can be lithologically divided into three parts, medium- to coarse-grained sandstone (30-35 m in thickness), tuffaceous fine-grained sandstone (ca. 150 m) and cross-bedded, medium- to coarse-grained sandstone (40-140 m), in ascending order. The total thickness of this formation is about 250 meters. On the basis of the lithofacies and fossils of the Kubota Formation, the sedimentary environment of the formation has been inferred to be open and shallow marine condition (Shimamoto *et al*., 1998).

The geological age of the Kubota Formation has been determined by planktonic microfossils and radiometric dating. Studies of planktonic microfossils were made on several taxa from this formation: planktonic foraminifera by Aita (1988) and Shimamoto *et al*. (1998); calcareous nannofossils by Shimamoto *et al*. (1998); radiolarians by Taketani and Aita (1991) and Shimamoto *et al*. (1998); and diatoms by Yanagisawa *et al*. (2000). In addition, this formation intercalates many tuff layers, seven of which are useful for key beds (Kt-1 to Kt-7) (Shimamoto *et al*., 1998). Potassium-Argon (K-Ar) and fission track (FT) ages of the Kt-1 Tuff in the lower middle part of the Kubota Formation are 10.6±0.2 Ma (errors in a standard deviation) and 10.7±0.2 Ma, respectively (Takahashi *et al*., 2001a). The Kt-7 Tuff in the upper part of the formation yields a FT age of 10.6±0.3 Ma (Takahashi *et al*., 2001b).

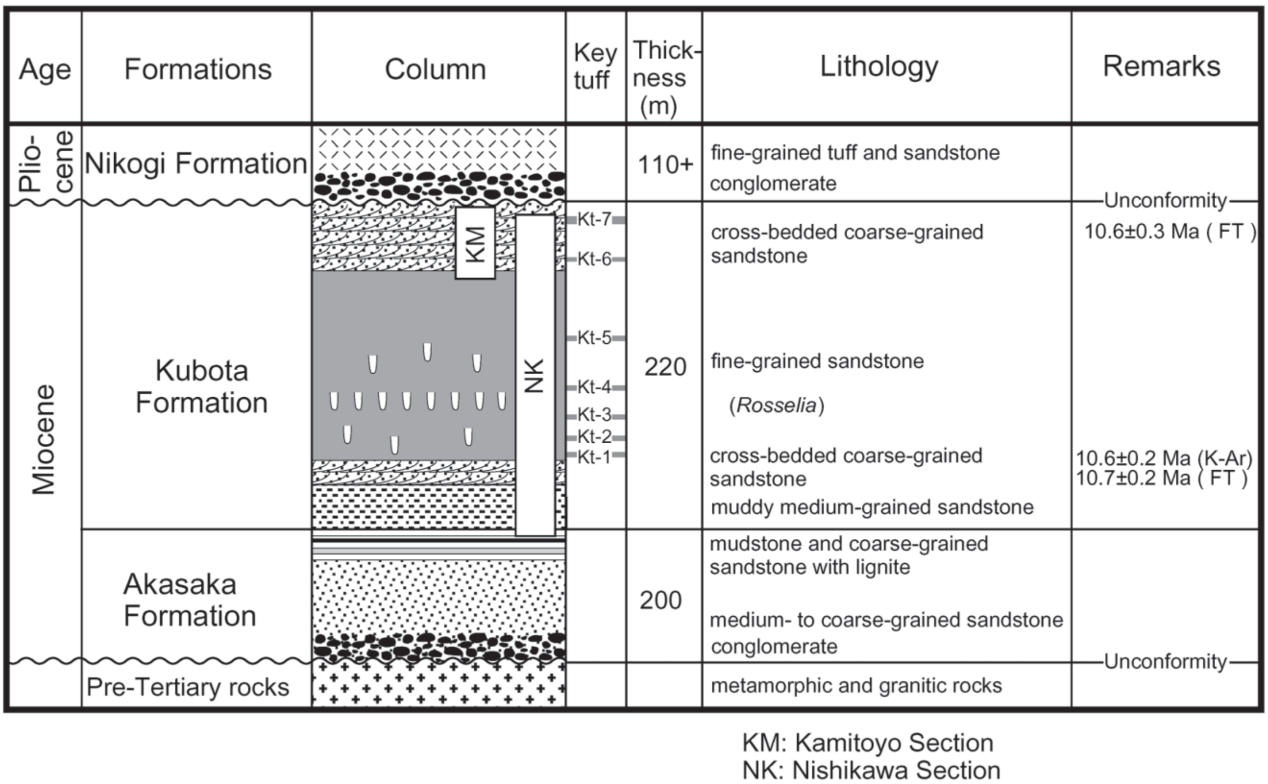

Fig. 2 Schematic stratigraphic column of the Neogene sequences distributed in the eastern Tanagura area.

3. Materials and methods

Sixty rock samples were collected from two geological sections, namely, the Nishikawa (samples NK1 - NK45 and NK34.5) and Kamitoyo (KM1 - KM14) sections (Figs. 3 and 4) at stratigraphic intervals of 1 to 10 m. In the Nishikawa section, the Kubota Formation is well exposed except for its upper part which remains concealed. In the Kamitoyo section, the upper part of the formation is well exposed. These two sections are correlated with each other by two intervening Kt-6 and Kt-7 key tuff beds.

In the laboratory, rock samples (80 g in dry weight) were disintegrated with the use of a saturated sodium sulfate solution and naphtha. After maceration, each sample was washed on a 200-mesh (74 μm openings) sieve. Dried residues were then divided into suitable volumes yielding around 200 planktonic foraminiferal specimens with the use of a sample splitter. Planktonic foraminiferal specimens were picked up from size fractions coarser than 125 μm. Twenty samples with a small content of microfossils were treated by the water-agitation method to concentrate fossil specimens. According to our preliminary results, this method appears to have altered the original composition of a foraminiferal assemblage. Therefore, we did not count specimens from the concentrated fractions. The species detected from the concentrated fractions are displayed with the symbol "+" in Table 1.

The SEM microphotographs of several important species were taken by a field-emission type scanning electron microscope (JSM-6330F; JEOL Co. Ltd., Tokyo, Japan).

4. Results

Thirty-nine species from a total of 40 samples were identified (Fig. 5; Table 1). The preservation state of these fossils ranged from "poor" to "moderate". The maximum number of fossil specimens per one gram of dry sediment was observed in the middle part of the Kubota Formation, sample NK11 (550 individuals / g). The lowest part of the formation representing the coarse-grained lithofacies, which contains abundant molluscan fossils, yielded a few planktonic foraminifers. The uppermost part of the formation, which is composed of crossbedded coarse-grained sandstone, contained a few foraminifers.

The foraminiferal fauna predominantly consists of *Globigerina bulloides*, *Globigerina woodi*, *Globigerinita glutinata*, and *Neogloboquadrina* cf. *continuosa*. *Globigerinoides* species commonly occur, especially in the middle part of the formation.

Based on the stratigraphic distribution of the identified species, four biohorizons were recognized (Fig. 6). These are as follows in ascending order: the first occurrence (FO) of *Neogloboquadrina acostaensis* detected between samples NK7 and NK8; FO of *Globorotaloides falconarae* recognized between samples NK8 and NK10; the last occurrence (LO) of *N.* cf. *mayeri* detected between samples NK11 and NK13; and the FO of *Globorotalia merotumida* recognized between samples NK18 and NK19.

5. Discussion

The Kubota Fauna is characterized by abundant occurrences of species belonging to the genera *Globigerina*, *Neogloboquadrina*, and *Globigerinita*, which are known to have flourished in the middle latitude regions (e.g. Kennett *et al*., 1985). In addition, the genera *Globigerinoides*, *Globorotalia*, and *Sphaeroidinellopsis*, which are known to inhabit warm currents, commonly occur. Such faunal characteristics suggest that the depositional regime of the Kubota Formation, with the exception of its lowermost part, was open sea influenced by a warm-temperate climate.

Two age-diagnostic species of Blow (1969)'s Neogene planktonic foraminiferal zonation, namely, *N. acostaensis* and *G. merotumida*, are present in the Kubota Formation. The presence of the two species coupled with the absence of *Globorotalia plesiotumida* unequivocally establishes a correlation of this fauna with that of Zone N.16.

The LO of *N. mayeri* defines the upper boundary of Zone N.14 (Blow, 1969). We think that the age significance of the LO of *N.* cf. *mayeri* identified in the present study is still considerable. The morphotype *N.* cf. *mayeri* somewhat differs from the typical *N. mayeri* (for details, see *Taxonomic notes*). In addition, the LO of *N. mayeri* shows diachrony in the middle latitude region (Berggren *et al*., 1995). Miller *et al*. (1994) pointed out that the LO of *N. mayeri* crossed over the FO of *N. acostaensis* at DSDP Site 563 in the subtropical North Atlantic.

We conclude that the coexisting interval of *N.* cf. *mayeri* and *N. acostaensis* should be correlatable with the lowermost part of Zone N.16 rather than with the top of Zone N.14. Consequently, the Kubota Formation is assigned to only Zone N.16. Aita (1988) reported *Candeina nitida* from the upper part of the Kubota Formation (around sample KM6 of the present study). This species is known to have appeared in Zone N.17 and upward (Kennett and Srinivasan, 1983; Bolli and Sounders, 1985). We failed to detect the presence of *C. nitida* and other species assigning Zone N.17 in the Kubota Formation. The FT age of the Kt-7 Tuff in the uppermost part of this formation is 10.6±0.3 Ma, which suggests that the formation is situated in the lower half of Zone N.16. Moreover, the age assignment of later mentioned data of other microfossils suggests that this whole formation is younger than Zone N.17. We con-

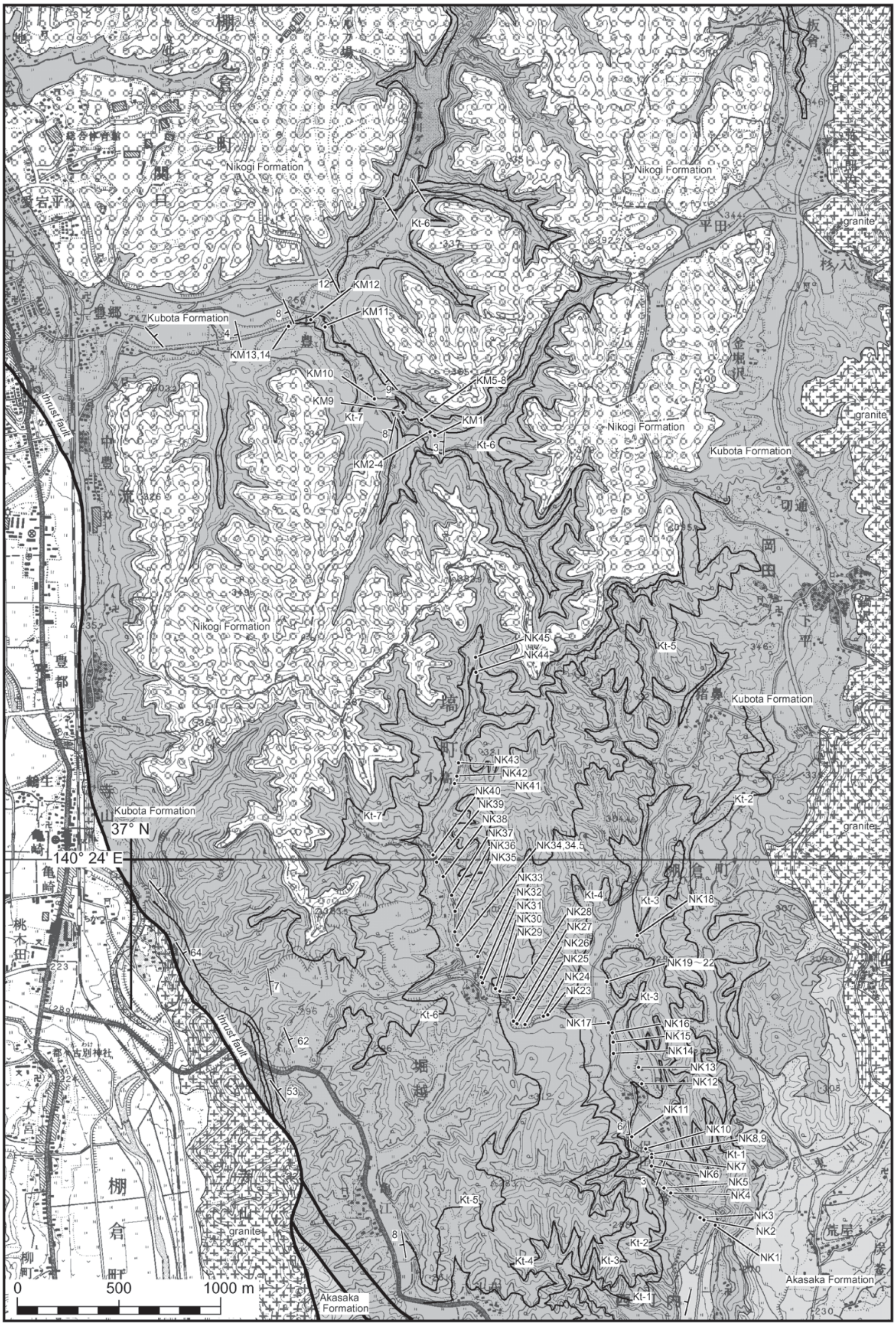

Fig. 3 Sample localities on the geological map of the studied area (modified from Shimamoto *et al*., 1998). Topographic maps "Tanagura" and "Hanawa" , scale 1:25,000 published by the Geographical Survey Institute are used.

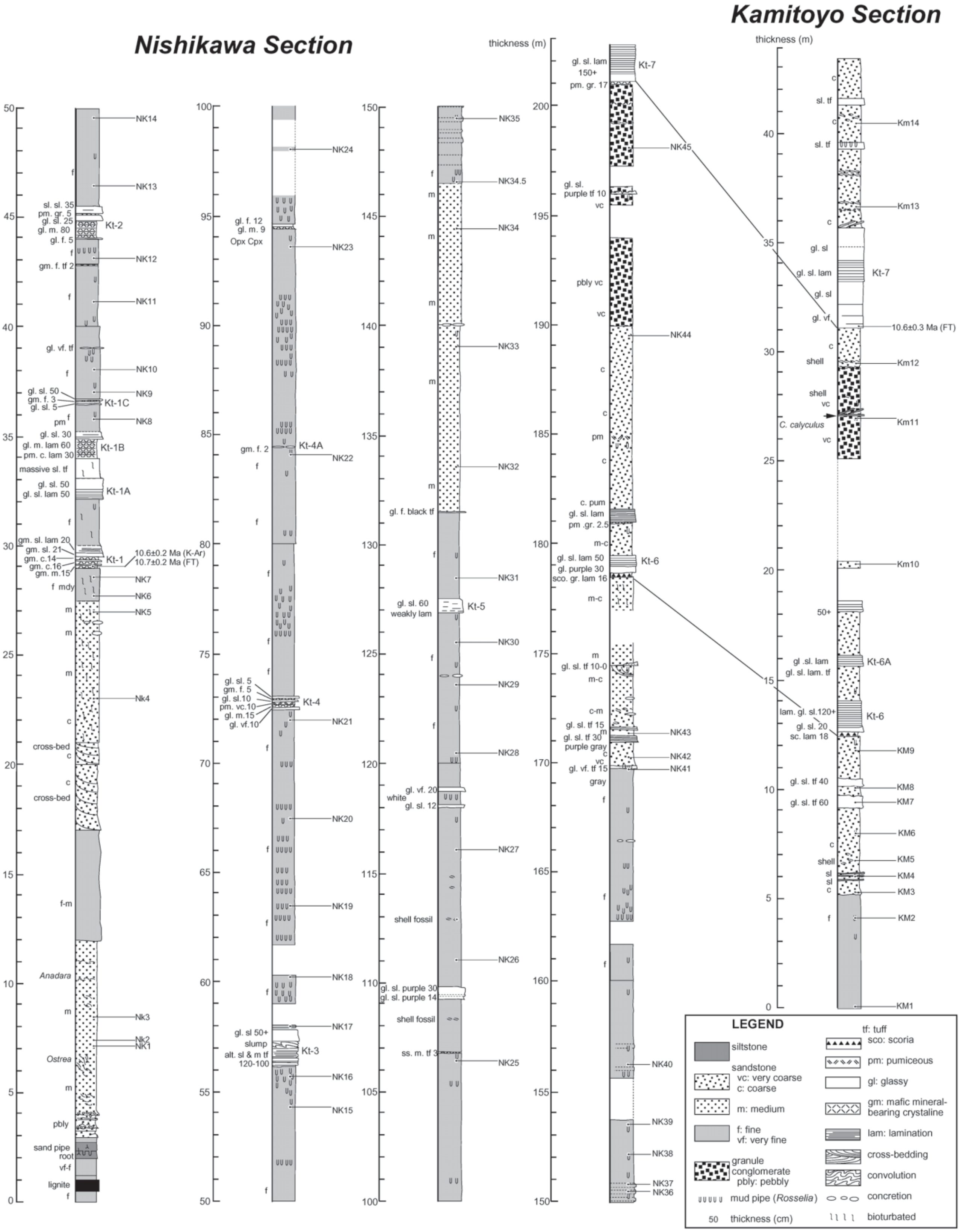

Fig. 4 Detailed columnar sections of the Kubota Formation with sample horizons.

Table 1 Planktonic foraminifers from the Kubota Formation, eastern Tanagura area.

	Biorbulina bilobata (d'Orbigny)	*Globigerina angustiumbilicata* Bolli	*Globigerina decoraperta* Takayanagi and Saito	*Globigerina falconensis* Blow	*Globigerina bulloides* d'Orbigny	*Globigerina nepenthes* Todd	*Globigerina pseudociperoensis* Blow	*Globigerina woodi* Jenkins	*Globigerinella obesa* (Bolli)	*Globigerinita glutinata* (Egger)	*Globigerinita uvula* (Ehrenberg)	*Globigerinoides bollii* Blow	*Globigerinoides immaturus* LeRoy	*Globigerinoides obliquus* Bolli	*Globigerinoides quadrilobatus* (d'Orbigny)	*Globigerinoides ruber* (d'Orbigny)	*Globigerinoides trilobus* (Reuss)	*Globoquadrina altispira altispira* (Cushman and Jarvis)	*Globoquadrina altispira globosa* Bolli	*Globoquadrina* cf. *conglomerata* (Schwager)	*Globoquadrina dehiscens* (Chapman, Parr and Collins)	*Globoquadrina venezuelana* (Hedberg)	*Globorotalia cultrata* (d'Orbigny)	*Globorotalia lenguaensis* Bolli	*Globorotalia merotumida* Blow and Banner	*Globorotalia scitula* (Brady)	*Globorotalia* spp.	*Globorotaloides falconarae* Giannelli and Salvatorini	*Globorotaloides* spp.	*Neogloboquadrina acostaensis* (Blow) (dextral)	*Neogloboquadrina acostaensis* (Blow) (sinistral)	*Neogloboquadrina* cf. *continuosa* (Blow) (dextral)	*Neogloboquadrina* cf. *continuosa* (Blow) (sinistral)	*Neogloboquadrina* cf. *mayeri* (Cushman and Ellisor) (dextral)	*Neogloboquadrina pseudopachyderma* (Cita, Premoli-Silva and Rossi) (dextral)	*Neogloboquadrina pseudopachyderma* (Cita, Premoli-Silva and Rossi) (sinistral)	*Orbulina suturalis* Brönnimann	*Orbulina universa* d'Orbigny	*Sphaeroidinellopsis seminulina* (Schwager)	*Sphaeroidinellopsis subdehiscens* (Blow)	*Tenuitella* aff. *minutissima* (Bolli)	*Turborotalita quinqueloba* (Natland)	Species	Total number of counted specimens	Miscellaneous	Total number of specimens	Preservation (poor 1←→5 good)
KM14		+			+			+		+	+																	+				+			+				+	+			10	-	-	87	3
KM13		+			+			+	+	+		+	+									+						+				+			+							+	12	-	-	239	2
KM11			+		+			+					+		+									+								+			+				+				9	-	-	86	2
KM10					+			+		+				+	+						+						+	+				+			+		+					+	12	-	-	120	2
KM9					+			+		+	+	+	+		+																				+				+				9	-	-	82	1
KM8		+		+	+			+	+	+	+	+	+	+	+		+			+					+		+	+				+			+			+	+			+	21	-	-	583	2
KM6					+					+			+	+	+																	+											6	-	-	31	1
KM4		+	+	+	+	+		+		+		+	+	+	+			+	+					+				+		+		+			+		+	+			+	+	22	-	-	871	3
KM3		1		1	42			9		1		1	8	3	4	1	1											1				7			1		2	+				3	17	86	9	191	2
KM2		+			+			+		+		+	+	+	+		+				+																					+	12	-	-	149	2
KM1					+					+																																	2	-	-	7	1
NK43			+		+			+		+	+	+	+	+	+					+	+		+	+		+		+				+			+				+	+	+	+	21	-	-	336	2
NK40		4		1	61			35	2	4	1	1	3	4								3						2				11					1	1	2	1		6	18	145	23	168	3
NK39		+			+			+		+		+	+	+						+								+				+							+			+	12	-	-	136	2
NK37		2			37			15	1	8	1	4	3	5	1								+					3		1		4							2			3	16	90	30	246	2
NK35		1	1	2	59	2		24	1	+		2	36	43	7	1		1	+			+	2		+			3				12			2		1		2				24	202	23	411	2
NK34					19			9		1		1	12	16	1		2								1			1				2			+				1			+	14	66	8	278	2
NK32		1		1	22			12	1			1	2	1							1	1			+			3		+		9	2		2		2		+			+	18	61	6	337	2
NK31		2		3	68			23		1		8	15	4	8							3										34	4		4		2		4			2	15	185	40	225	3
NK30					59			23	1						2		2											4				19	2		3		1					5	10	121	25	146	2
NK29		4			51	1		10		4		3	4	2	1							2								1		35	3		1				7			4	15	133	20	153	2
NK28					44			20		1	1	5	10	3	2						1							12				16	1						3			6	13	125	12	137	4
NK27		1		5	152	2	2	37	5	1	1	2	4	3	11	1							1			2		3		7	1	70	6		4	1	1		4			7	24	333	63	396	3
NK26		7			67			16		1		1																4				32	3									5	8	136	39	175	3
NK25		5			57			23		9		3	3		4		1					1				1		12		1		57	2									14	14	193	42	235	3
NK23		3		2	35			4		5	2	1			3							1								1		36	2									16	12	111	40	151	2
NK21					64	1		5		7	3		2									3			1			6	1	1		70	10									5	13	179	48	227	2
NK20		1		6	40			34		14	2		1															7		1		38	4		1				2			15	11	166	46	212	2
NK19		2		1	24			11		9	2	1	1		1										1		1	9		1		25	3		2				5			4	17	103	56	159	2
NK18		5			6			2		13	+							+										1				9			+							2	10	38	22	241	1
NK17		+			+	+		+		+	+											+		+				+		+		+			+							+	13	-	-	342	2
NK16		33	2	4	34	1		21	3	24	6			5							1							5				12	1		2								14	154	43	197	2
NK14					17			1		4																		1														6	5	29	8	37	2
NK13		21		3	97	1		12		5	3		3									2						1		1		14	1						4			1	14	169	63	232	3
NK11				6	19			16		12		1										1						9				39	4	3								1	10	111	50	161	2
NK10		3		16	122			83	5	39		6	8	5	2	2						2						5		2		87	7	3	11	1			15			1	19	425	115	540	2
NK8		4			82		5	35		19		2	2						1											1		55	6	8	11	1							12	232	80	312	2
NK7	1	2		15	96			22		20			1	1																									8				9	165	44	209	1
NK6					+			+		+		+	+	+																												+	7	-	-	73	2
NK3										+		+																															2	-	-	2	2

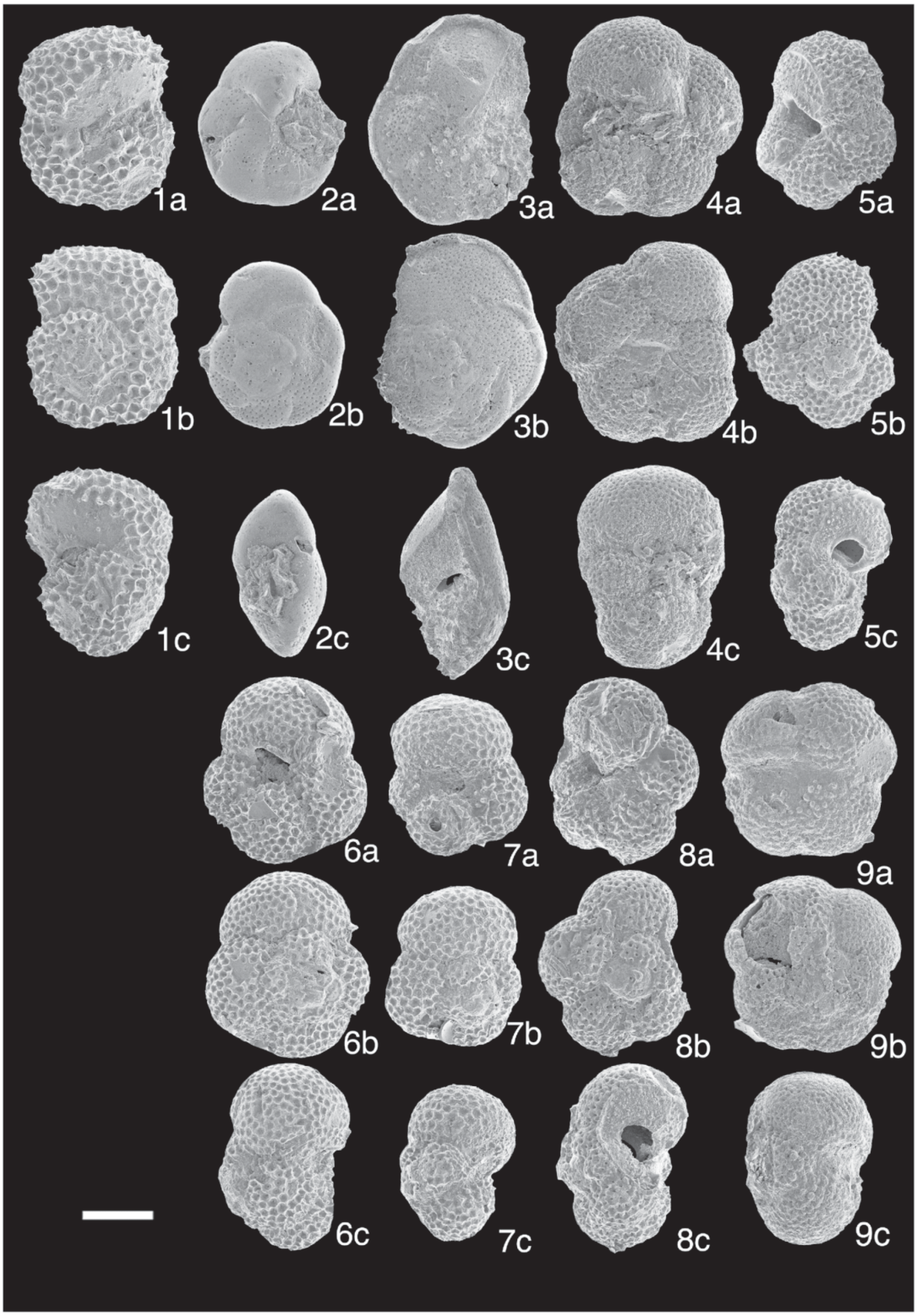

Fig. 5 SEM microphotographs of selected species of planktonic foraminifera from the Kubota Formation. 1a-c: *Globoquadrina dehiscens* (Chapman, Parr and Collins), IGPS 108634, sample NK16. 2a-c: *Globorotalia lenguaensis* Bolli, IGPS 108635, sample KM4. 3a-c: *Globorotalia merotumida* Blow and Banner, IGPS 108636, sample KM8. 4a-c: *Neogloboquadrina acostaensis* (Blow), IGPS 108637, sample NK10. 5a-c: *Neogloboquadrina* cf. *continuosa* (Blow), IGPS 108638, sample NK21. 6a-c: *Neogloboquadrina* cf. *continuosa* (Blow) (with umbilical-restricted aperture such as G. falconarae), IGPS 108639, sample NK21. 7a-c: *Globorotaloides falconarae* Giannelli and Salvatorini, IGPS 108640, sample NK21. 8a-c: *Neogloboquadrina* cf. *mayeri* (Cushman and Ellisor), IGPS 108641, sample NK10. 9a-c: *Neogloboquadrina pseudopachyderma* (Cita, Premoli-Siva and Rossi), IGPS 108642, sample NK10. Scale bar = 100 μm.

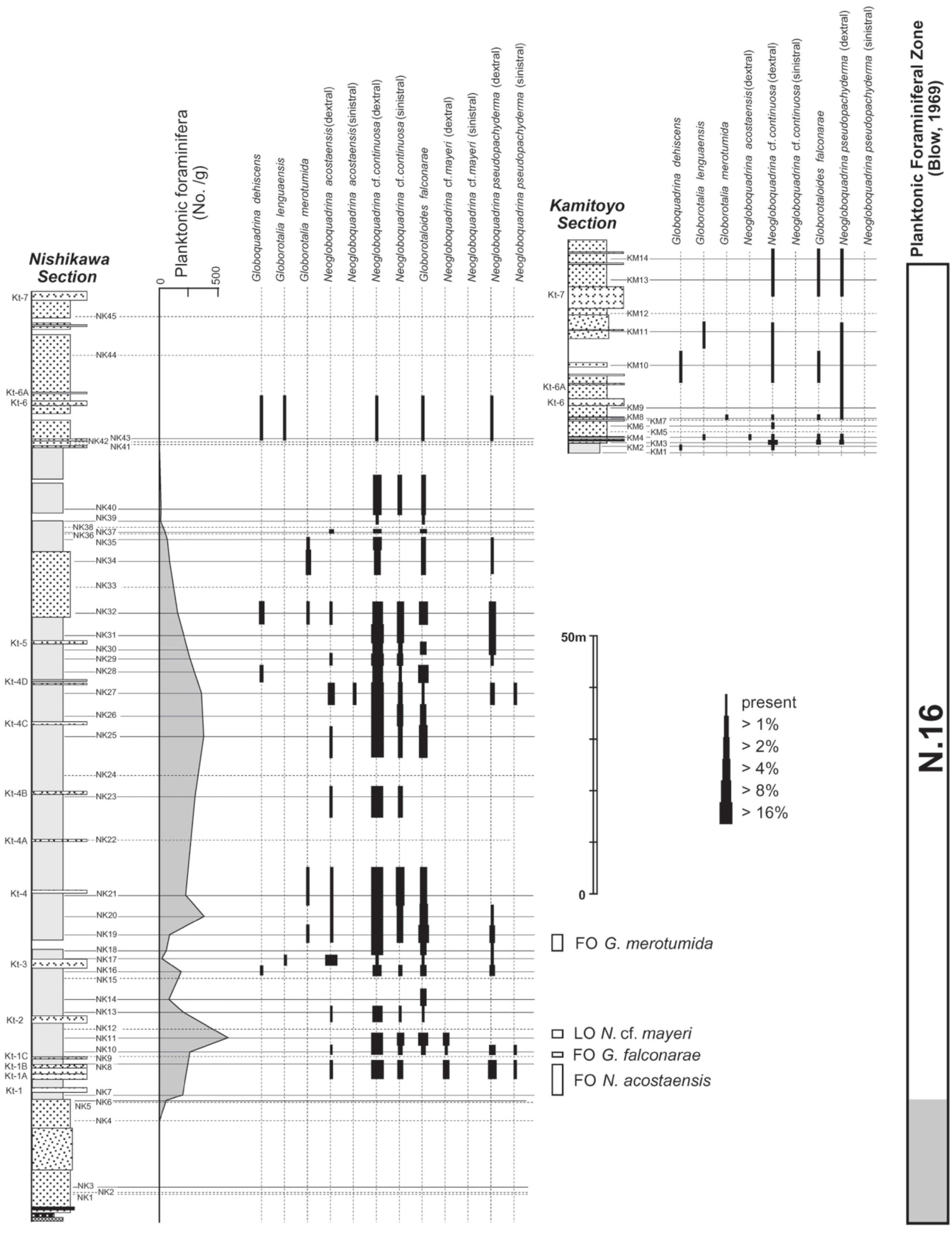

Fig. 6 Stratigraphic distributions of selected species of planktonic foraminifera in the Kubota Formation, eastern Tanagura area.

cluded that the Kubota Formation is younger than Zone N.17, though more investigation is needed on *C. nitida* reported by Aita (1988).

Judging from the above discussion of the geological age, the four biohorizons, the FOs of *N. acostaensis*, *G. falconarae*, and *G. merotumida* and the LO of *N.* cf. *mayeri* are restricted to the lower part of Zone N.16 around a numerical age of 10.6 - 10.7 Ma. It is reasonable that these four biohorizons could be employed for assigning a marine sequence to the lower part of Zone N.16.

Shimamoto *et al*. (1998) reported radiolarian and calcareous nannofossil biostratigraphies of the present sequence. Their results show that the Kubota Formation is correlatable with the zonal interval from CN6 to CN7b/8 of Okada and Bukry (1980) and *Lychnocanoma magnacornuta* zone of Motoyama and Maruyama (1996). Yanagisawa *et al*. (2000) reported a diatom stratigraphy of the same sequence and correlated it with the diatom zone NPD5C of Yanagisawa and Akiba (1998). The inter-taxon relationship of these three zonations is consistent with the recent combined time scale proposed by Saito (1999) (Fig. 7).

6. Conclusion

In order to elucidate the characteristics of upper Miocene planktonic foraminiferal faunas in the mid-latitudinal regions of the Northwest Pacific, the present study was undertaken by examining the Kubota Formation of Northeast Japan. Thirty-nine species of fossil planktonic foraminifers occur in the Miocene Kubota Formation in the eastern Tanagura area. The general feature of the planktonic foraminiferal faunas of the Kubota Formation is a large content of the genera *Globigerina*, *Neogloboquadrina*, and *Globigerinita*, accompanied by common occurrences of such genera as *Globigerinoides*, *Globorotalia*, and *Sphaeroidinellopsis*. These faunal characteristics are taken to suggest that the depositional regime of the Kubota Formation, with the exception of its lowermost part which poorly yields foraminifers, was in an open sea environment with prevailing warm-temperate climatic conditions.

The presence of *N. acostaensis* and *G. merotumida* with the absence of *G. plesiotumida* establishes a correlation of the Kubota Fauna with Zone N. 16 of Blow (1969). Four foraminiferal biohorizons can be recognized, namely, the FO of *N. acostaensis*, the FO of *G. falconarae*, the LO of *N.* cf. *mayeri*, and the FO of *G. merotumida* in ascending order. These biohorizons can be used for determining Zone N.16 in Japan. On the basis of a recently proposed time scale (Saito, 1999), this foraminiferal age agrees with the calcareous nannofossil, radiolarian, diatom and radiometric ages.

7. Taxonomic notes

The taxonomy adopted in the present study largely follows the work of Kennett and Srinivasan (1983) and Bolli and Saunders (1985). Full references to type descriptions of all the taxa with the exception of *G. falconarae* can be found in these two publications.

Family Globorotaliidae Cushman, 1927

Genus *Globorotaloides* Bolli, 1957

Globorotaloides falconarae Giannelli and Salvatorini, 1976 Figs. 5-7a,b,c

Globorotaloides falconarae Giannelli and Salvatorini, 1976, p. 170-172, pl.2, figs. 1-6.

Material:- IGPS coll. no. 108640.

Remarks:- About 100 specimens were obtained. A detailed description of this species is given by Iaccarino (1985). This species is characterized by having a very small umbilicus, four ovate chambers in the last whorl, a very low arched aperture with a distinct lip, and occasionally having umbilical bulla. This species closely resembles *N.* cf. *continuosa*, but differs in having a less arched aperture in a smaller umbilicus. This species also resembles *Catapsydrax parvulus* Bolli, Loebulich and Tappan, especially in its immature forms. However, this species is distinguishable from *C. parvulus* by having a more low-spired test.

This species is not widely reported from the northern Pacific, but it is known from the late Miocene of the Mediterranean and Atlantic areas (Iaccarino, 1985). Saito (1988) reported this species from the upper Miocene Shitazaki and Fujikotogawa Formations in Northeast Japan. It needs further consideration for using this species as an index fossil in the northern Pacific region.

Genus *Neogloboquadrina* Bandy, Frerichs and Vincent, 1967

Neogloboquadrina cf. *continuosa* (Blow), 1959 Figs. 5-5a, b, c, 6a, b, c

Compare:-

Globorotalia opima continuosa Blow, 1959, p.218, pl. 19, figs. 125a-c.

Neogloboquadrina cf. *pachyderma* (Ehrenberg). Aita, 1999, p. 105, pl. 6, figs. 2a-c.

Material:- IGPS coll. no. 108638, 108639

Remarks:-More than 800 specimens were obtained. This morphospecies is compared to *Neogloboquadrina continuosa* (Blow) by having four chambers in the final whorl, radial sutures on both the spiral and umbilical sides and an arched aperture with a distinct rim, but differs in having a widely varying position of aperture, which is often umbilical-extraumbilical (typical form: Figs. 5-6a,b,c) to restricted-in-umbilical position (Figs. 5-6a, b, c). There are a large number of intermediate forms between the two morphotypes. The

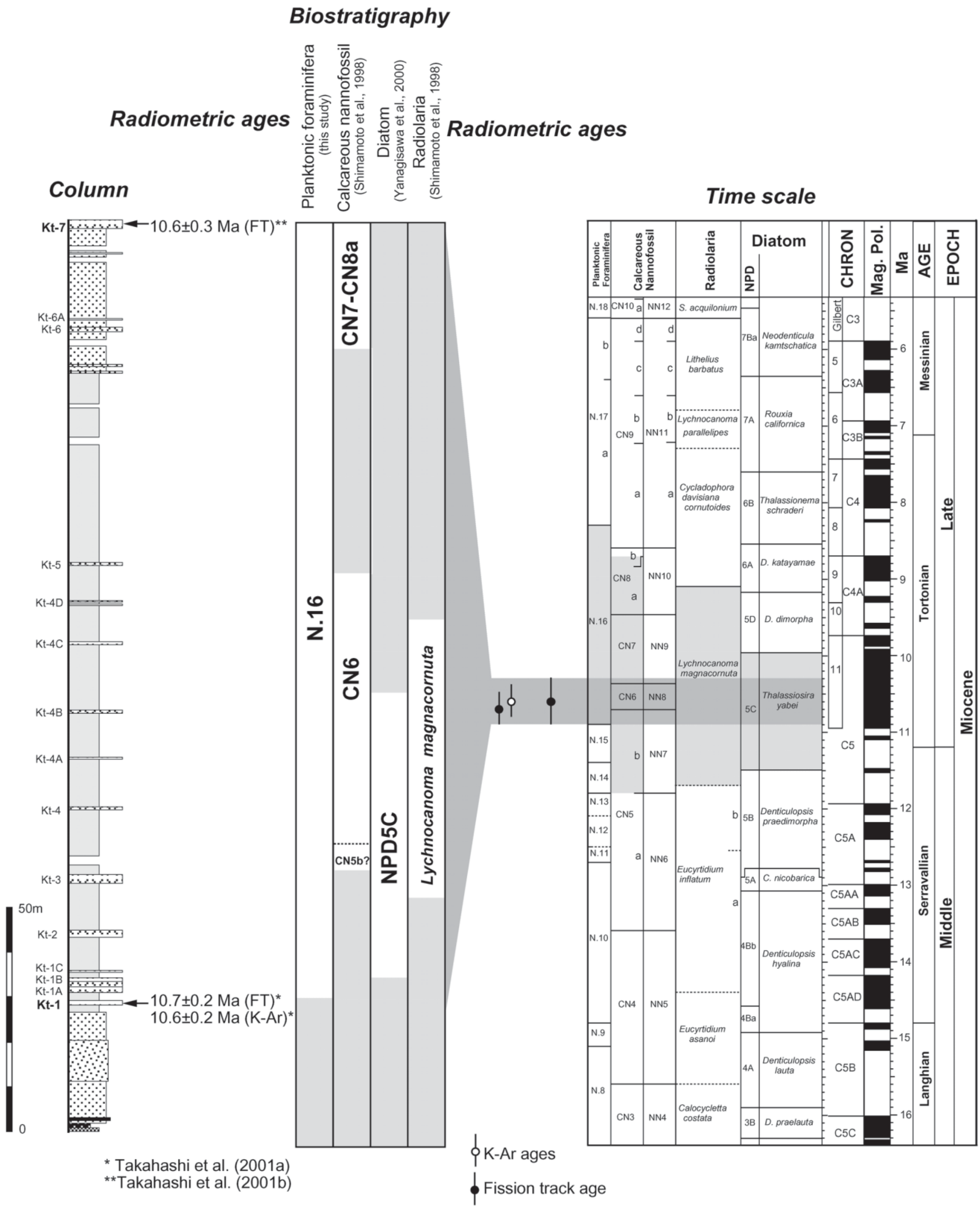

Fig. 7 Correlation of the Kubota Formation with an integrated magneto-biostratigraphic time scale.

latter morphotype closely resembles *Globorotaloides falconarae* Giannelli and Salvatorini, but is distinguished by possessing a high-arched aperture.

Neogloboquadrina cf. *mayeri* (Cushman and Ellisor), 1939

Figs. 5- 8a,b,c.

Compare:-

Globorotalia mayeri Cushman and Ellisor, 1939, p. 11, pl.2, figs. 4a-c.

Material: - IGPS coll. no. 108641.

Remarks: - Only 14 specimens were detected. This morphotype is characterized by its deep umbilicus, a high-arched aperture with an apertural rim and by having four and a half to five chambers in the final whorl. These features are comparable with the original description of *N. mayeri*, but the specimens from the Kubota Formation is distinct from the typical form in having a smaller, strongly lobated test with more spherical chambers. The present form is distinguishable from *N. acostaensis* by its high-arched aperture, deeper umbilicus and lack of umbilical plate.

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福島県東棚倉地域に分布する上部中新統久保田層の浮遊性有孔虫生層序

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要　旨

福島県東棚倉地域に分布する上部中新統の久保田層から，39種より構成される浮遊性有孔虫化石群集を報告した．得られた群集は，浮遊性有孔虫の産出が乏しい最下部以外の久保田層が，暖流の影響下にある外洋で堆積したことを示唆している．年代指標種である*Neogloboquadrina acostaensis*の産出，および*Globorotalia plesiotumida*の非産出，また久保田層中部が*Globorotalia merotumida*の初産出イベントを含むことから総合的に解釈すると，この群集を含む層準はBlow (1969)の浮遊性有孔虫化石帯N.16帯に対比される．この浮遊性有孔虫化石年代は，すでに久保田層について報告されている凝灰岩の放射年代や，石灰質ナンノ化石，放散虫および珪藻化石層序に基づく年代と一致する．本研究では前述の*G. merotumida*の初産出のほか，*N. acostaensis*の初産出，*Globorotaloides falconarae*の初産出，そして*Neogloboquadrina* cf. *mayeri*の終産出が認識された．これらの生層準は，日本周辺地域においてN.16帯を認識する有用な指標になると考えられる．