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Paleogene radiolarians from the Hyuga and Nichinan Groups in the Sueyoshi district, southeastern Kyushu, Japan

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Abstract: The Paleogene to lowest Neogene sedimentary complex is extensively distributed in the Sueyoshi district, near the border of Kagoshima and Miyazaki Prefectures, Kyushu. It is divided into the Hyuga Group and Nichinan Group, which are further subdivided into five and two tectonostratigraphic units, respectively. Radiolarians occur in fine-grained sedimentary rocks of both groups, and are quite useful in clarifying the detailed geology owing to their biostratigraphic potential.

This study reports the occurrences of 50 Paleogene radiolarians in the Hyuga and Nichinan Groups of the Sueyoshi district, and intends to present the detailed description of the age assignments for the units. As a result, it is confirmed that the groups are composed mainly of the Middle Eocene and Oligocene strata, respectively.

Of the identified species, *Podocyrtis* (*Lampterium*) *mirabilis* and *Lochocyrtis* (?) *cavifundus* are new to science.

1. Introduction

The Eocene to Lower Oligicene Hyuga and the Lower Oligocene to Lower Miocene Nichinan Groups, constituting the Southern Belt of the Shimanto Terrane, are widely distributed in eastern part of the Southern Kyushu (Fig. 1). The Hyuga Group is considered to be an accretionary complex, whereas the Nichinan Group is represented by olistostromal facies (e.g. Sakai, 1983). Recent micropaleontological studies have contributed to claryfing their stratigraphy and structures (e.g. Kato, 1985; Nishi, 1988, 1992). However, those studies have been performed mainly in the eastern and southeastern parts of Kyushu, so that little is known about the detailed geology of the central and southern parts including the Sueyoshi district.

The Sueyoshi district extending over Miyazaki and Kagoshima Prefectures is underlain by the Northern and Southern Belt of the Shimanto Terrane consisting of the Morotsuka, Hyuga and Nichinan Groups (Fig. 2). Kato (1985) first reported Eocene to Early Miocene microfossils from the Nichinan district involving the eastern part of the study district. In order to clarify the detailed geologic structures and establish consistent stratigraphy, the authors have also accumulated micropaleontological data in the Sueyoshi district, a part of which concerning the Cretaceous Morotsuka Group has already been pub-

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Keywords: Radiolaria, Nassellaria, Pterocorythidae, *Podocyrtis (Lampterium) mirabiris*, *Lochocyrtis*(?) *cavifundus*, Sueyoshi, Kagoshima, Miyazaki, Kyushu, Japan, Tertiary, Paleogene, Eocene, Oligocene, Shimanto Supergroup, Hyuga Group, Nichinan Group, accretionary complex

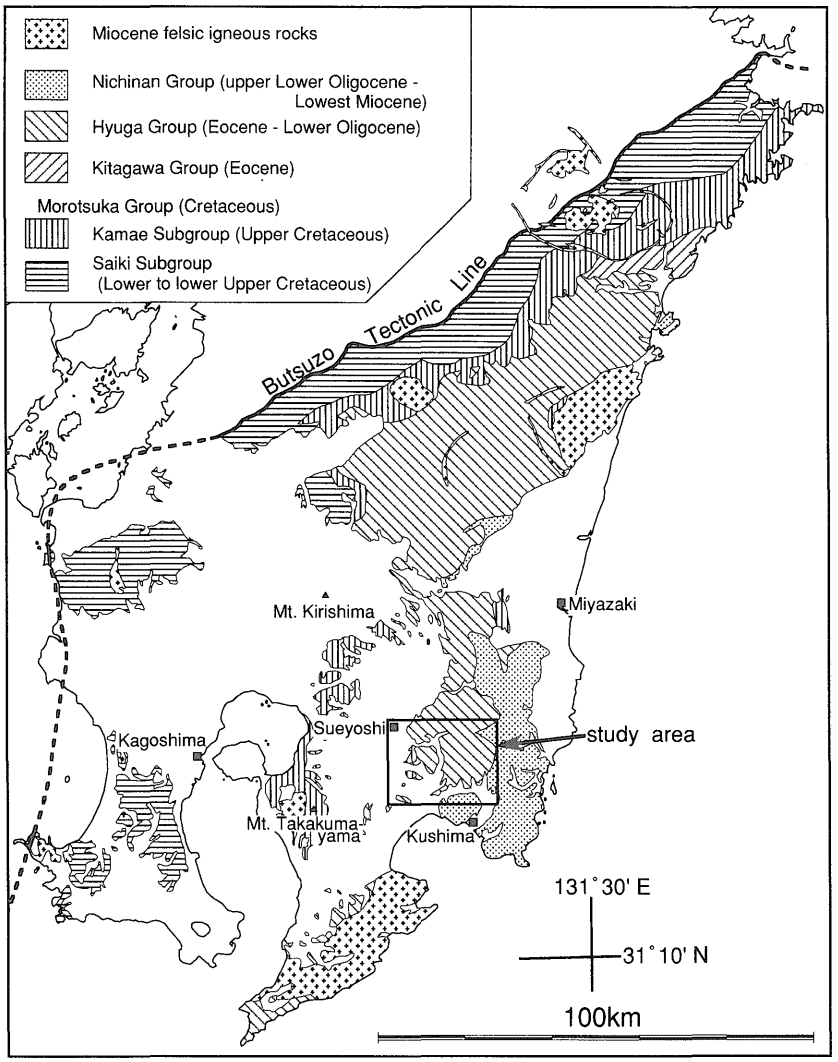


Fig. 1 Geologic map of the southern Kyushu, showing the location of the study area (modified from Saito *et al.*, 1994).

lished (Saito *et al.*, 1993).

This paper, therefore, focuses on radiolarian chronology of the Hyuga and Nichinan Groups; namely, the ages of their subdivided units are assigned by radiolarians. Two new species are described in the systematic section.

2. Outline of geology

The detailed geology of the Sueyoshi district is fully discussed in a separate paper (Saito *et al.*, 1994). Only the outline is thus mentioned below.

The Hyuga Group is widely distributed in the eastern and central parts of the Sueyoshi district, and subdivided into following tectonostratigraphic units which occur in fault contact with one another; the Uchinokura, Yanagidake, Bishagano, Tanoura and Taino Units.

The Uchinokura Unit in the southeastern part is composed mainly of sandstone and sandstone-dominant turbidite with mudstone and melange. The mudstone is reddish, greenish and blackish, and has generally undergone deformation. It sometimes comprises clasts of

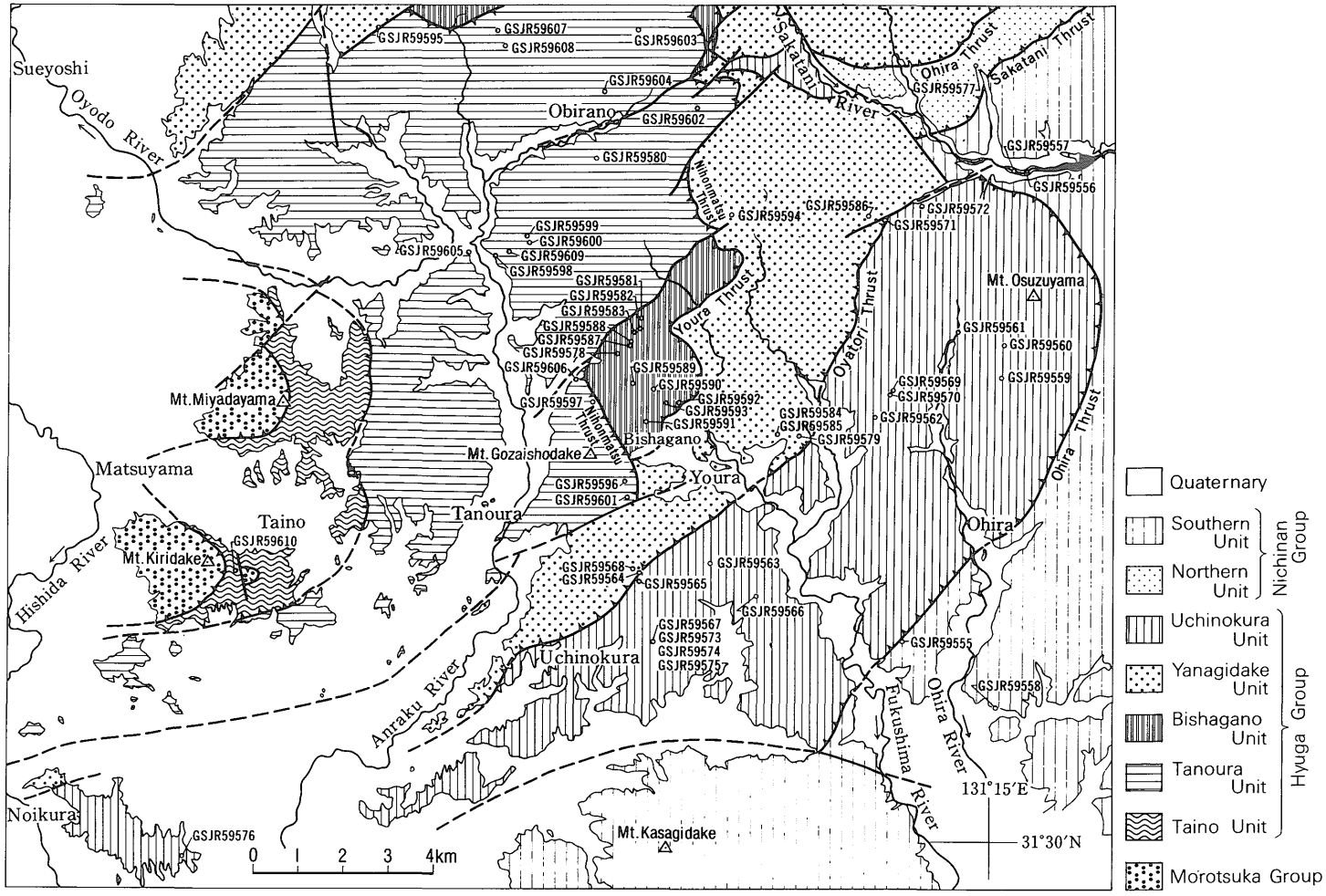


Fig. 2 Stratigraphic divisions of the study area, also showing sample localities.

acidic tuff, siltstone and sandstone. The melange is dominated by siltstone and sandstone clasts associated with greenstone clasts, which were also deformed. This unit is thrust over the Nichinan Group along the Ohira Thrust.

The Yanagidake Unit consists mainly of massive sandstone with intercalated conglomerate layers, and grades southwestward into bedded sandstone, turbidite and siltstone. The conglomerate layers comprise rounded to subrounded pebbles and cobbles of sandstone, siltstone, granite, basic to intermediate volcanic rocks, and minor amount of acidic tuff, schist and siliceous shale. The siltstone and siltstone-dominant turbidite sometimes embed calcareous nodules. This unit is thrust over the Uchinokura Unit along the Oyatori Thrust.

The Bishagano Unit, which is separately distributed in the central and northern parts, is characterized by siltstone and siltstone breccia, associated with bedded sandstone and siltstone-dominant turbidite. The siltstone as well as that of the Yanagidake Unit sometimes contains calcareous nodules. The siltstone breccia is commonly composed of pebble to cobble sized siltstone clasts in a fine-grained matrix. It also comprises subangular to angular clasts of sandstone and rarely subrounded to rounded granitic rocks. This unit is thrust over the Yanagidake Unit along the Youra Thrust.

The Tanoura Unit, which widely occurs in the central part, is mainly composed of siltstone-dominant turbidite and sandstone, accompanied by siltstone breccia. The sandstone intercalates conglomerate layers whose components are similar to those of the Yanagidake Unit. The siltstone breccia resembles that of the Bishagano Unit, but contains more amount of sandstone clast than the latter. This unit is thrust over the Bishagano and Yanagidake Units along the Nihonmatsu Thrust.

The Taino Unit is composed mainly of siltstone, siltstone-dominant turbidite and melange, and also greenstone along the Yashikidera Thrust. They had undergone deformation, which resulted in the development of scaly foliation. Sandstone layers of the turbidites are often disrupted. The melange contains the clasts of siltstone, acidic tuff and sandstone in an argillaceous matrix. This unit is thrust over the Tanoura Unit along the Yashikidera Thrust, and the Cretaceous Morotsuka Group is thrust over this unit along the Miyadayama Thrust.

The Lower Oligocene to Lower Miocene Nichinan Group in the northeastern and southeastern parts is composed mainly of olistostromal facies (Sakai, 1983; Sakai, 1988a, 1988 b), and is divided into sandstone-dominant Northern Unit and mudstone-dominant Southern Unit. The former is thrust over the latter along the Sakatani Thrust. The Southern Unit in this district consists of mudstone-rich lower part conformably overlain by sandstone-rich upper part. The mudstone of the Southern Unit is rich in benthic and planktonic foraminifera and rare in mollusks, all of which are indicative of bathyal depositional environment. The sandstone contains plant remains and mollusks of the late Early Oligocene Ashiya Fauna (Tsuchi *et al.*, 1987).

3. Age assignment

Radiolarians were extracted by means of HF method from 56 rock samples, five of which are from the Nichinan Group and the remaining are from the Hyuga Group (Fig. 3). The preservation is in general not good owing to diagenetic effect. Abundance of nassellarains is far less than spumellarians in most samples, but spherical forms usually remain unnamed.

The samples were assigned to radiolarian zones of Sanfilippo *et al.* (1985) and Saunders *et al.* (1984) (the zonal names are abbreviated to eE1, eE2 and so on), based on biostratigraphic distributions of diagnostic species as shown in Fig. 4 that is compiled from previous studies. As a result, the ages of 46 samples are assigned as given in Table 1, and of the units are also shown in Fig. 5.

3.1 Hyuga Group

Fifty-one samples from the Hyuga Group were examined. It becomes clear that the units are mainly of Eocene age; namely, the ages of the units do not show significant differences with one another. The details are mentioned

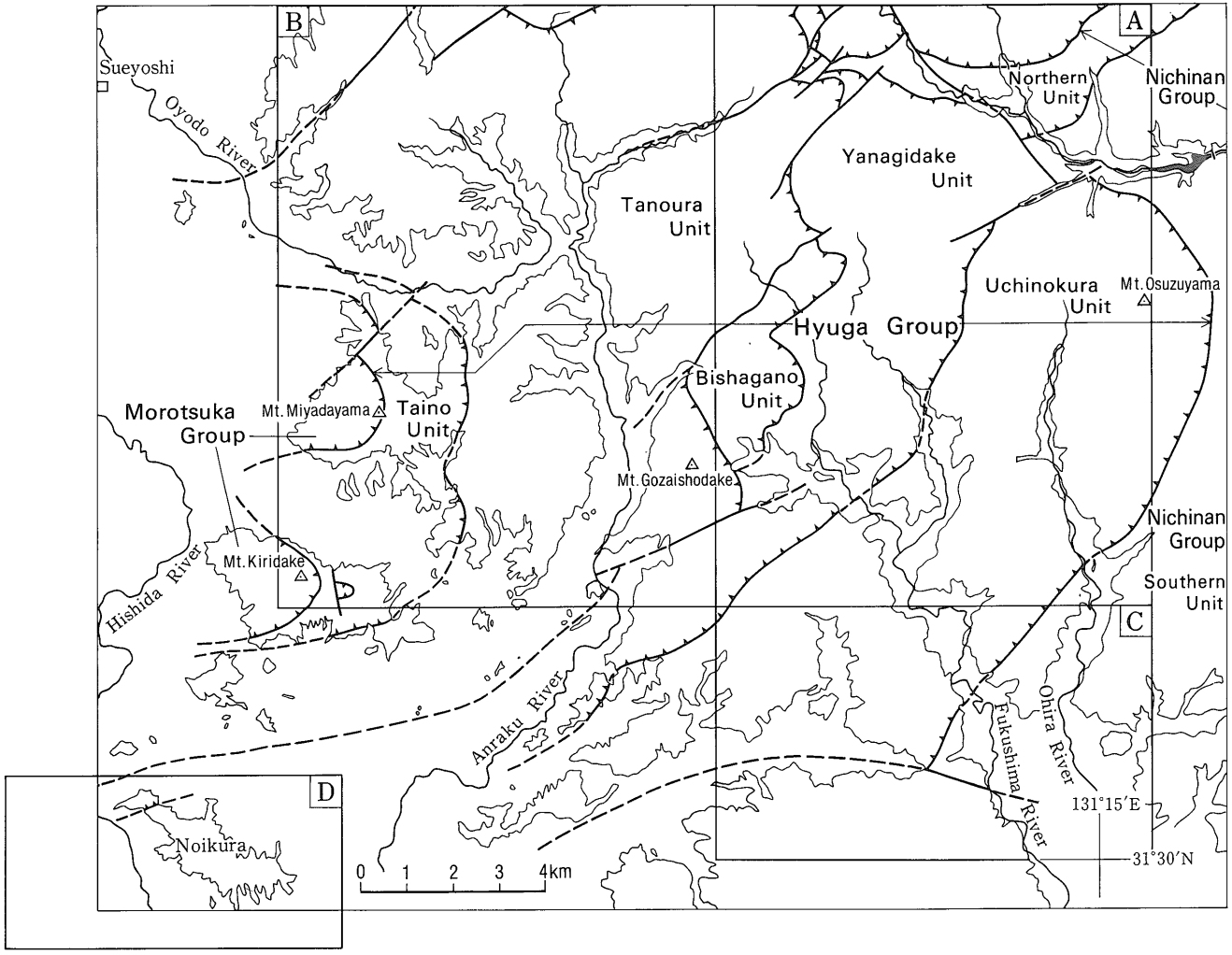
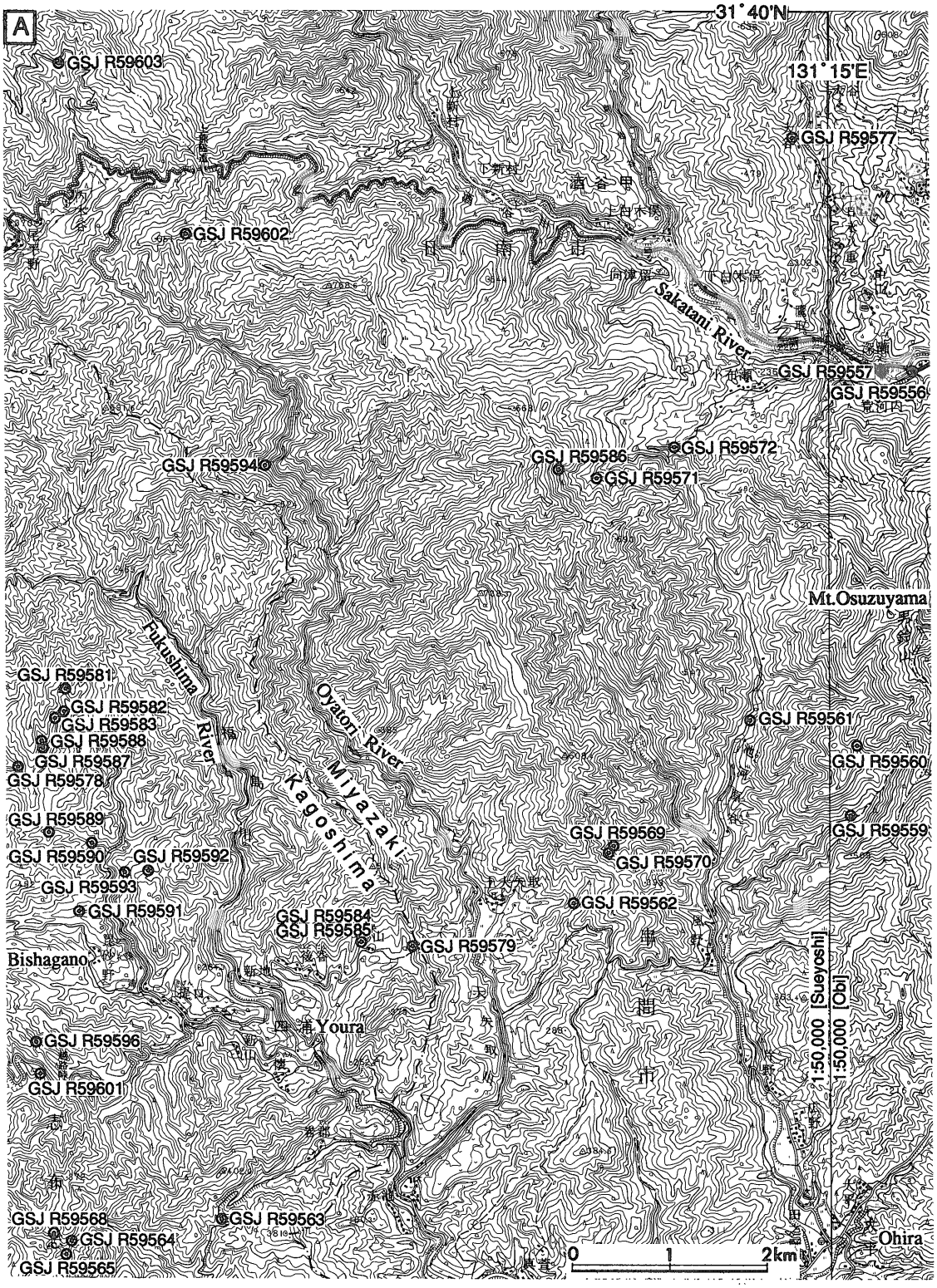
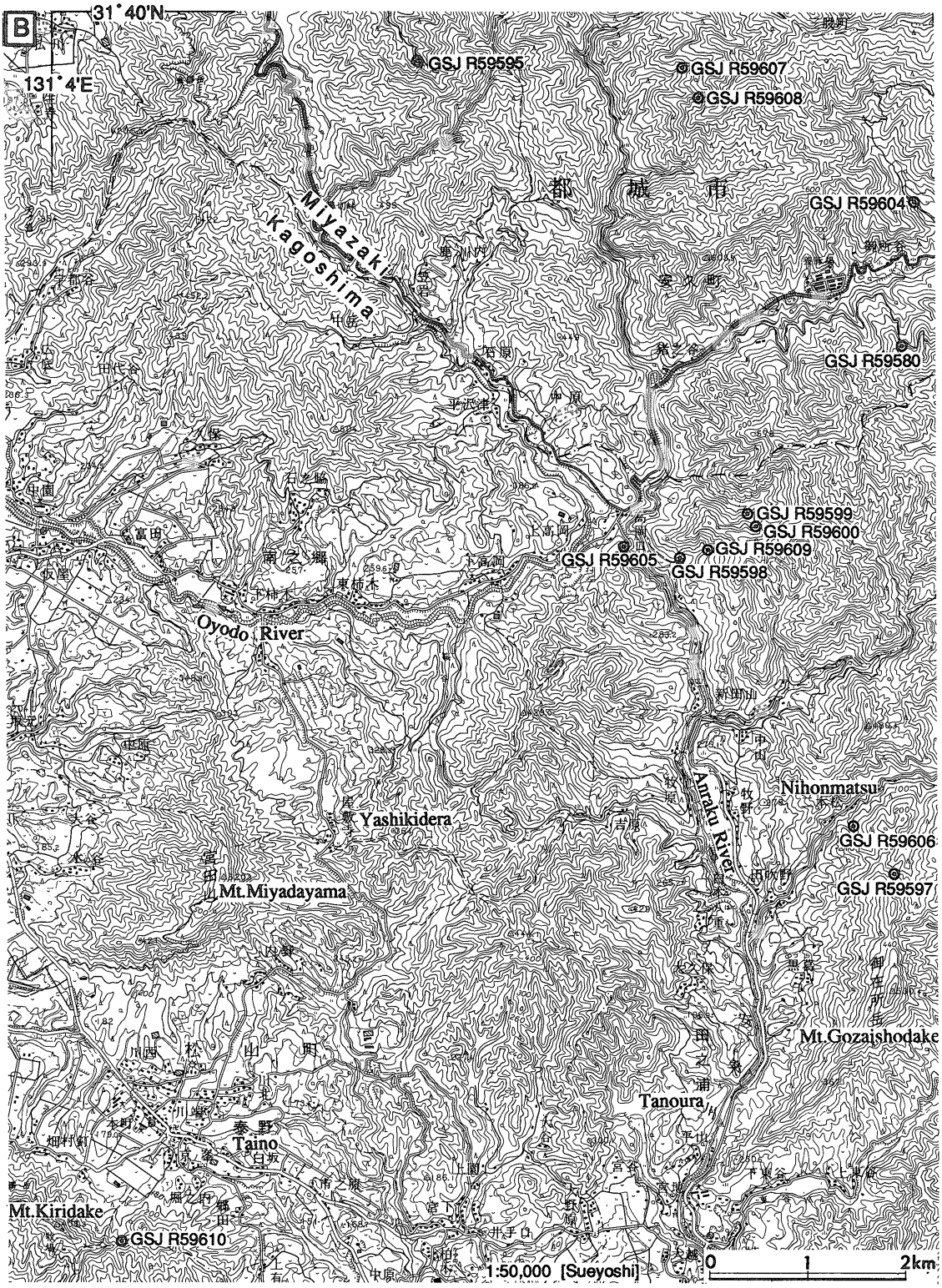
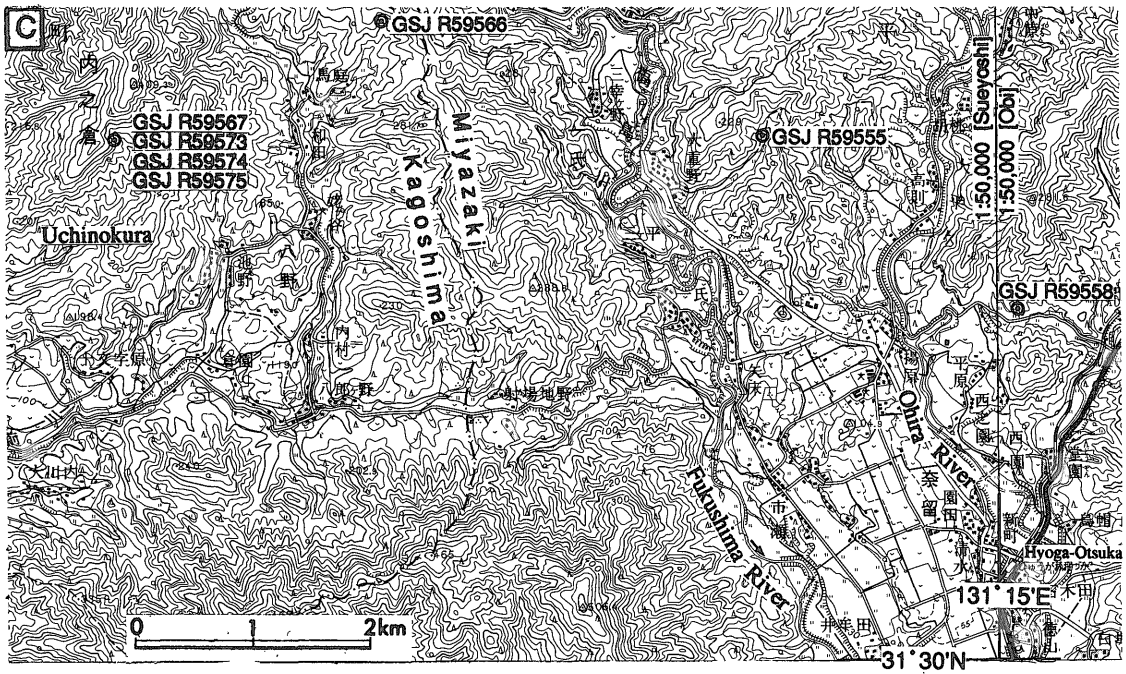
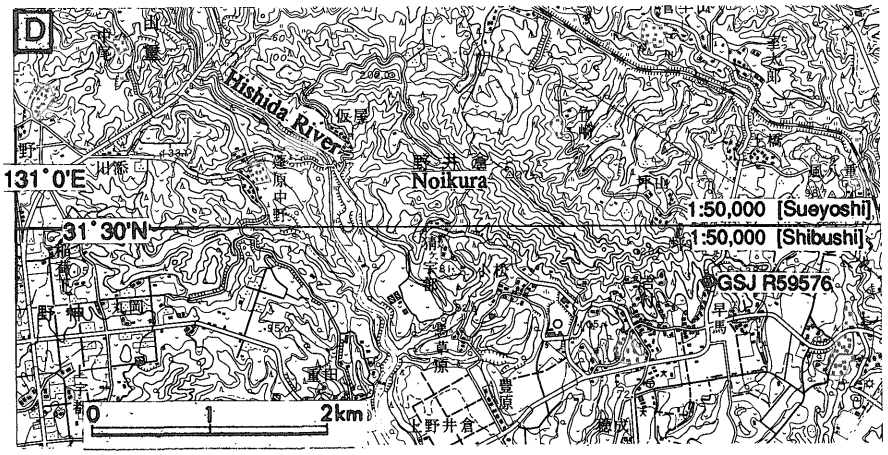


Fig. 3 Detailed sample localities. Topographic maps are cited from "Sueyoshi", western part of "Obi" and northern part of "Shibushi"(1 : 50,000) published from Geographical Survey Institute.


A
31°40'N
131°15'E
GSJ R59603
GSJ R59602
GSJ R59577
GSJ R59557
GSJ R59556
GSJ R59572
GSJ R59586
GSJ R59571
GSJ R59594
Sakatani River
Mt.Osuzuyama
Fukushima River
Oyatori River
Miyazaki
Kagoshima
GSJ R59581
GSJ R59582
GSJ R59583
GSJ R59588
GSJ R59587
GSJ R59578
GSJ R59589
GSJ R59590
GSJ R59592
GSJ R59593
GSJ R59591
GSJ R59584
GSJ R59585
GSJ R59579
GSJ R59561
GSJ R59560
GSJ R59559
GSJ R59569
GSJ R59570
GSJ R59562
Bishagano
Youra
GSJ R59596
GSJ R59601
GSJ R59568
GSJ R59564
GSJ R59565
GSJ R59563
Ohira
1:50,000 [Sueyoshi]
1:50,000 [Obi]
0
1
2km


B
31°40'N
131°4'E
GSJ R59595
GSJ R59607
GSJ R59608
GSJ R59604
GSJ R59580
GSJ R59599
GSJ R59600
GSJ R59609
GSJ R59605
GSJ R59598
GSJ R59606
GSJ R59597
GSJ R59610
Miyazaki
Kagoshima
Oyodo River
Anraku River
Yashikidera
Mt.Miyadayama
Nihonmatsu
Mt.Gozaishodake
Tanoura
Taino
Mt.Kiridake
0 1 2km
1:50,000 [Sueyoshi]


C
GSJ R59566
GSJ R59567
GSJ R59573
GSJ R59574
GSJ R59575
GSJ R59555
GSJ R59558
Uchinokura
Miyazaki
Kagoshima
Fukushima River
Oura River
Hyoga-Otsuka
1:50,000 [Sueyoshi]
1:50,000 [Oji]
131°15'E
31°30'N
0
1
2km


D
Hishida River
Noikura
131°0'E
31°30'N
1:50,000 [Sueyoshi]
1:50,000 [Shibushi]
GSJ R59576
0
1
2km

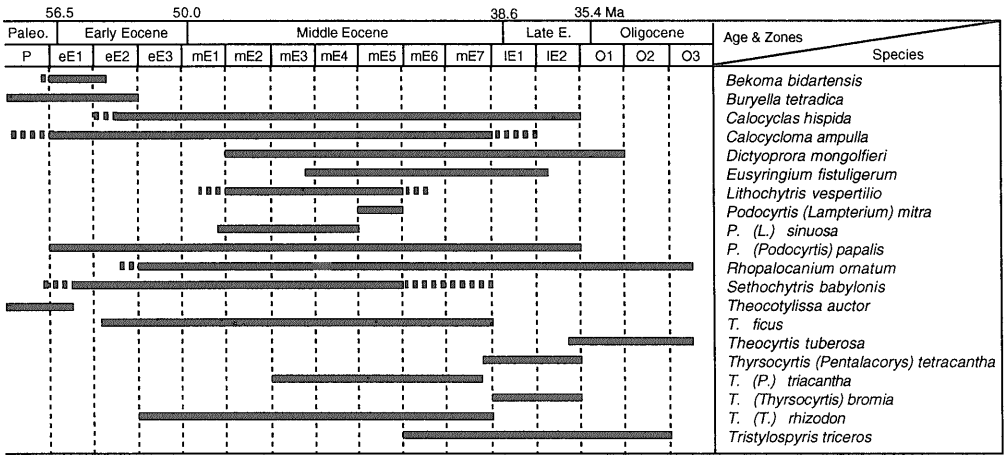


Fig. 4 Biostratigraphic distributions of diagnostic species, compiled from Nigrini(1974), Nishimura(1987, 1992), Riedel and Sanfilippo(1970, 1971), Sanfilippo and Riedel(1992), Sanfilippo *et al.*(1985) and Saunders *et al.*(1984). Abbreviations for zones: P, *Bekoma campechensis*; eE1, *Bekoma bidartensis*; eE2, *Buryella clinata*; eE3, *Phormocyrtis striata striata*; mE1, *Theocotyle cryptocephala*; mE2, *Dictyoprora mongolfieri*; mE3, *Thyrsocyrtis triacantha*, mE4, *Podocyrtis ampla*; mE5, *Podocyrtis mitra*; mE6, *Podocyrtis charala*; mE7, *Podocyrtis goetheana*; lE1, *Carpocanistrum azyx*; lE2, *Calocyclas bandyca*; O1, *Cryptoprora ornata*; O2, *Theocyrtis tuberosa*; O3, *Dorcadospyris ateuchus*.

below for each unit.

(1) Uchinokura Unit: Available radiolarians for age assignment were obtained from 13 of 15 rock samples, which can be classified into three groups based on their lithology and ages. The first group is collected from siltstone and intercalated siltstone within turbidite, and of Middle Eocene to Early Oligocene age (samples R59562, 565, 566, 569 and 570). R59565, 569 and 570 are placed in mE5 based on the presence of the nominated species *Podocyrtis (Lampterium) mitra* Ehrenberg. R59562 and 566 are assigned to mE2-O1 because of the presence of *Dictyoprora mongolfieri* (Ehrenberg). The second group includes samples R59561, 563, 567, 573, 574 and 575 collected from reddish mudstone and clasts of acidic tuff and blackish mudstone within melange, and of Early Eocene to Early Oligocene age. The zones of the samples are assigned by following species; R59561 (eE1-mE5) by *Sethochytris babylonis* (Campbell and Clark), R59563 (eE2-mE7) by *Calocyclas hispida* (Ehrenberg) and *Calocycloma ampulla* (Ehrenberg), R59567 (mE3-?mE4) by *Thyrsocyrtis (Pentalacorys) triacantha* (Ehrenberg) and *P.* (*L.*) cf. *sinuosa* Ehrenberg, R59573 (mE2-O1) by *D. mongolfieri*, R59574 (?mE1-?mE4) by *P.* (*L.*) cf. *sinuosa* and R59575 (mE2-?mE5)by *D. mongolfieri* and *S.* cf. *babylonis*. The age of the second group is, however, considered to be limited in Early and Middle Eocene since R59573 is obtained almost from the same horizon to R59574 and R59575. The last group is represented by samples R59559 and 572, collected from reddish mudstone and mudstone blocks of the melange, and of Early Eocene in age, possibly ranging from latest Paleocene. R59559 (eE1) yields *Bekoma bidartensis* Riedel and Sanfilippo, *Buryella tetradica* Foreman, *Podocyrtis* (*P.*) *papalis* Ehrenberg and *Theocotylissa* cf. *auctor* Foreman, and appears to be the oldest samples of all. R59572 (?eE1-?eE2) yields *B.* cf. *tetradica* and *S.* cf. *babylonis*.

It is, therefore, concluded that the main part of this unit ranges in age from Early Eocene to Early Oligocene. This is in agreement with the result of Kato (1985) who reported the occurrence of Middle and Late Eocene planktonic foraminifer *Subbotina angiporoides lindiensis* Blow, indicative of Blow's (1969) zone P 15 to P 16 from his sample KUS68. It is also inferred that the structures of the Uchinokura Unit can be explained

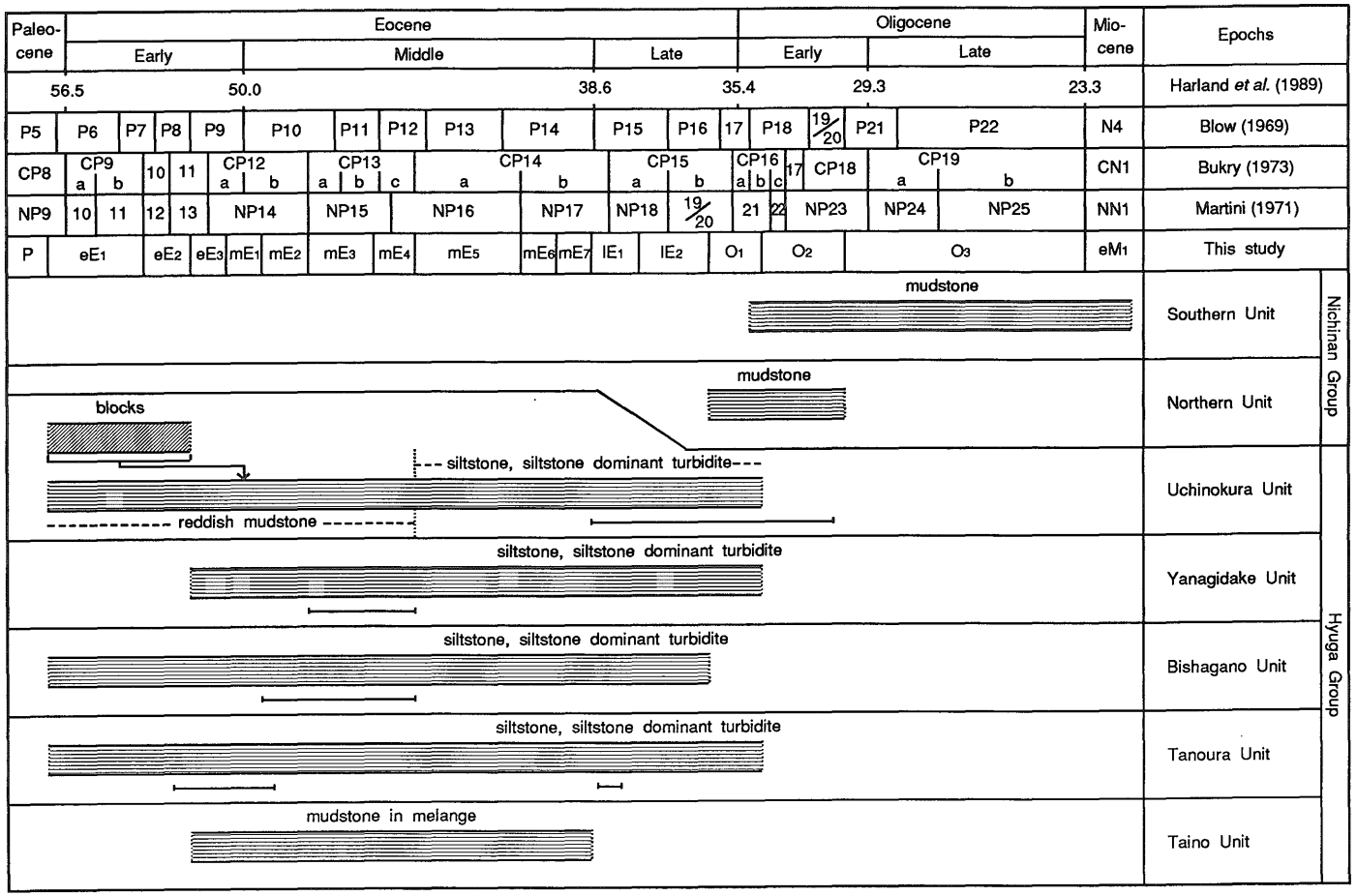


Fig. 5 Age of ewjach unit. Bars are the results shown by the present study, whereas lines show data given by Kato(1985). See Fig. 4 for abbreviations of radiolarian zones.

Table 1 List of radiolarians. Question marks at the head of abbreviated zonation names mean that the zones are assigned by indeterminable (cf.) species.

List of Radiolaria

N.S: Nichinan Group (N: Northern Unit. S: Southern Unit). U.Y.B.A.T: Hyuga Group (U: Uchinokura Unit. Y: Yanagidake Unit. B: Bishagano Unit. A: Tanoura Unit. T: Taino Unit). M: Morotsuka Group

Sample No. (GSJ No.)	R59555	R59556	R59557	R59558	R59577	R59559	R59560	R59561	R59562	R59563	R59565	R59566	R59567	R59569	R59570	R59572	R59573	R59574	R59575	R59576	R59564	R59568	R59571	R59579	R59584	R59585	R59586	R59594	R59595	R59578	R59581	R59582	R59583	R59587	R59588	R59589	R59590	R59591	R59592	R59593	R59580	R59596	R59597	R59598	R59599	R59600	R59601	R59602	R59603	R59604	R59605	R59606	R59607	R59608	R59609	R59610
Species name Unit	S	S	S	S	N	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	Y	Y	Y	Y	Y	Y	Y	Y	Y	B	B	B	B	B	B	B	B	B	B	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	T
Acanthodesmiidae gen(n). et sp(p). indet.					X	X							X		X			X		X						X													X	X				X								X	X			X
Actinomma (?) sp.															X																																									
Archipilium sp.															X																																									
Axoprunum (?) sp.					X						X					X											X							X																					
Bathropyramis sp.					X										X																	X																							
Bekoma bidartensis Riedel & Sanfilippo						X																																																	
Buryella tetradica Foreman						X										cf.																																								
Calocyclas hispida (Ehrenberg)									cf.	X				X										X		X					cf.		X		X	X	X					X									X			cf.	
Calocyclas sp.			X	X	X																																																	
Calocycloma ampulla (Ehrenberg)										X					X				X										X		X	X													X					X		X	
Ceratocyrtis (?) sp.															X																																								
"Clathrocyclas" universa (Clark & Campbell)															X																																							
Cornutella sp.															X																																								
Dictyophimus craticula Ehrenberg																																																				X		
Dictyoprora mongolfieri (Ehrenberg)									X		X	X	X	X	X		X		X					X			X	X		X		X		X	X		X			X		X		X							X	X		X	
D. urceolus (Haeckel)														X	X																																							
Eusyringium fistuligerum (Ehrenberg)															X																				X	X		X		X													X	
Lithochytris vespertilio Ehrenberg													X																																									
Lophocyrtis (?) *cavifundus* sp. nov.	X	X	X							cf.		cf.																																												
L. sp.		X																																																					
"Lophophaena" auriculaleporis Clark & Campbell																																																					X	
Lychnocanoma sp(p).	X	X	X	X	X	X		X	X		X	X	X	X	X	X			X	X			X	X		X	X	X	X	X	X	X		X	X	X	X	X		X	X			X	X	X	X		X	X		X	X
Phacodiscidae gen. et sp. indet.		X	X		X										X			X																X	X					X	X													
Podocyrtis (Podocyrtis) papalis Ehrenberg						X	cf.	cf.				cf.		X		X									cf.							cf.		cf.	cf.				cf.				cf.									cf.			cf.	
P. (Lampterium) mirabilis sp. nov.				cf.					X		cf.	X			X					X					cf.						X	X		X	X							X	X	X	X							X		
P. (L.) mitra Ehrenberg											X			X	X																													X								X			
P. (L.) sinuosa Ehrenberg													cf.						cf.																																					
P. sp(p).									X		X		X				X		X		X		X		X					X			X								X	X	X	X		X		X			X			
Pseudodictyophimus (?) sp.															X																												X												
Rhopalocanium ornatum Ehrenberg														X																												X												
Sethochytris babylonis (Clark & Campbell)								X			X				X	cf.			cf.							cf.	cf.			cf.				X	cf.								X												
Sethoperidae gen. et sp. indet.															X																																								
Spongodiscidae gen. et sp. indet. A						X					X				X																				X								X	X		X	X				X		
S. B				X								X			X																X	X			X									X									X	X
S. gen(n). et sp(p). indet.	X												X	X	X		X	X	X	X						X	X					X																						X	X
Stylosphaeridae gen(n). et sp(p). indet.						X		X					X	X	X	X	X	X	X	X				X			X				X	X			X	X		X	X		X		X	X		X		X	X	X	X	X	X	
Theocotylissa auctor Foreman						cf.																																																
Theocotylissa ficus (Ehrenberg)													X																										X														
Theocyrtis tuberosa Riedel			X		X																																																
Theoperidae gen(n). et sp(p). indet.	X	X			X		X	X	X	X					X							X								X				X		X	X				X									X			
Thyrsocyrtis (Thyrsocyrtis) bromia Ehrenberg																										X																										
Thyrsocyrtis (Thyrsocyrtis) rhizodon Ehrenberg											X				X															cf.					X	cf.	cf.		X	cf.									cf.		cf.	cf.
T. (Pentalacorys) triacantha (Ehrenberg)													X		X											X																										X		
T. (P.) tetracantha (Ehrenberg)																								cf.																														
T. (P.) sp.																									X					X				X							X												
Tristylospyris triceros (Ehrenberg)	X	X			X																																																
Zone	mE6-O2	mE6-O2	lE2-O3	(P22)	lE2-O2	eE1		eE1-mE5	mE2-O1	eE2-mE7	mE5	mE2-O1	mE3-?mE4	mE5	mE5	?eE1-?eE2	mE2-O1	?mE1-?mE4	mE2-?mE5					mE2-lE2	?mE7-?lE2	lE1-lE2	mE3-?mE5	mE2-O1		mE2-?mE5		mE2-mE7	eE1-mE7	mE3-lE2	mE3-mE5	mE3-?mE5	mE2-?mE7	mE3-?mE7		mE3-mE7	?eE3-?mE7		mE2-O1	eE2-lE2	mE5	eE1-mE7		eE2-mE7			mE2-mE7	mE5		mE3-mE7	?eE3-?mE7

X: present. cf.: confer

by a duplex model possessing mudstone and melange as thrusts (Saito *et al.*, 1994).

(2) Yanagidake Unit: Five of nine rock samples were dated by radiolarians. Samples R59586 and 594, collected near the upper reaches of the Oyatori River where sandstone-dominant facies crops out, are siltstone intercalated within sandstone and turbidite. R59586 is assigned to mE3-?mE5 by the occurrences of *S.* cf. *babylonis* and *T.* (*P.*) *triacantha*, and R59594 is mE2-O1 by *D. mongolfieri*. Samples R59579, 584 and 585 were obtained from siltstone-dominant facies occurring east of Youra. R59579 is a siltstone sample assigned to mE2-lE2 by the occurrences of *C. hispida* and *D. mongolfieri*. R59584 is a calcareous nodule assignable to ?mE7-?lE2 by the occurrence of *T.* (*P.*) cf. *tetracantha* (Ehrenberg). R59585 are siltstone samples from the same outcrop to R59584, and yields *S.* cf. *babylonis* and *Thyrsocyrtis* (*T.*) *bromia* Ehrenberg. It is tentatively assigned to lE1-lE2 based on the presence of *T.* (*T.*) *bromia*.

Kato (1985) reported the occurrences of Eocene calcareous nannoplanktons *Reticulofenestra dictyoda, R. umbilica, R. hillae* and *Chiasmolithus* aff. *solitus* in his samples YAN20 and 21, and Early Eocene to Early Oligocene radiolarians such as Podocyrtis diamesa Riedel and Sanfilippo, *P.* (*L.*) *sinuosa, Phormocyrtis striata exquisita* (Kozlova) and *Thyrsocyrtis hirsuta* (Krasheninnikov) in his samples YAN 11 to 14. Based on the results of this study and Kato (1985), it is concluded that the Yanagidake Unit is Early Eocene to Early Oligocene, mainly Middle to Late Eocene in age.

(3) Bishagano Unit: Nine of 11 siltstone samples were dated by radiolarians. Sample R59578 from siltstone-dominant turbidite and R59588, 590, 591 and 593 from massive or bedded siltstone are of Middle Eocene age. Their diagnostic species are as follows; *D. mongolfieri* and *S.* cf. *babylonis* for R59588 (mE2-?mE5), *Eusyringium fistuligerum* (Ehrenberg) and *S. babylonis* for R59588 (mE3-mE5), *D. mongolfieri* and *T.* (*T.*) cf. *rhizodon* Ehrenberg for R59590 (mE2-?mE7), *E. fistuligerum* and *T.* (*T.*) cf. *rhizodon* for R59591 (mE3-?mE7), and *E. fistuligerum* and *T.* (*T.*) *rhizodon* for R59593 (mE3-?mE7). Sample R59589 from massive siltstone yields Early to Middle Eocene (eE3-?mE5) radiolarians such as *C. hispida, S.* cf. *babylonis* and *T.* (*T.*) *rhizodon* and also planktonic foraminifer *Subbotina eocaena* Gümbel which indicates that the sample is older than Blow's (1969) zone P 21. R59582 (mE2-mE7) from bedded siltstone is dated by *C. ampulla* and *D. mongolfieri*, and R59587 (mE3-lE2) from massive siltstone is by *C. hispida* and *E. fistuligerum*. R59583 is also of Eocene age (eE1-mE7) based on the occurrence of *C. ampulla*.

Kato (1985) also reported the occurrences of Middle Eocene radiolarians from the north of Bishagano in his samples YAN18R and YAN22R. It is thus concluded that the Bishagano Unit is of Early to Late Eocene, mainly Middle Eocene age.

(4) Tanoura Unit: Of the 15 examined samples the ages of nine samples were determined. Siltstone samples R59603 and 607 are collected from siltstone-dominant turbidite north of Obirano; the former is assigned to eE2-mE7 by the occurrence of *Theocotylissa ficus* (Ehrenberg), and the latter is to mE5 by *P.* (*L.*) *mitra*. GSJ R59580 is also a siltstone sample of the siltstone-dominant turbidite collected southwest of Obirano, and yields *T.* (*T.*) cf. *rhizodon* indicative of ?eE3-?mE7. Siltstone samples R59598, 599, 600, 609, the first of which is from siltstone-dominant turbidite and the latter three from bedded siltstone, were collected east of Takaokaguchi. Their diagnostic species are as follows; *C. hispida* for R59598 (eE2-lE2), *P.* (*L.*) *mitra* for R59599 (mE5), *C. ampulla* for R59600 (eE1-mE7), and *C. ampulla* and *E. fistuligerum* for R59609 (mE3-mE7). Samples R59597 and 606 are collected from bedded and massive siltstone outcrops north of Mt. Gozaishodake. R59597 is assigned to mE2-O1 by the occurrence of *D. mongolfieri*, and R59606 is to mE2-mE7 by both *D. mongolfieri* and *T. ficus*.

Kato (1985) also reported the occurrences of Early to Late Eocene radiolarians in areas the east of Mt. Gozaishodake, the north and south of Obirano (Kato, 1985, samples YAN24R, 17R and 10R, respectively). It is thus concluded

that the Tanoura Unit ranges in age from the Early Eocene to Early Oligocene.

(5) Taino Unit: Age-assignable radiolarian *T.* (*T.*) cf. *rhizodon* is obtained from only one siltstone sample R59610 from the argillaceous matrix of melange. It indicates that this unit may also be of Early to Late Eocene age (?eE3 -?mE7), but further examination is necessary in future.

3.2 Nichinan Group

From the Nichinan Group, radiolarians were obtained from five mudstone samples; R59555 to 558 from the Southern Unit and R59577 from the Northern Unit. Based on results shown below, one can regard that the Nichinan Group ranges in age from Middle Eocene to Oligocene. Moreover, planktonic foraminiferal data given by Saito *et al.*(1994) suggests that the group is composed mainly of younger strata than the Oligocene.

(1) Northern Unit: R59577 was collected from the neighboring Obi district, and is assigned to lE2-02 by the occurrences of *Tristylospyris triceros* (Ehrenberg) and *Theocyrtis tuberosa* (Riedel).

(2) Southern Unit: R59555 is a deformed mudstone from the southern side of the Ohira Thrust near Oshigeno, and yields T. triceros assignable to mE6-O2. It also yields planktonic foraminifera diagnostic for Early Oligocene age. Thus the age of R59555 is considered to be limited within Early Oligocene. R59556 (mE6-O2) and 557 (lE2-O3) were collected from the northwestern part of the Obi district. They are characterized by the occurrences of *T. triceros* and *T. tuberosa*, respectively. R59557 also yields planktonic foraminifers *Globigerina angulioffícinalis* and *Globorotaria pseudokugleri* characteristic of Blow's (1969) zone P 22.

4. Systematic paleontology

All the illustrated specimens (F) and rock samples (R) are deposited in the Geological Museum, Geological Survey of Japan (GSJ).

Family Pterocorythidae Haeckel, 1881, emend. Riedel, 1967

Genus *Podocyrtis* Ehrenberg, 1847

Subgenus *Lampterium* Haeckel, 1881

Type species: Cycladophora goetheana Haeckel, 1887, designated by Campbell, 1954.

Podocyrtis (*Lampterium*) *mirabilis* Sugiyama and Saito n. sp.

Pl. 1, figs. 1a-6b

(?) *Podocyrtis* aff. *diamesa* Riedel and Sanfilippo - Watanabe and Iwata, 1985, pl. 1, figs. 4, 5.

(?) *Podocyrtis* sp. - Watanabe and Iwata, 1985, pl. 1, fig. 3.

Artophormis gracilis Riedel - Takahashi and Ishii, 1993, p.292, pl. 1, fig. 5 (only).

Description: Test large, thick walled, and consisting of three-segments. Cephalis small, subspherical, pierced by scattered pores of small size, having four or more spines. Two of the spines situated at the sagittal plane are larger and thicker, and the largest one is prolonged from the apical ray of the internal spicule. Collar stricture well expressed by a change in contour. Thorax conical; pores small and circular; bars edged, bearing small nodes at their junctions. Lumbar stricture also pronounced externally. Abdomen long, with the maximum width at the middle to lower third, gradually tapered distally; pores larger than thoracic ones, longitudinally aligned and quincuncially arranged; bars thicker than thoracic ones, edged, also bearing small nodes at their junctions like thoracic ones, and without forming thick longitudinal ridges. Peristome more or less developed and ornamented by more than four, short terminal teeth projecting slightly outward.

Remarks: The present new species is distinguished from other members of the subgenus by its spinose cephalis. Moreover, it differs from the co-occurring *P.* (*L.*) mitra Ehrenberg, 1854, in possessing smaller abdominal pores and larger numbers of terminal teeth projecting slightly outward.

Dimensions (in μm): Length of cephalis, 20-35; of thorax, 35-50; of abdomen including peristome and teeth, 105-155; maximum width of abdomen; 105-140.

Type material: GSJ R59570, corresponding to the *Podocyrtis mitra* Zone (mE5), Middle Eocene

in age.
Range: At least within the *Podocyrtis mitra* Zone (mE5), but the detailed range is uncertain.
Etymology: The name is derived from the Latin adjective *mirabilis*, meaning strange.

Family Theoperidae Haeckel, 1881,
emend. Riedel, 1967

Genus *Lophocyrtis* Haeckel, 1887
Type species: Eucyrtidium stephanophorum Ehrenberg, 1873, designated by Campbell, 1954.

Lophocyrtis (?) *cavifundus*
Sugiyama and Saito n. sp.
Pl. 2, figs. 1a-2b, 4, 5

Description: Test large and two-segmented. Cephalis small, hemispherical, imperforate, and without external spines. Thorax large, subtrapezoidal to subovate in lateral view, with the maximum width at the lower third; pores circular, longitudinally aligned and quincuncially arranged; bars edged, bearing small nodes at their junctions, and hexagonally surrounding the pores. Thoracic margin imperforated, turning up inside, and hemming around a large aperture whose diameter is approximately one third of the maximum width of the thorax.
Remarks: The general shape of the cephalothorax resembles those of some Lophocyrtis species belonging to the subgenera *Lophocyrtis* Haeckel and *Cyclampterium* Haeckel. However, this species differs from all the members of Lophocyrtis in its characteristic two-segmented form with a concave base and without an apical spine. Two-segmented form of *Lophocyrtis*, ie. *L.* (*Cyclampterium*) *neatum* (Sanfilippo and Riedel), is known from after the late Miocene (Sanfilippo, 1990). The generic assignment thus remains tentative. This species is also somewhat similar to *Theocotylissa ficus* (Ehrenberg), but it left no descendants in the Oligocene (Sanfilippo and Riedel, 1982).
Dimensions (in μm): Length of cephalis, 10-20; of thorax, 90-130; maximum width of thorax, 125-165.
Type material: GSJ R59557, corresponding to the planktonic foraminiferal zone P 22, late Oligocene in age.
Range: Not well defined, but ranging at least from the Middle Eocene to Late Oligocene.
Etymology: The name is derived from the Latin adjective *cavus* and noun *fundus*, meaning concave base.

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Plate 1 1-6 : *Podocyrtis (Lampterium) mirabilis* Sugiyama and Saito n. sp.
1a: Holotype, Fossil No. GSJ F14597 / Sample No. GSJ R59570
1b: Enlargement of proximal part, oblique apical view
1c: Enlargement of thoracic and abdominal surface
2: Transmitted light micrograph, GSJ F14598 / GSJ R59570
3: GSJ F14599 / GSJ R59570
4: GSJ F14600 / GSJ R59570
5: GSJ F14601 / GSJ R59570
6a: Broken specimen, GSJ F14602 / GSJ R59570
6b: Enlargement of internal spicule, basal view
7: *Podocyrtis (Lampterium) mitra* Ehrenberg, GSJ F14603 / GSJ R59569
Scale bars: 1b, 1c and 6b = 20μm; others = 50μm

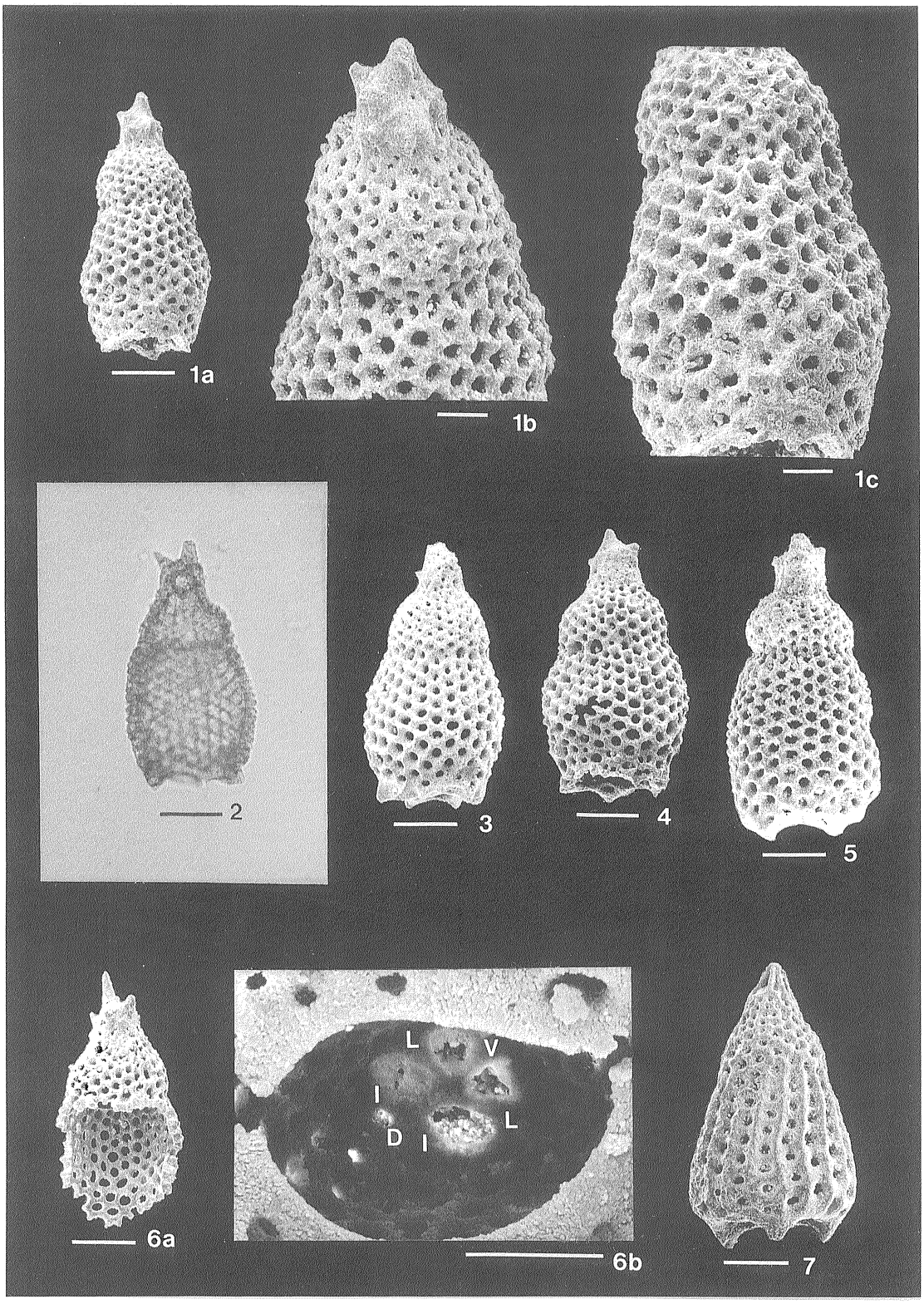
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Plate 2 1, 2, 4, 5: *Lophocyrtis* (?) *cavifundus* Sugiyama and Saito n. sp.
1a: Holotype, GSJ F14604 / GSJ R59557
1b: Oblique basal view of 1a, showing aperture
2a: GSJ F14605 / GSJ R59555
2b: Oblique basal view of 2a
4: GSJ F14606 / GSJ R59556
5: GSJ F14607 / GSJ R59557
3a: *Lophocyrtis* sp., GSJ F14608 / GSJ R59556, missing abdomen
3b: Oblique basal view of 3a, showing thoracic margin
6, 7: *Theocotylissa ficus* (Ehrenberg)
6: GSJ F14609 / GSJ R59566
7: GSJ F14610 / GSJ R59567
8–10: Acanthodesmiidae genn. et spp.
8: GSJ F14611 / GSJ R59570
9: GSJ F14612 / GSJ R59591
10: GSJ F14613 / GSJ R59570
11: *Tristylospyris triceros* (Ehrenberg), GSJ F14614 / GSJ R59577
12: *Dictyoprora mongolfieri* (Ehrenberg), GSJ F14615 / GSJ R59570
13: *Dictyoprora urceolus* (Haeckel), GSJ F14616 / GSJ R59570
14: *Pseudodictyophimus* (?) sp., GSJ F14617 / GSJ R59570
15: *Archipilium* sp., GSJ F14618 / GSJ R59570
16: "*Clathrocyclas*" universa Clark and Campbell, GSJ F14619 / GSJ R59570.
Scale bars: 1b and 3b = 20μm; others = 50μm

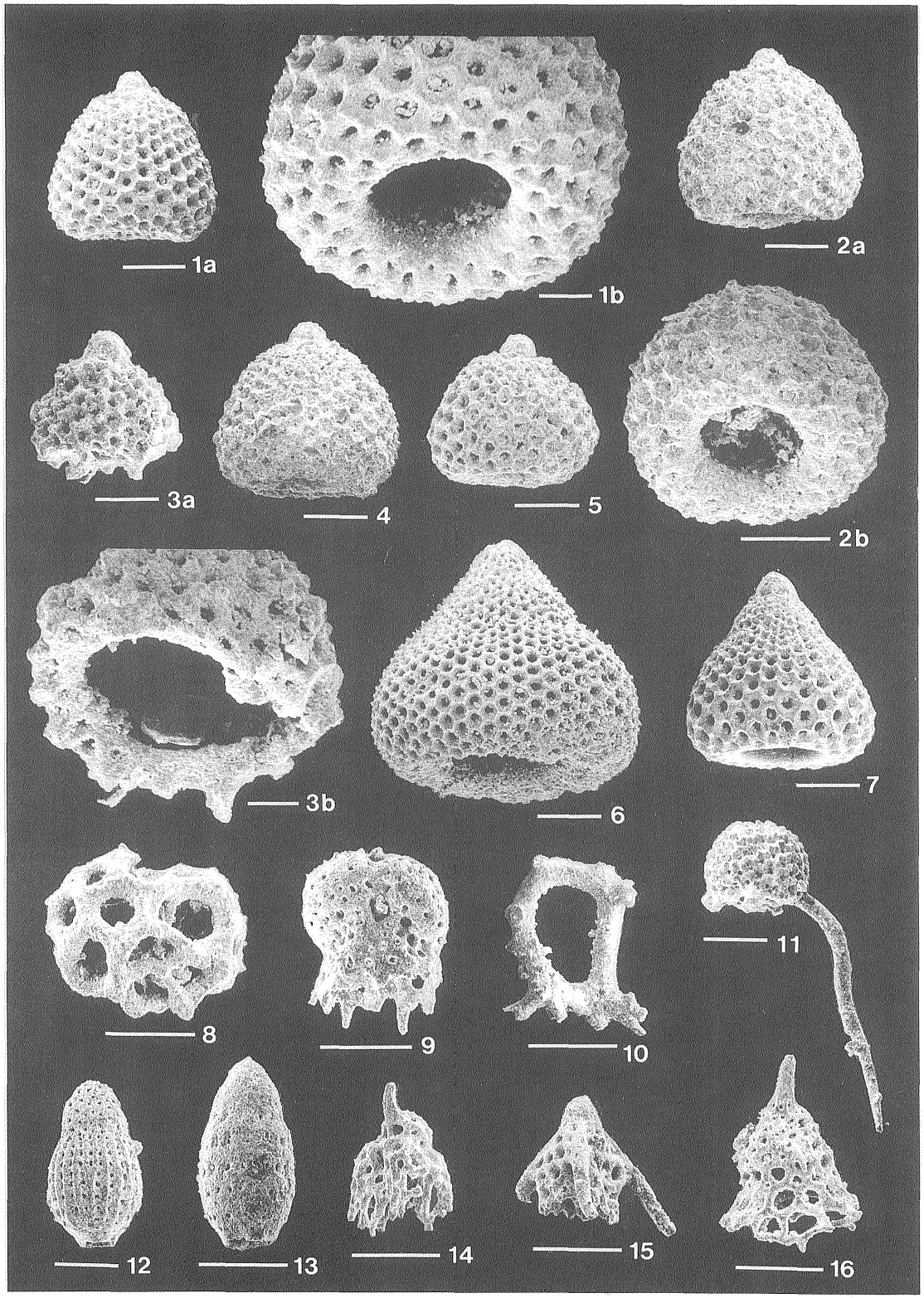
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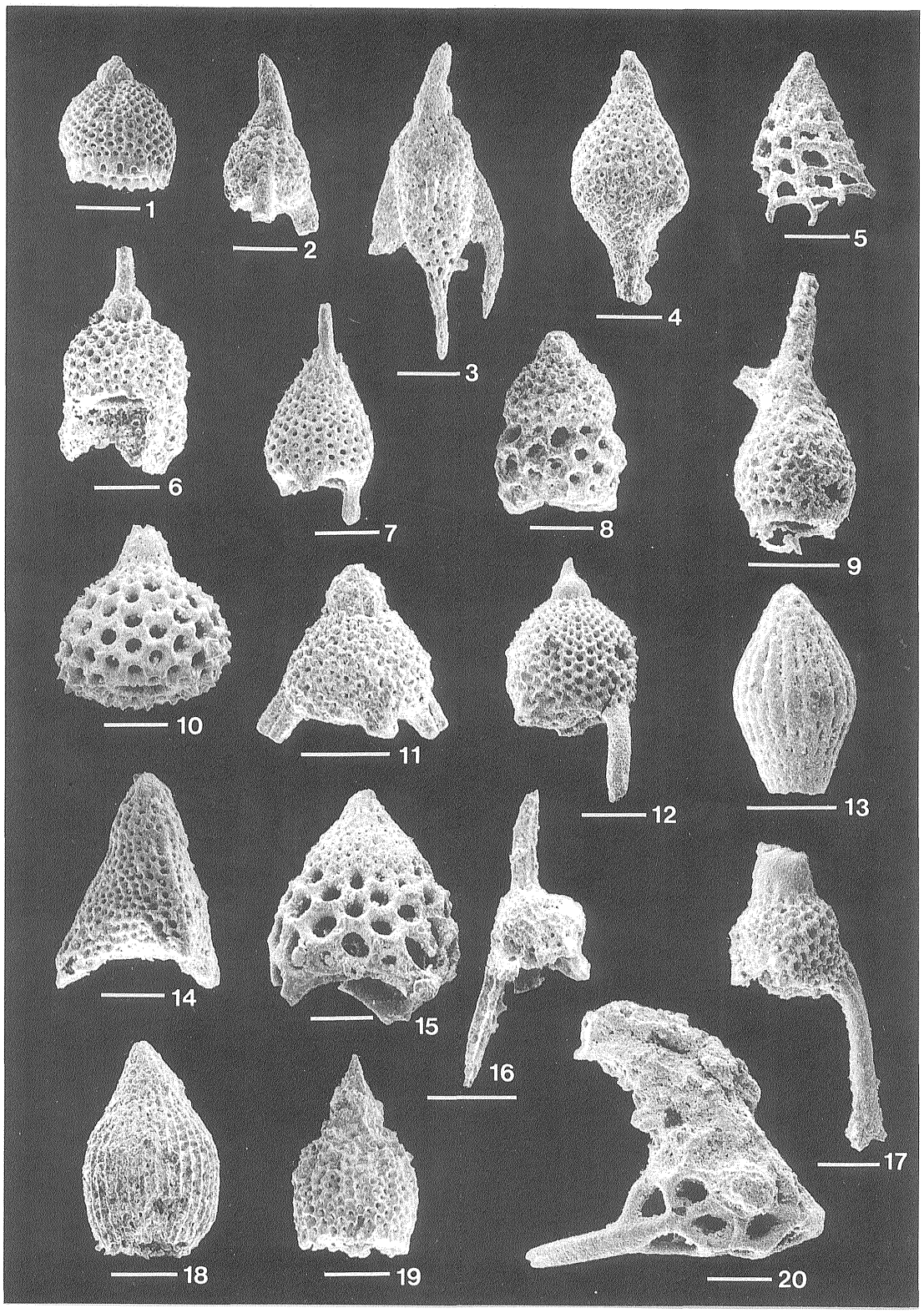
Plate 3 1: *Calocyclas hispida* (Ehrenberg), GSJ F14620 / GSJ R59569
2: *Sethochytris babylonis* (Clark and Campbell), GSJ F14621 / GSJ R59570
3: *Rhopalocanium ornatum* Ehrenberg, GSJ F14622 / GSJ R59593
4: *Eusyringium fistuligerum* (Ehrenberg), GSJ F14623 / GSJ R59570
5: *Bathropyramis* sp., GSJ F14624 / GSJ R59570
6: Theoperidae gen. et sp. indet., GSJ F14625 / GSJ R59570
7: *Thyrsocyrtis (Thyrsocyrtis) rhizodon* Ehrenberg, GSJ F14626 / GSJ R59570
8: *Thyrsocyrtis (Thyrsocyrtis) bromia* Ehrenberg, GSJ F14627 / GSJ R59585
9: "*Lophophanea*" *auriculaleporis* Clark and Campbell, GSJ F14628 / GSJ R59609
10: *Calocycloma ampulla* (Ehrenberg), GSJ F14629 / GSJ R59570
11, 12: *Lychnocanomma* spp.
11: GSJ F14630 / GSJ R59591
12: GSJ F14631 / GSJ R59607
13: *Buryella tetradica* Foreman, GSJ F14632 / GSJ R59559
14: *Lithochytris vespertilio* Ehrenberg, GSJ F14633 / GSJ R59567
15: *Thyrsocyrtis (Pentalacorys) triacantha* (Ehrenberg), GSJ F14634 / GSJ R59570
16: Sethoperidae gen. et sp. indet., GSJ 14635 / GSJ R59570
17: *Bekoma bidartensis* Riedel and Sanfilippo, GSJ F14636 / GSJ R59559
18: *Podocyrtis (Podocyrtis) papalis* Ehrenberg, GSJ F14637 / GSJ R59569
19: *Theocyrtis tuberosa* Riedel, GSJ F14638 / GSJ R59577
20: *Dictyophimus craticula* Ehrenberg, GSJ F14639 / GSJ R59607
Scale bars = 50μm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九州南東部末吉地域より産出した古第三紀放散虫化石

杉山和弘・斎藤　眞

要　旨

鹿児島県と宮崎県の県境付近に位置する「末吉」地域には，複雑な地質構造を持つ古第三系－最下部新第三系堆積岩コンプレックスが分布する．これらは覆瓦構造の卓越する日向層群と，主にオリストストロームからなると考えられている日南層群に区分される．さらに，日向層群は構造的下位より順に内之倉，柳岳，毘砂ヶ野，田之浦，泰野の各ユニットに，日南層群は同じく南部ユニットと北部ユニットに細分される．

本報告では，両層群の泥質岩から得られた50タクサに及ぶ放散虫化石に基づいて，各ユニットの年代決定を行った．その結果，本地域の日向層群，日南層群はそれぞれ中部始新統，漸新統を主体としていることが確認された．

また，*Podocyrtis (Lampterium) mirabiris*，*Lochocyrtis*(?) *cavifundus*の2新種を記載した．