Dinoflagellate cysts from the basal Miocene coarse-grained facies, Hozakayama area, northern Niigata, central Japan

Hiroshi KURITA* and Yukako ISHIKAWA**

Abstract

Dinoflagellate cysts of 16 taxa from thick, coarse-grained facies in the Hozakayama area evidenced a marine depositional environment and correlation to the Subzone b of the *Diphyes latiusculum* Zone (late Early - early Middle Miocene; 16.9-14.7 Ma). This is the first constraint by marine planktonic microfossils on the age and depositional environments of the gravelly interval at the base of the clastic Miocene in the northern part of the Niigata sedimentary basin.

Key words: dinoflagellate cysts, Hozakayama, Kamagui Formation, Miocene, Niigata sedimentary basin.

Introduction

This study aims to describe dinoflagellate cysts from the oldest Miocene clastic sediments in the Hozakayama area in the northern part of the Niigata sedimentary basin (Fig. 1).

Stratigraphic subdivision of the Neogene in the Kitakanbara - southern Iwafune region in northern Niigata by Nishida and Tsuda (1961) established the Kamagui, Shimoseki, Uchisugawa and Kuwae formations in ascending order. The Kamagui Formation, at the basal part of this clastic succession, is composed of conglomerate, sandstone, siltstone and pyroclastic rocks. Nishida and Tsuda (1961) reported the Arcid-Potamid molluscan fauna and *Miogypsina-Operculina* foraminifera fauna from the sandstone layers of the Kamagui Formation. This confirms deposition during the age range of 16.5-15 Ma (Tsuchi, 1990) that corresponds

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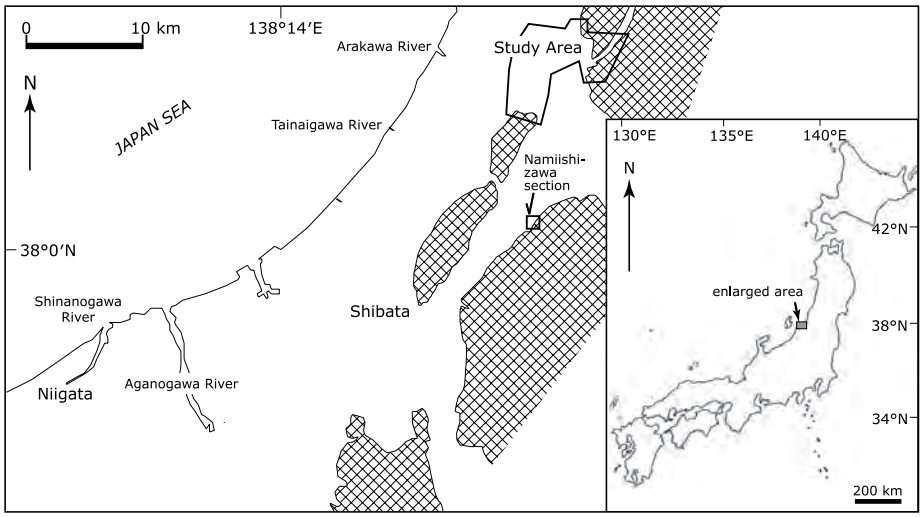


Fig. 1. Index map. Solid lines denote coastlines. Hatched areas indicate exposed areas of the pre-Neogene basement rocks (after Niigata Prefecture, 2000). The location of the Namiishizawa section discussed by Kurita and Ishikawa (2009) is also shown.

to the Middle Miocene Climatic Optimum (MMCO; Zachos et al., 2001). This age assignment of the formation is supported by pollen assemblages (Yamanoi, 1976) and dinoflagellate cysts from the mudstone in the Tainaigawa River area (Kurita and Ishikawa, 2009), as well as by fission track ages of the rhyolite and pyroclastic rocks (15.1±0.7 Ma and 15.5±0.9 Ma; Sato and Muramatsu, 1998). No age constraints, however, have been available for the coarse-grained clastic sediments of the lower part of the Kamagui Formation that are occasionally as much as hundreds meters thick and that should have recorded the timing and paleoenvironments of the earliest deposition within the Miocene clastic basin.

The present study provides not only the first paleontological age constraint but also the evidence of a marine depositional environment for the coarse-grained clastic sediments at the basal part of the clastic Miocene in northern Niigata. The study area lies between the Ishikawa and Arakawa rivers and belongs to the southern part of Murakami City (formerly Kamihayashi Village) and to Sekikawa Village. Geology of the study area was previously mapped and discussed by Katahira (1969a, 1969b, 1974a, 1974b), Takahashi (1976), Nakamura and Yokoyama (1987), Shirai et al. (1999) and Niigata Prefecture (2000).

Geology

Geologic map and generalized columnar section of the Hozakayama area are illustrated on Figs. 2 and 3.

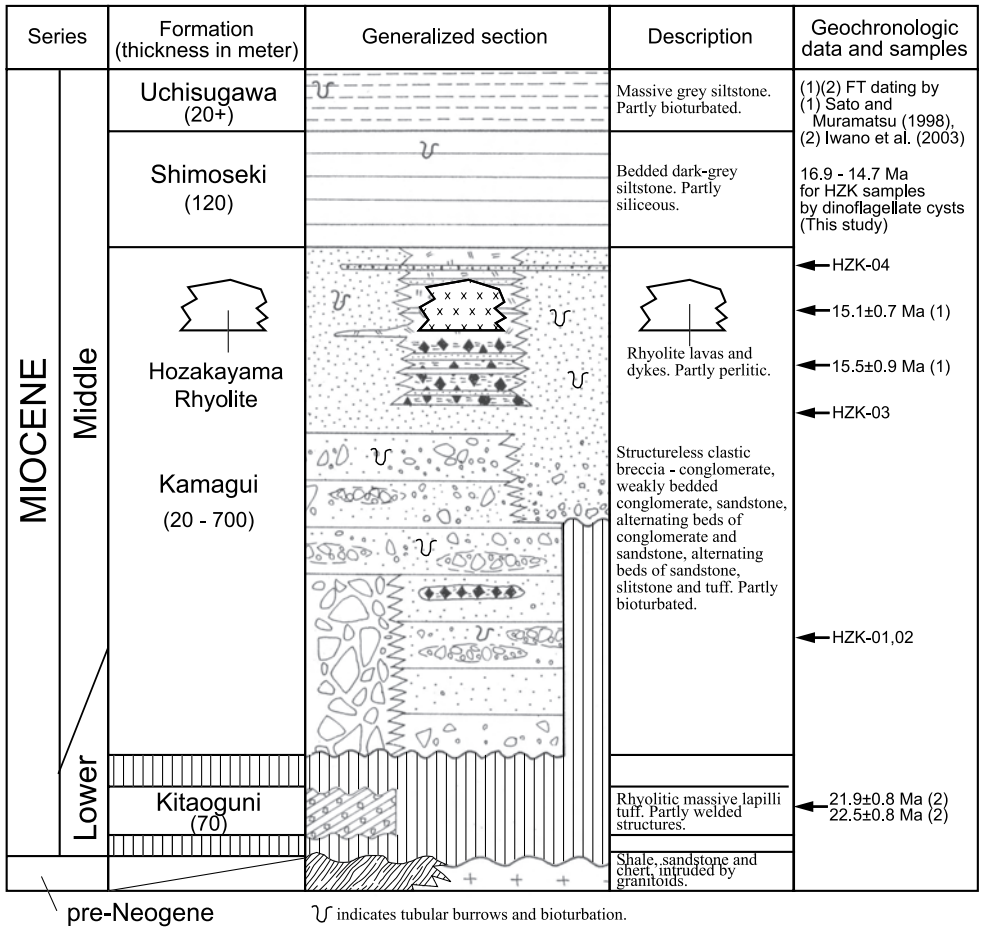


Fig. 2. Generalized geological column of the Hozakayama area.

The basement rocks are siliceous mudstone, sandstone and chert that are regarded as part of a Jurassic accretionary complex assignable to the Ashio Belt (Komatsu et al., 1985) and granitic rocks. The oldest Miocene rocks in the study area are the Kitaoguni Formation (Minakawa, 1959) that is composed of thick rhyolitic lapilli tuff. It is massive and partly shows welded structures. The formation in the Oguni area, Yamagata Prefecture, was dated as 22.5±0.8 Ma and 21.9±0.8 Ma by the fission track method (Iwano et al., 2003). The Kamagui Formation (Nishida and Tsuda, 1961), lying unconformably on the basement and the Kitaoguni Formation, is composed of coarse-grained clastic and pyroclastic rocks and shows considerable lateral variation in lithology and thickness. Basically, the lower part of the Kamagui Formation consists of thick conglomerate and alternating beds of conglomerate and sandstone. A large portion of the conglomerate beds is very poorly-sorted and lacks internal

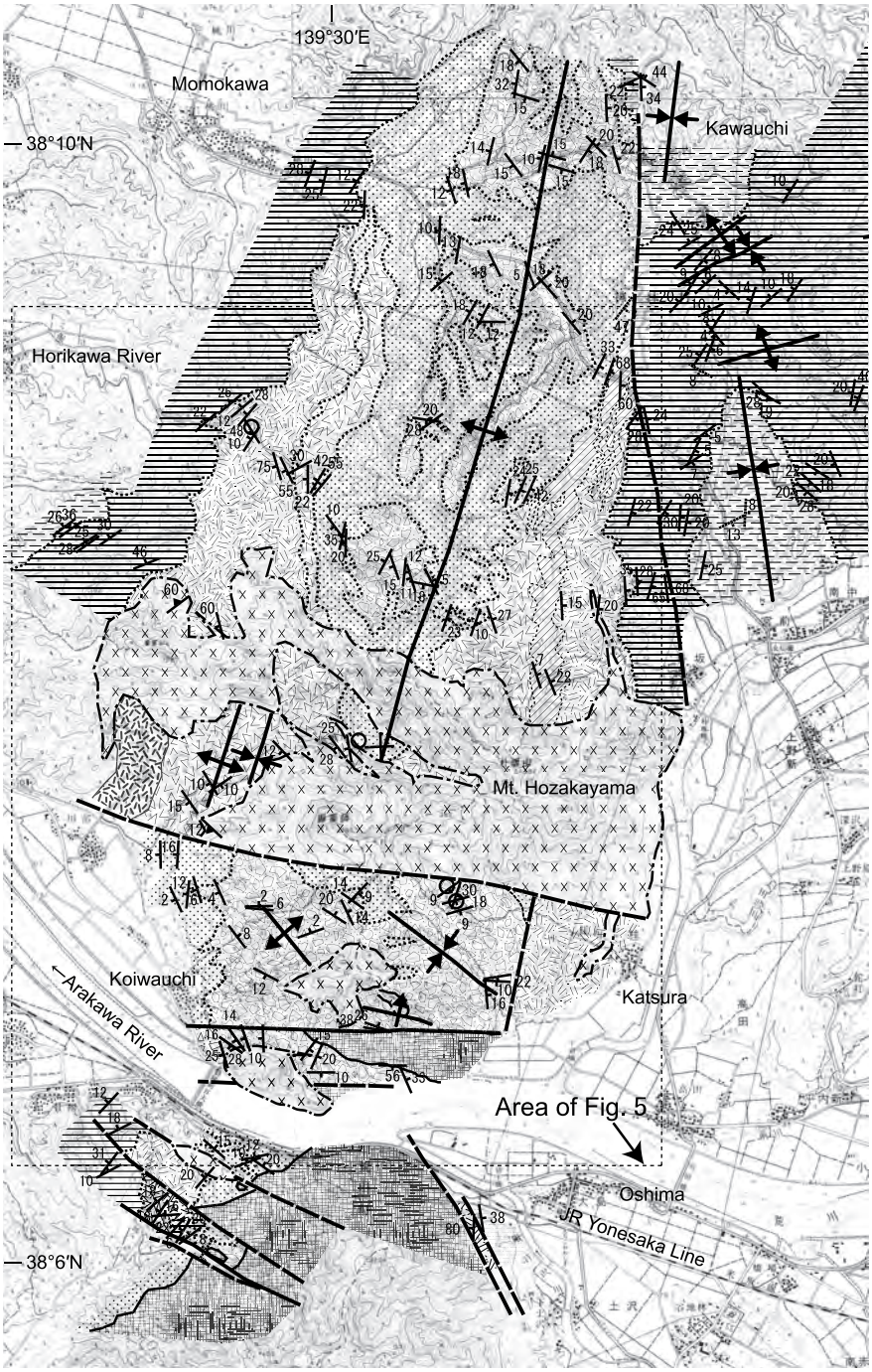
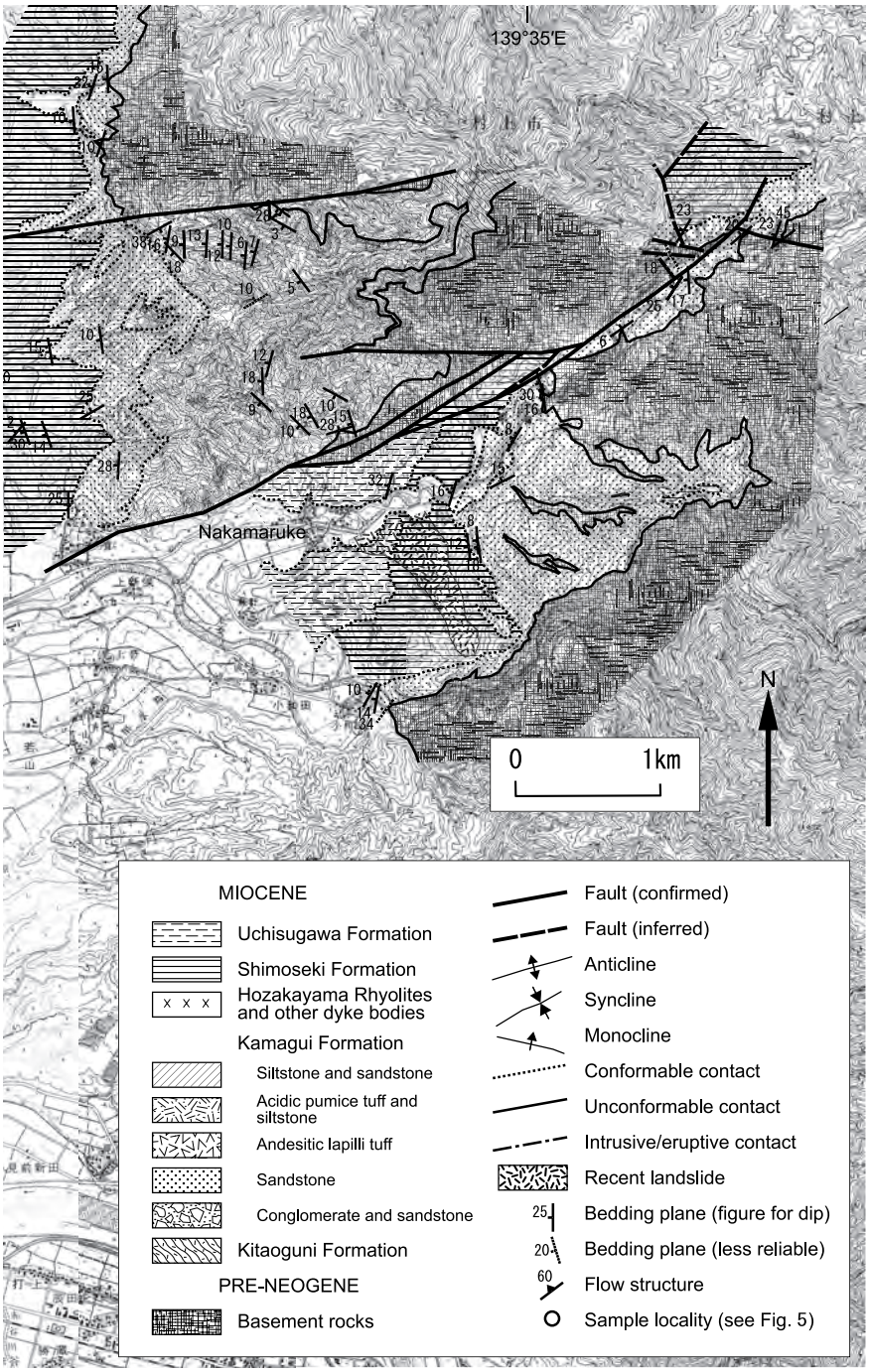


Fig. 3. Geological map of the Hozakayama area. Topographic map is after "Echigomonzen" by the Geographical Survey Institute with coordinates near Nakamaruke (occurred in 1981) refers to the web site of the http://www.jisuberi-kyokai.or.jp/kobetu/niigata/nakamaru/model.html.



1/25,000 scale “Sakamachi”, “Echigoshimoseki”, “Murakami” and
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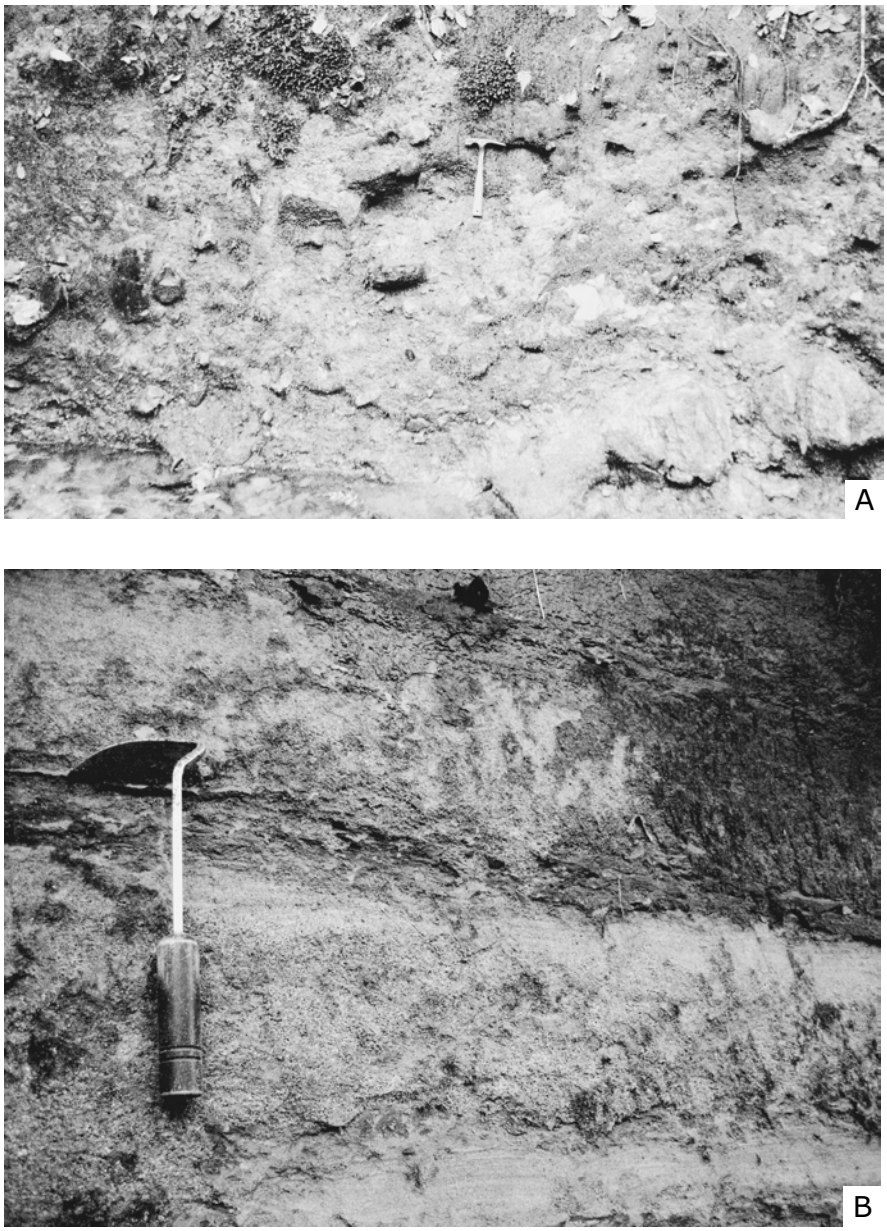

Fig. 4. Outcrops of the clastic rocks of the Kamagui Formation in the Hozakayama area, northern part of the Niigata sedimentary basin. **A:** Cobble–boulder conglomerate of the lower part of the Kamagui Formation at the Yaginosawa section. Almost no internal structures are observed except weak stratification (dipping to the left). Most of the gravels are very angular and derived from granitoids of the basement. Samples HZK-01 and -02 were collected from outcrops containing thin, fine-very fine sandstone layers nearby the location of this picture. Hammer (16 cm × 28 cm) for scale. **B:** Alternating beds of coarse to fine sandstone and siltstone of the middle part of the Kamagui Formation at the Akasakagawa section. Sandstones grade upward with parallel laminae at their top, frequently containing burrows and bioturbation, suggesting a shelf paleoenvironment. Sample HZK-03 was collected from an outcrop nearby the location of this picture. Tool at left is 25 cm long.

structures (Fig. 4A). The gravels have varying sizes from granule to boulder, some of which occur as outsized-clasts in finer matrix. These suggest substantial contribution of sediment-gravity-flow deposits to the lower part of the Kamagui Formation. In addition, some of the fine sandstone layers within the alternation bear tubular, *Ophiomorpha*-like burrows, each of which measures a few centimeters across. The middle part of the formation consists mainly of sandstone with frequent burrows and bioturbation (Fig. 4B). Alternating beds of sandstone, pyroclastic rocks and mudstone comprise the upper part of the Kamagui Formation. The Hozakayama Rhyolite is a complex of lava domes and their feeder dykes. Its activity was simultaneous with the deposition of the upper part of the Kamagui Formation. This is based on the intrusive relationship between the rhyolite dykes and the middle part of the Kamagui Formation, as well as on the lateral intercalation of the lava facies and the upper part of the Kamagui Formation. The lava facies includes massive or brecciated rhyolite, perlite and pitchstone. The Shimoseki and Uchisugawa formations (Nishida and Tsuda, 1961) consist of siliceous, bedded mudstone and massive siltstone, respectively. Basal layers of the Shimoseki Formation in some sections contain a lot of glauconite grains.

These strata form a N-S trending anticline (Momokawa anticline; Katahira, 1969a) and syncline in the western part of the study area, whereas a west-dipping homoclinal structure dominates in the eastern part. Faults of N-S and E-W trends also characterize the geologic structures.

Samples and methods

This study analysed four samples, HZK-01 to 04 from the southern part of the Momokawa anticline (Figs. 5 and 6). HZK-01 and 02 are from thin fine sandstone beds interbedded with conglomerate in the lower part of the Kamagui Formation (Fig. 4A). HZK-03 and 04 are claystone from the middle and upper part of the formation (Fig. 4B).

The samples were treated with HCl and HF under room condition to eliminate carbonate and siliceous minerals. The organic residues were then concentrated using zinc bromide heavy liquid (specific gravity = 2.0), screened on a 20 μm sieve, and mounted on a glass slide with polyvinylalchohol and polyester resin. No oxidation was carried out in the sample processing.

A Carl Zeiss Axioplan microscope was used for microscopic analysis. Each microscope slide was traversed at 160× along the shorter side of the coverslip. Identification was conducted at 600× using interference contrast. Each raw count of a given taxon in a sample is shown in Table 1. Relative abundance of cysts in each sample was calculated by the cyst counts per microscope traverse. In Table 1, abundance is expressed as R (rare, less than an average of one specimen per microscope traverse), C (common, 1-10), A (abundant, 10-30) and VA (very abundant, 30 or more). The density of residue strewn on the slide is not constant for all the samples, thus the abundance is only approximately true in this case. The cyst nomenclature used in this study generally follows Williams et al. (1998). All the material discussed in this

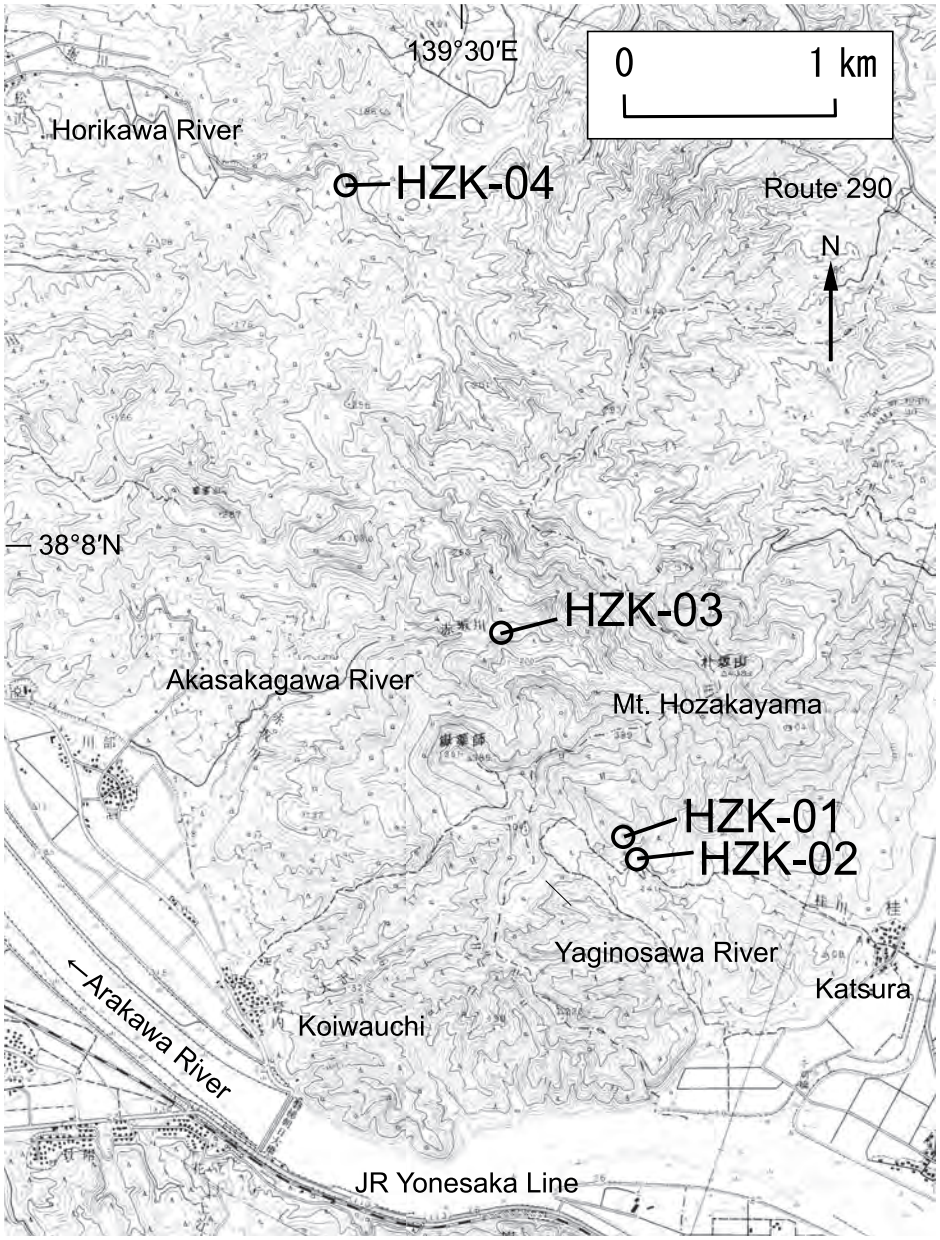

Fig. 5. Localities of the studied samples. Topographic map is after 1/25,000 scale "Sakamachi" and "Echigoshimoseki" by the Geographical Survey Institute with coordinates after Japanese Geocentric Datum according to ITRF.

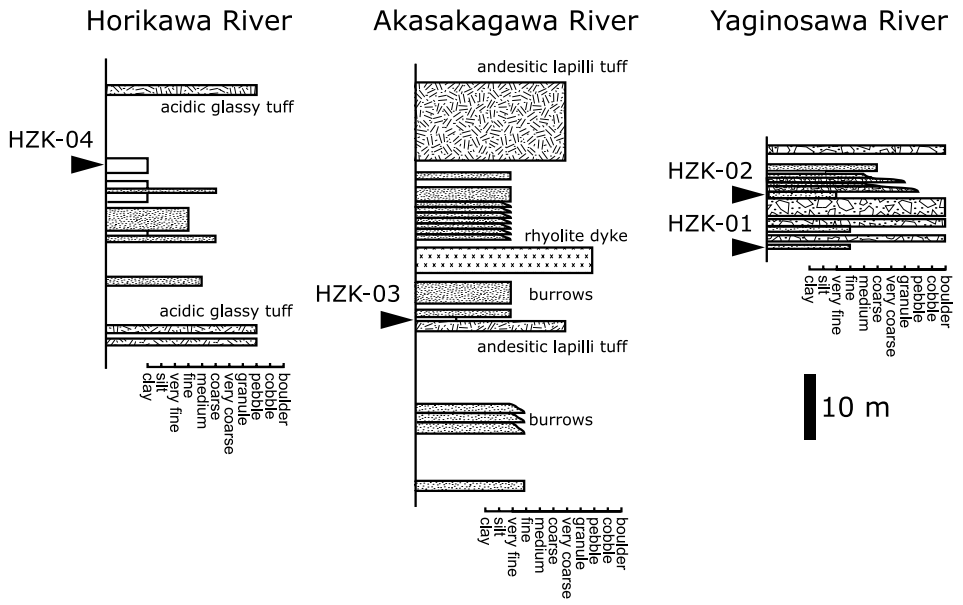

Fig. 6. Sedimentological log and horizons of the samples from the Kamagui Formation.

paper is housed in the palynological collection at the Department of Geology, Faculty of Science, Niigata University.

Dinoflagellate cysts from the Hozakayama area

Table 1 shows the results. Figs. 7 and 8 illustrate selected specimens. The number of encountered specimens varies from 4 to 37 per sample, which means the range of abundance between samples is rare to common. Preservation is generally moderate, as most specimens were folded and received slight diagenetic corrosion.

The dinoflagellate cyst assemblages are characterized by occurrences of *Achomosphaera* spp.*, Cribroperidinium giuseppei, Cribroperidinium*? *granomembranaceus, Lingulodinium machaerophorum, Operculodinium centrocarpum, Operculodinium giganteum, Spiniferites* spp. and *Systematophora placacantha.* Other relatively minor taxa include *Batiacasphaera minuta*, *Hystrichokolpoma denticulata*, *Spiniferites solidago* and *S. pseudofurcatus*. Most of the identified taxa belong to gonyaulacaceans, while protoperidiniacean taxa were represented only by a minor occurrence of *Selenopemphix nephroides*. There is no significant stratigraphic change in species composition within the studied interval. The assemblages were occasionally

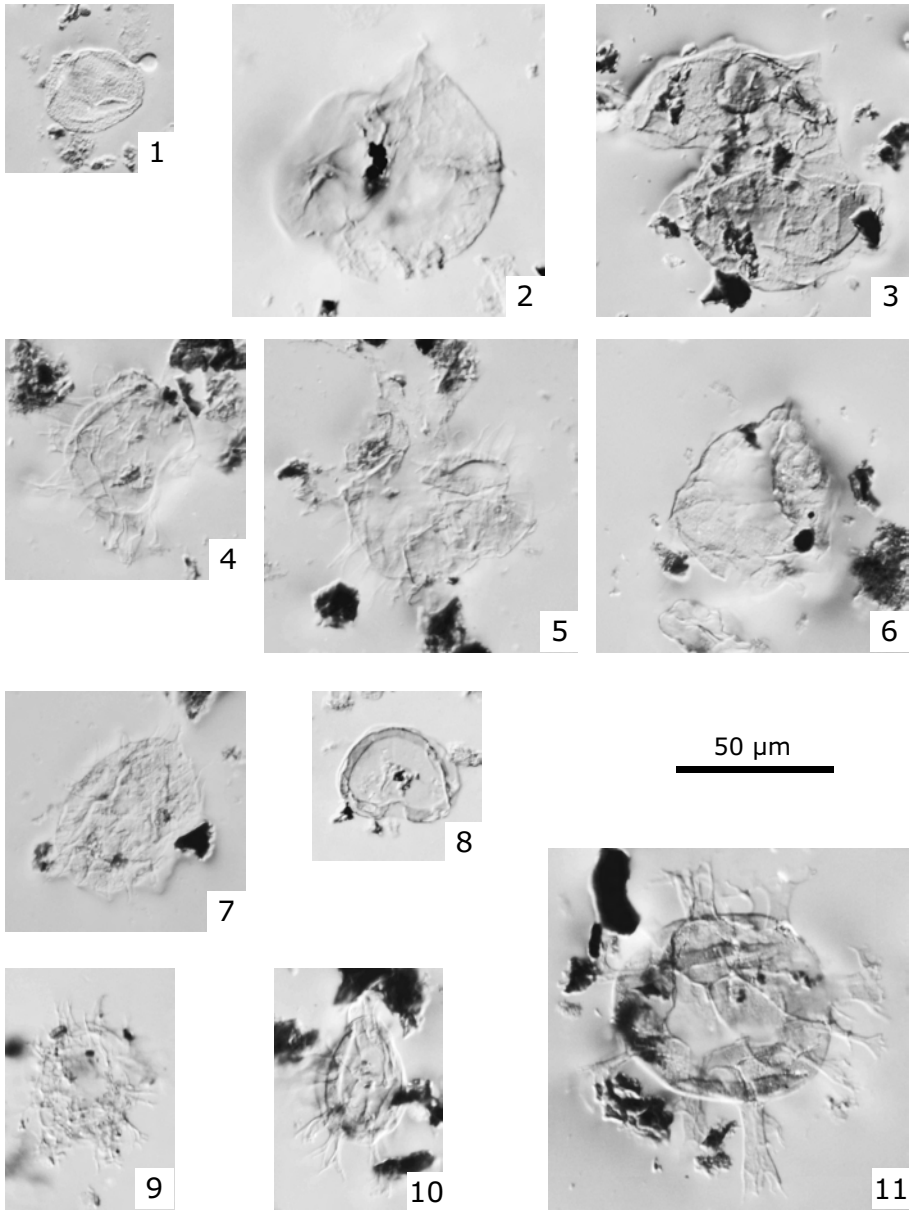

Fig. 7. Photomicrographs of selected dinoflagellate cysts from the Kamagui Formation in the Hozakayama area, under interference contrast. Scale bar is 50 µm. Each species name is followed by Sample ID and X-Y stage coordinates at a Carl Zeiss 45-35-02 stage for Axioplan microscope. **1:** *Batiacasphaera minuta*. HZK-04, 78.2 × 9.9. **2:** *Cribroperidinium giuseppei*, HZK-02, 87.9 × 14.9. **3:** *Cribroperidinium*? *granomembranaceum*, HZK-01, 102.2 × 9.0. **4:** *Hystrichokolpoma denticulata*, HZK-02, 96.6 × 11.2. **5:** *Lingulodinium machaerophorum*, HZK-02, 79.0 × 14.2. **6:** *Cribroperidinium*? *granomembranaceum*, HZK-02, 81.2 × 8.8. **7:** *Operculodinium centrocarpum*, HZK-02, 105.8 × 19.0. **8:** *Selenopemphix nephroides*, HZK-04, 89.0 × 14.2. **9:** *Spiniferites mirabilis*, HZK-02, 83.5 × 3.9. **10:** *Spiniferites solidago*, HZK-01, 90.5 × 10.2. **11:** *Spiniferites pseudofurcatus*, HZK-02, 80.3 × 11.5.

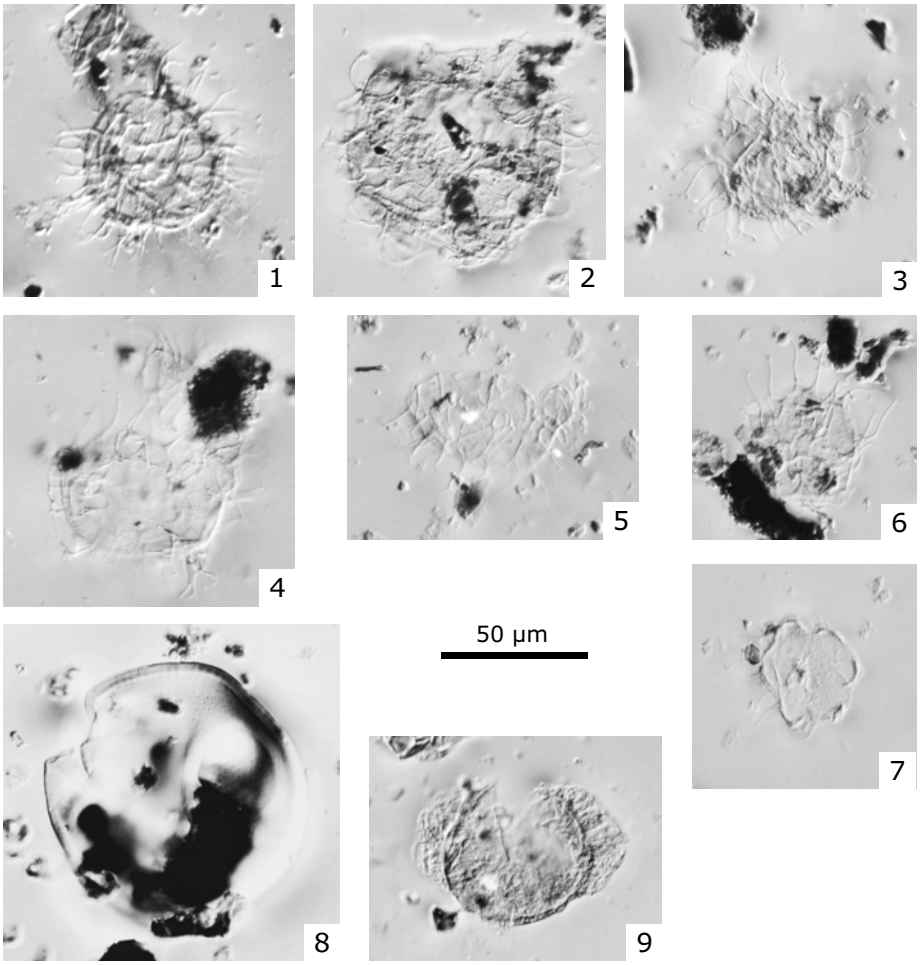

Fig. 8. See Fig. 7 for general captions. **1-7:** *Systematophora placacantha*, 1: HZK-04, 93.6 × 17.0, 2: HZK-02, 79.2 × 6.7, 3: HZK-02, 82.5 × 6.1, 4: HZK-02, 91.0 × 16.9, attached operculum at upper right, 5: HZK-04, 86.7 × 18.7, notches around archeopyle distinct, 6: HZK-01, 88.2 × 8.8, free operculum, 7: HZK-04, 93.7 × 8.2, free operculum. **8:** *Tasmanites* sp., prasinophycean alga, HZK-01, 90.4×19.4. **9:** *Dacrydium*, tropical conifer pollen, HZK-04, 96.7 × 8.9.

Table 1. Dinoflagellate cysts and other associated organic microfossils from the Kamagui Formation in the Hozakayama area.

	upsection→			
rock unit	Kamagui Formation			
	Lower		M.	U.
sample number	HZK-			
	01	02	03	04
number of traverses on slide	22	22	22	22
cysts counted	9	37	4	18
averaged cyst count per traverse	0.4	1.7	0.2	0.8
abundance	R	C	R	R
Dinoflagellate cysts				
Achomosphaera ramulifera (Deflandre) Evitt	1	3		2
Achomosphaera sp. cf. *A. spongiosa* Matsuoka and Bujak		2		
Achomosphaera spp.			2	
Batiacasphaera minuta (Matsuoka) Matsuoka and Head				1
Cribroperidinium giuseppei (Morgenroth) Helenes		1		
Cribroperidinium ? *granomembranaceum* (Matsuoka) Lentin and Williams	1	2		
Hystrichokolpoma denticulata Matsuoka		1		
Lingulodinium machaerophorum (Deflandre and Cookson) Wall		3		2
Operculodinium centrocarpum (Deflandre and Cookson) Wall		6		4
Operculodinium giganteum Wall		1		
Selenopemphix nephroides Benedeck				1
Spiniferites mirabilis (Rossignol) Sarjeant		1		
Spiniferites pseudofurcatus (Klumpp) Sarjeant		2		
Spiniferites solidago de Verteuil and Norris	1	1		1
Spiniferites spp.	1	5	1	1
Systematophora placacantha (Deflandre and Cookson) Davey et al.	5	9	1	6
Other palynomorphs				
Dacrydium (tropical conifer pollen)				+
Tasmanites sp. (prasinophycean alga)	1	2		

+=present

accompanied with prasinophycean species *Tasmanites* spp., as well as with pollen of a tropical-subtropical conifer *Dacrydium*.

The consistent occurrences of *Systematophora placacantha* and overall species composition of the assemblages indicate the correlation of the studied section to the Subzone b of the *Diphyes latiusculum* Zone. The *D. latiusculum* Zone was originally established by Matsuoka et al. (1987) and subsequently redefined, subdivided and age-calibrated by Obuse and Kurita (1999) and Obuse et al. (2004). According to Obuse et al. (2004), the Subzone b of the *D. latiusculum* Zone is coeval with the interval of the diatom *Crucidenticula kanayae* Zone to the basal part of the *D. hyalina* Zone (16.9-14.7 Ma, late Early - early Middle Miocene; Yanagisawa and Akiba, 1998).

As the identified dinoflagellate cysts are all marine-inhabiting taxa, the deposition of the Kamagui Formation in the Hozakayama area, even of the gravelly section in the lower part, should have occurred under a marine paleoenvironment. Occasional occurrences of the tubular burrows in the lower part of the Kamagui Formation (Fig. 2) advocate this interpretation.

Conclusion

This study provides the first paleontological constraint by marine planktonic microfossils on the age and depositional environments of the gravelly facies at the base of the clastic Miocene in the northern part of the Niigata sedimentary basin. The present study has shown that the age range of the Kamagui Formation in the Hozakayama area falls within 16.9-14.7 Ma. This is consistent with the dinoflagellate cyst age of the same formation at the Namiishizawa section in the Tainaigawa River area, 8 km south of the study area (Fig. 1; Kurita and Ishikawa, 2009), and correlates well with the Middle Miocene Climatic Optimum (MMCO; Zachos et al., 2001) interval. This confirms that the deposition of the Kamagui Formation, including its gravelly facies at the basal part, should be located within the MMCO interval at ca. 17-15 Ma, as suggested by previous studies (e.g., Kobayashi and Tateishi, 1992). The marine depositional environment for the gravelly facies of the lower part of the Kamagui Formation, together with the frequent occurrences of sediment-gravity-flow deposits within it, suggests that this part was formed as the subaqueous part of either a fan delta or braidplain delta system (McPherson et al., 1987; Orton, 1988; Miall, 1992).

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