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Fossil Diatoms from the Neogene Sannohe Group on the Northwest Margin of the Kitakami Mountains, Northeast Honshu, Japan

By

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Abstract

This paper deals with the fossil diatom assemblages from the Neogene Sannohe group on the northwest margin of the Kitakami mountains.

Ecologically the assemblages are of marine, planktonic, north-boreal and mixed zone of oceanic and neritic. Biostratigraphically the Shimotomai diatomite member corresponds to the assemblage B of Kanaya and to the B_1 of Sawamura, whereas the Shimoda siltstone and the Hakamada alternation members correspond to the assemblage C of Kanaya, B_3 of Sawamura, and the flora of the Pliocene Narusawa formation of Koizumi.

Introduction

The purpose of this paper is to describe some fossil diatom assemblages of the Neogene Sannohe group on the northwest margin of the Kitakami mountains for a basis of correlation and paleogeography of the group.

A correlation by fossil diatoms has been often discussed on the Neogene geologic column and the informations on its stratigraphic and paleoecologic values are accumulated today (Kanaya, 1959; Ichikawa, 1950, 1960; Sawamura, 1963 a, b, c; Sawamura and Yamaguchi, 1961).

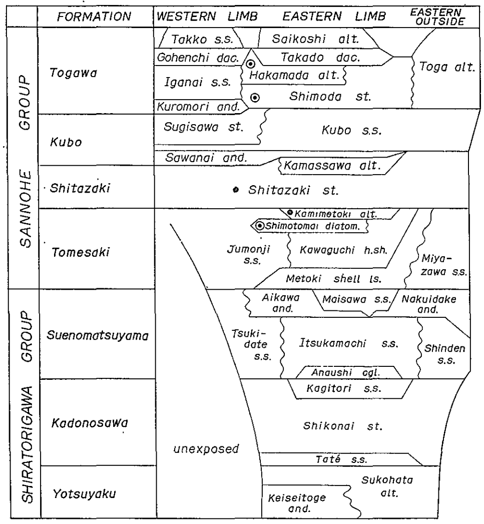
The detailed stratigraphy of upper part of Neogene Tertiary—Sannohe group—on the northwest margin of the Kitakami mountains has been recently clarified through Chinzei's works (Chinzei, 1958 a, b, 1966). Nevertheless, there seem to remain some problems, particularly concerning correlation and geologic age of the lower half of Sannohe group which yield no characteristic mega-fossils. To obtain some micropaleontologic data on such problems, the writer preliminarily studied the fossil diatom flora of a part of the group.

According to Chinzei (1958 a, b, 1966), the Sannohe group, representing one cycle of sedimentation, is stratigraphically divided into four formations (Table 1). The Kubo and Togawa formations, the middle and upper parts of the Sannohe respectively, are assigned to Pliocene by the occurrence of the Pliocene Omma-Manganjian-type fauna, and the uppermost of the Tomesaki formation, is assigned also to Pliocene by the occurrence of two individuals of Pliocene *Fortipecten*. On the other hand, the lower part of the Tomesaki formation belongs to Miocene by the occurrence of the Miocene mollusca. From these evidences he concluded that the biostratigraphical boundary between Miocene and Pliocene was at some horizon in the middle part of the Tomesaki formation.

* 地 質 部

Table 1 Stratigraphic succcesion of the younger Tertiary deposits in the Mabechi River valley

(CHINZEI 1966)



st.: siltstone s.s.: sandstone alt.: alternation ls.: limestone
and.: andesite dac.: dacite cgl.: conglomerate h.sh.: hard shale

Marks • showing the horizon from which diatom samples were examined.
Marks ⊙ showing the horizon in which diatoms aboundantly occur.

The fossil diatoms of this area were once studied by MURAI (1958), who described a diatom assemblage of the diatomite deposit (Shimotomai diatomite member of CHINZEI). Analyzing the diatom assemblage he thought that the diatomite was deposited in a shallow cold sea at the latest Miocene.

Samples and their geologic horizons

Samples used in this study were collected by K. SAWAMURA, A. MIZUNO and M. HATA and they came from the following members: the Shimotomai diatomite, the Kamimetoki sandstone and siltstone, the Shitazaki siltstone, the Kamassawa alternation of sandstone and siltstone, the Shimoda siltstone, and the Hakamada alternation.

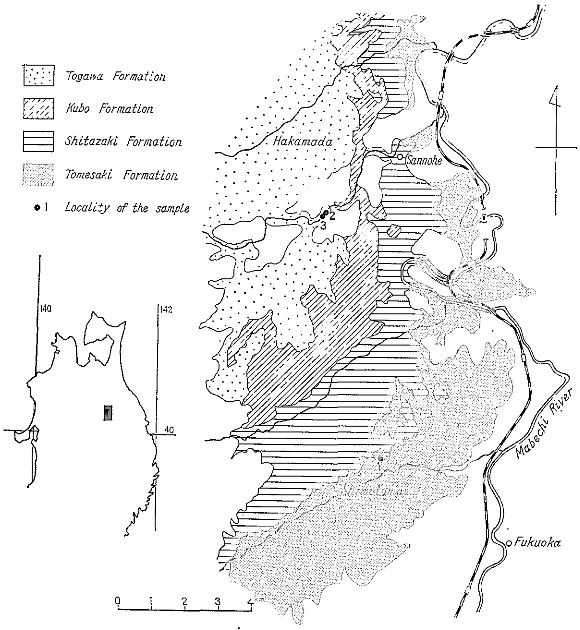


Fig. 1 Locality map of the samples
Sample locality
1: Shimotomai diatomite
2: Shimoda siltstone
3: Hakamada alternation
(Geology: simplified after CHINZEI, 1966)

Among them, three specimens, from the Shimotomai diatomite member, from the Shimoda siltstone member and from the Hakamada alternation member respectively, contain rich fossil diatoms, and only for these three, frequencies of individuals of every species were obtained by identifying 200 diatom valves in each specimen. The specimens from other three horizons contain only minor amounts of diatom and a description on them is excluded from this paper.

Xanthiopyxis spp. and other resting spores were not counted.

Samples were prepared for microscopic observation following the way reported by SAWAMURA (1961).

Occurrence of flora

From the Shimotomai sample 29 species and a variety of 17 genera were discriminated, from the Shimoda sample 21 species and a variety of 9 genera and from the Hakamada sample 18 species and a variety of 12 genera were identified. They are summarized in Table 2.

Table 2 Floral list, showing ecology and frequencies of the assemblages

Name of species	Shimotomai	Shimoda	Hakamada	Ecology
Oceanic				
Actinocyclus curvatulus JANISCH		0.5		M P O NB
Coscinodiscus curvatulus GRUNOW	1.5			M P O NB
C. lineatus EHRENBERG		1.0		M P O SB
C. marginatus EHRENBERG	2.5	24.0	35.0	M P O NB
C. oculus iridis EHRENBERG	1.0	0.5		M O B
C. radiatus EHRENBERG	0.5	0.5	0.5	M P O SB
Pseudoeunotia doliolus GRUNOW	0.5			M O T
Thalassiothrix longissima CLEVE et GRUNOW	3.0	1.5	1.0	M P O A–NB
	9.0	28.0	36.5	
Neritic				
Actinoptychus undulatus (BAILEY) RALFS	3.5		1.0	M P N NB
Cocconeis costata GREGORY	0.5	1.5	1.0	M B N NB
Nitzschia pacifica CUPP		0.5		M P N
Stephanopyxis turris (GREVILLE et ARNOTT) RALFS			1.0	M P N SB
Thalassionema nitzschioides GRUNOW	11.0	29.0	13.0	M P N NB
Thalassiosira spp.	2.0	28.0	24.5	M P N B
	17.0	59.0	40.5	
Sublittral				
Actinocyclus ehrenbergi RALFS		0.5		M P S SB
Cocconeis vitrea BRUN	0.5			M B S NB
Grammatophora sp.	1.0		1.0	M B S SB
Melosira sol (EHRENBERG) KÜTZING	1.0			M B S SB
M. sulcata (EHRENBERG) KÜTZING	1.0			M P S NB
	3.5	0.5	1.0	

Name of species	Shimotomai	Shimoda	Hakamada	Ecology
unknown				
Actinocyclus ingens RATTRAY	8.0	0.5	0.5	M P
A. tsugaruensis KANAYA	3.0		0.5	M
Cocconeis antiqua TEMPERE et BRUN		0.5		M B
C. scutellum EHRENBERG		0.5		M B
C. sp.		1.0		M B
Coscinodiscus elegans GREVILLE	1.0			M P
C. endoi KANAYA	1.5			
C. subtillis EHRENBERG		1.0		
C. yabei KANAYA	1.0			
C. vetustissimus PANTOCSEK		0.5		M P
Denticula hustedtii SHIMONSEN et KANAYA	30.5			M P
D. spp.		4.5	2.0	M P
Dicladia sp.	0.5			M P
Diploneis fusca (GREGORY) CLEVE var. *pervasta* (PANTOCSEK) HUSTEDT		0.5	0.5	M P
Goniothecium spp.	4.5			
Hyalodiscus ukaiensis ICHIKAWA			0.5	
Melosira granulata (EHRENBERG) RALFS			1.5	F
Nitzschia seriata CLEVE	1.0			
Rhizosolenia sp.	0.5		0.5	M P
Rouxia peragalli BRUN et HERIB	0.5			M
Synedra affinis var. *fasciculata* (KÜTZING) GRUNOW	0.5			
Thalassiosira condensata (CLEVE)	4.5			
Triceratium condecorum BRIGHT *f. brunii* (PANTOCSEK) TSUMURA	0.5			M
T. sp.	0.5			
Miscellaneous	12.5	3.5	16.0	
	70.5	12.5	22.0	

Remarks on ecology:
The ecology followed JOUSE (1957), except *Coscinodiscus lineatus* which she showed as tropical, but here followed SHESHKOVA (1967).
M: marine F: fresh-water P: planktonic B: benthonic O: oceanic N: neritic S: sublittoral A: arctic NB: north-boreal B: boreal SB: south-boreal T: tropical

Discussion on diatom assemblages on the Shimotomai flora

MURAI (1958) analyzed diatom assemblage from Shimotomai diatomite member, diatomite formation named by him, and described that Centrales predominated in numbers of individuals as well as in that of species over Pennales to which only 6 species, 4 genera, belonged out of 32 identified species. Genus *Coscinodiscus* was most frequent and *Coscinodiscus elegans* GREV. sometimes exceeded a half of total individuals*. The frequency of the species of Shimotomai flora obtained in this study are shown in Table 3**.

The differences between both the results are summarized as following two points.

1) Different species show high frequency in each counting. Most frequent species in the latter, *Denticula hustedtii* which occupies 30.5% did not appear at all in the former. Frequent species in the former, *Coscinodiscus elegans* and *C. marginatus*, are not frequent and

* KANAYA (1959) has shown that *Actinocyclus ingens* and *A. tsugaruensis* are formerly included in *Coscinodiscus elegans*.

** Comparing with MURAI's (1958) result, in the present analysis MURAI's "rare species" did not appear in the 200 specimens counted, but may be found present here if more than 200 diatom valves are counted.

Table 3 Comparison between the frequency by MURAI and ONO from the assemblages of the Shimotomai

Centrales	MURAI	ONO
Actinocyclus ingens RATTRAY		8.0
A. tsugaruensis KANAYA		3.0
Actinoptychus undulatus (BAILEY) RALFS	C	3.5
Coscinodiscus curvatulus GRUNOW	R	1.5
C. elegans GREVILLE	F	1.0
C. endoi KANAYA		1.5
C. marginatus EHRENBERG	F	2.5
C. oculus iridis EHRENBERG	R	1.0
C. radiatus EHRENBERG	C	0.5
C. yabei KANAYA		1.0
Melosira sol (EHRENBERG) KÜTZING	C	1.0
M. sulcata (EHRENBERG) KÜTZING		1.0
Thalassiosira sp.		2.0
T. condensata (CLEVE)		4.5
Triceratium condecorum BRIGHT *f. brunii* (PANTOCSEK) TSUMURA		0.5
T. sp.		0.5
Arachnoidiscus ehrenbergii BAILEY	C	
A. ornatus (BRÉBISSON) GREVILLE	R	
Asterolampra marylandica EHRENBERG ?	R	
Asteromphalus flabellatus (BRÉBISSON) GREVILLE	R	
Biddulphia sp.	R	
Cocconeis sp. (*C. placentula* EHRENBERG ?)	R	
C. sp.	R	
Coscinodiscus apiculatus EHRENBERG var. *ambigua* GRUNOW	C	
C. asteromphalus EHRENBERG	R	
C. concavus GRUNOW	R	
C. excentricus EHRENBERG	R	
C. kützingi A. SCHMIDT ?	R	
C. lineatus EHRENBERG	C	
C. perforatus EHRENBERG	R	
C. sp.	R	
Cyclotella cf. *kützingiana* var. *radiosa* FRICKE	R	
C. sp.	R	
Hyalodiscus sp. (*H. subtilis* BAILEY ?)	R	
Triceratium alternans BAILEY	R	
T. sp.	R	
Miscellaneous		7.5
Total		40.5

Pennales	MURAI	ONO
Cocconeis costata GREGORY		0.5
C. vitrea BRUN		0.5
Denticula spp.		30.5
Dicladia sp.		0.5
Goniothecium spp.		4.5
Grammatophora sp.		1.0
Nitzschia seriata CLEVE		1.0
Pseudoeunotia doliolus GRUNOW		0.5
Rhizosolenia sp.		0.5
Rouxia peragalli BRUN et HERIB		0.5
Synedra affinis var. *fasciculata* (KÜTZING) GRUNOW		0.5

Pennales	Murai	Ono
Thalassionema nitzschioides Grunow		11.0
Thalassiothrix longissima Cleve et Grunow		3.0
Cocconeis sp. (*C. placentula* Ehrenberg?)	R	
C. sp.	R	
Diploneis splendida (Gregory) Cleve	R	
D. sp. (*D. bomboides* (A. Schmidt) Cleve?)	R	
D. sp.	R	
Navicula sp.	R	
Rhabdonema sp.	R	
Miscellaneous		5.0
Total		59.5

occupy only 12.0% and 2.5% in the latter (even including *Actinocyclus ingens* and *A. tsugaruensis* as *Coscinodiscus elegans* type).

2) In the former only few Pennales appear, but in the latter Pennales occupy 59.5% in numbers of individuals and 13 species of Pennales appear for 16 species of Centrales.

In Murai's examination the small specimens of *Denticula* species and other Pennales species might not be detected.

Ecological analysis

The assemblages from the Shimotomai, Shimoda and Hakamada members are analyzed with regard to the type of water in which diatoms inhabit, their mode of life, marine environment, and water temperature according to Jouse and Sheshkova.

1) The ratio between the marine and fresh-water species among 200 specimens.

	marine	fresh-water
Shimotomai	74.0	—
Shimoda	95.5	—
Hakamada	82.0	1.5

2) The ratio between the planktonic and benthonic species in marine species.

	planktonic	benthonic
Shimotomai	88.5	4.1
Shimoda	95.8	3.7
Hakamada	97.0	2.4

3) The ratio between ecologically known and unknown species with regard to marine environment.

	known	unknown
Shimotomai	29.5	70.5
Shimoda	87.5	12.5
Hakamada	78.0	22.0

a) The ratio between oceanic, neritic, and sublittoral species.

	oceanic	neritic	sublittoral
Shimotomai	9.0 (30.5)	17.0 (57.6)	3.5 (11.9)
Shimoda	28.0 (32.0)	59.0 (67.4)	0.5 (0.6)
Hakamada	36.5 (46.8)	40.5 (51.9)	1.0 (1.3)

( ): The ratio in the ecologically known species.

b) The ratio of the species classified by water temperature.

	arcto-boreal	boreal	north-boreal	south-boreal	tropic
Shimotomai	3.0 (10.2)	3.0 (10.2)	20.5 (69.5)	2.5 (8.5)	0.5 (1.7)
Shimoda	1.5 (1.7)	28.5 (32.8)	55.0 (63.2)	2.0 (2.3)	
Hakamada	1.0 (1.3)	24.5 (31.4)	50.0 (64.1)	2.5 (3.2)	

( ) : The ratio in the ecologically known species.

Comparisons on ecology of the assemblages from the three members are summarized as follows:

1. Marine species constitute all or nearly all of ecologically known species with regard to type of water which cover over 70% of all in three assemblages.
2. Planktonic species amount nearly 90 % or more in marine species of the assemblages.
3. The assemblages are JOUSE's "mixed zone type of oceanic and neritic" judged from known species which are nearly 80 % or more of the flora of the Shimoda and Hakamada members whereas only 30 % of that of the Shimotomai diatomite member. *Denticula hustedtii*, the most frequent species in the flora of the Shimotomai diatomite, is the extinct one and its ecology is unknown, but it is probable that the species lived in the oceanic condition like as recent species *D. seminae*, which is marine, planktonic and north-boreal. If this species is added to the oceanic species of JOUSE, then oceanic species constitutes 65.8 % of known 60.0% of the Shimotomai flora and the assemblage is classified in the oceanic type.

In short, these assemblages are ecologically nearly identical and if *Denticula hustedtii* is assumed as an oceanic species, then the flora of the Shimotomai diatomite represents a more oceanic condition than those of the Shimoda and Hakamada members.

Difficulty remains concerning the ecological analysis of the present material because of the scarcity of ecologically known species in the assemblage from the Shimotomai diatomite member. The forms available for the analysis are only 29.5 %. Since the conclusion has been drawn from an analysis with the dominant species ecologically uncertain, it may be changed, as KANAYA pointed out (1959, p. 45), when the ecology of the species becomes known by future work, and thus becomes incorporative to the analysis.

Biostratigraphical significance

KANAYA (1959) divided the diatom assemblages from the Onnagawa formation into three zones by eight characteristic species; namely assemblage A, assemblage B (*Coscinodiscus yabei* assemblage) and assemblage C. Diatom assemblage A—The total frequencies of the eight marker species are low, and *Coscinodiscus yabei* is lacking. Diatom assemblage B (*Coscinodiscus yabei* assemblage)—The total frequency of the eight marker species is higher than 14 in a random sample of 200 specimens and *Coscinodiscus yabei* is restricted to this assemblage. Diatom assemblage C—The total frequency of the eight marker species show a marked decrease, being lower than 13 in a random sample of 200 specimens. In the assemblage, both *Coscinodiscus yabei* and *Stephanogonia hanzawae* are lacking and *Cocconeis antiqua and C. formosa* appear. And moreover *Coscinodiscus marginatus* abruptly increases.

Table 4 Total frequencies of KANAYA's marker species of the assemblages

Name of marker species	Shimotomai	Shimoda	Hakamada
Coscinodiscus yabei	1.0		
Stephanogonia hanzawae	(3.0)		
Actinocyclus ingens	8.0	0.5	0.5
A. tsugaruensis	3.0		0.5
Coscinodiscus endoi	1.5		
Stephanopyxis schenckii			
S. cf. *ferox*			
Coscinodiscus vetustissimus		0.5	
Total frequencies of marker species	13.5 (16.5)	1.0	1.0

( ): Total frequency to which *Stephanogonia hanzawae* are added. This species is omitted as resting spore in the counting of 200 specimens.

Total frequencies of the eight marker species of the three assemblages are shown in Table 4.

The assemblage from the Shimotomai diatomite member corresponds to KANAYA's assemblage B. Total frequencies of the eight marker species are 13.5 % (16.5 %) and *Coscinodiscus yabei*, characteristic to the assemblage B, occurs.

The assemblages from the Shimoda siltstone member and Hakamada alternation member correspond to KANAYA's assemblage C. The total frequencies of the eight marker species are 1.0% in both assemblages and *Coscinodiscus yabei* and *Stephanogonia hanzawae* are lacking in the assemblage, marked increase of *Coscinodiscus marginatus* and decrease of the total frequency of the eight marker species. Both characterize the assemblage C, however two species, *Cocconeis antiqua* and *C. formosa*, which may be expected in this assemblage, do not appear.

SAWAMURA and YAMAGUCHI (1961) classified the hard shale beds in the Abashiri-Urahoro area into three groups, A, B_1 and B_2 by considering predominance of three species, *Denticula lauta*, *Coscinodiscus marginatus* and *C. elegans* type species. The group A is characterized by the scarcity of the three species, the group B_1 by the predominance of *Denticula lauta* and *Coscinodiscus elegans* type species, and the group B_2 by the predominance of *Coscinodiscus marginatus*. Later, SAWAMURA (1963c) subdivided A group to $A_1 \sim A_3$ and suggested the existence of B_3 group. The group B_3 is characterized by the predominance of *Thalassiosira* spp. KOIZUMI (1966) showed in the Aomori area, that the Miocene are rich in *Coscinodiscus marginatus* and rare in *Thalassiosisa* while the Pliocene Narusawa formation is abundant in *Thalassiosira* spp. He reported that the difference deserves special emphasis.

Thus in terms of SAWAMURA (1963c)'s classification the assemblage from the Shimotomai diatomite member is referable to group B_1 and those from the Shimoda siltstone member and Hakamada alternation member to group B_3.

	Denticula spp.	*Coscinodiscus elegans* type	*Coscinodiscus marginatus*	*Thalassiosira* spp.
Shimotomai	30.5	12.0	2.5	2.0
Shimoda	4.5	0.5	24.0	28.0
Hakamada	2.0	1.0	35.0	24.5

Summary

1. Fossil diatoms from the Shimotomai diatomite member, the Shimoda siltstone and the Hakamada alternation members of the Sannohe group were studied. 29 species and a variety of 17 genera are identified from the Shimotomai, 21 species and a variety of 9 genera from the Shimoda, and 18 species and a variety of 12 genera from the Hakamada.

   Comparing to MURAI's work (1958), present study shows higher frequency of *Denticula hustedtii,* which did not appear in the former, and Pennales and much less frequency of *Coscinodiscus elegans* and *C. marginatus* than the former.
2. Ecologically the assemblages are of marine, planktonic, north-boreal and mixed zone of oceanic and neritic.

   Some uncertainty remains as to the ecology of the assemblage from the Shimotomai diatomite member and it is probable to be more oceanic than those of the Shimoda siltstone member and the Hakamada alternation member.
3. Biostratigraphically the Shimotomai diatomite member corresponds to the assemblage B of KANAYA (1959), and to the B_1 of SAWAMURA (1963) whereas the Shimoda siltstone member and the Hakamada alternation member correspond to the assemblage C of KANAYA and B_3 of SAWAMURA, and the flora of Pliocene Narusawa formation of KOIZUMI (1966).

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北上山地北西縁新第三紀三戸層群の化石珪藻群集

小野 美代子

この論文では，岩手県福岡町付近の新第三紀三戸層群留崎層下斗米含珪藻シルト岩層，および斗川層下田シルト岩層，袴田互層三層準の化石珪藻群集を扱い，古生態および地層対比の可能性を検討した。それによって次の結果が得られた。

1） 三層準の珪藻群集はいずれも，(1)海棲種，(2)浮遊性種，(3)North-boreal 型，(4)外洋性種と浅海性種との混合型組成によって特徴づけられる。

2） 生物層序学的には，下斗米含珪藻シルト岩層の珪藻群集は，金谷のB群集・沢村の B_1 群集に相当し，下田シルト岩層および袴田互層の珪藻群集は，金谷のC群集・沢村の B_3 群集・小泉の鮮新世鳴沢層の珪藻群集に対比できる。