Microfossil Assemblages from the Late Jurassic to Early Cretaceous Nikoro Pelagic Sediments, Tokoro Belt, Hokkaido, Japan

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Abstract

The Tokoro Belt in Hokkaido constitutes one of the major ophiolitic belts in the Japanese Islands. In order to clarify the origin of the Tokoro ophiolitic rocks which are represented by the Nikoro Group, new micropaleontologic data of the Nikoro pelagic sediments are presented in this paper as regards radiolarians, calcareous nannofossils and foraminifers.

The results show that (1) the age of the Nikoro Group ranges from the Kimmeridgian to the early Albian, and (2) the Nikoro pelagic rocks were deposited in a seamount environment near an oceanic ridge in the paleoequatorial productive region, where the paleodepth was about 1000 m and above the CCD.

I. Introduction

The Tokoro Belt in Hokkaido (Fig. 1) is one of the major ophiolitic belts in the Japanese Islands. Full understanding of the geology and tectonic history of the Tokoro Belt is very important for deciphering the geological evolution of the northwestern Pacific (OKADA, 1982). Consequently it is natural that a number of studies on the geology and tectonics of the Tokoro Belt have been done and are being carried on (for example, BAMBA, 1984; SAKAKIBARA et al., 1986; TARDUNO et al., 1988, and others).

Based on these previous studies, in this paper we intend to clarify the origin of the ophiolitic rocks in the Tokoro Belt. For this purpose we present new micropaleontologic data on the age and depositional environment of the pelagic sediments from the Tokoro Belt. In particular, we described fossil assemblages of radiolarians, foraminifers and calcareous nannofossils from the Tokoro Belt.

Paleomagnetic data from these sediments will be presented separately.

II. Geologic Setting of the Tokoro Belt

The Tokoro Belt consists of a Late Jurassic to Late Cretaceous sedimentary

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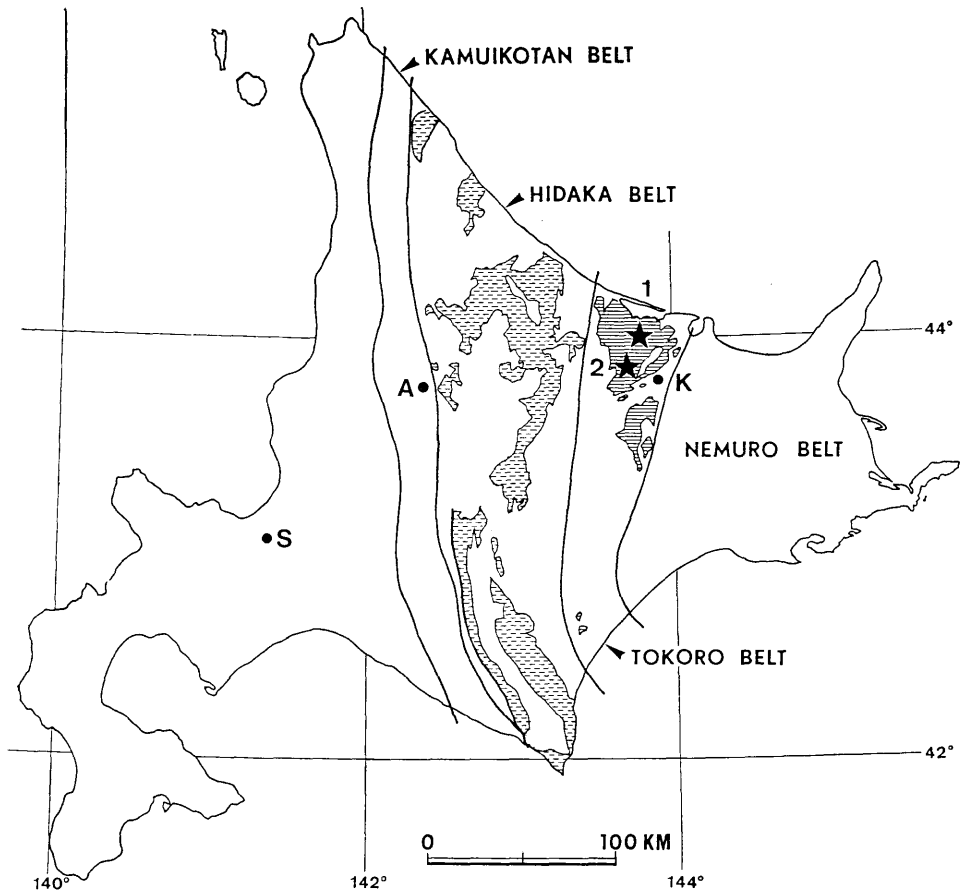 **** Department of Earth Sciences, Yamagata University, Yamagata 990

Fig. 1. Index map of Hokkaido showing the distribution of the Tokoro, Hidaka
    and Kamuikotan Belts. Star marks indicate the study areas: 1=Chirai Quarry
    and 2=Misato Cave. A: Asahikawa, S: Sapporo and K: Kitami.

complex of greenstone, chert, limestone, and terrigenous rocks. These rocks are
stratigraphically subdivided into three units, Nikoro, Saroma, and Yubetsu
Groups in ascending order. The geologic map of these units is shown in Fig. 2.

The Nikoro Group is characterized by ophiolite suites composed of alkali
basalt mostly with pillow structure, hyaloclastite, chert and micritic limestone,
ranging in age from Late Jurassic (Kimmeridgian–Tithonian) to Early Cre-
taceous (Berriasian–Aptian) (KIMINAMI et al., 1983; IWATA et al., 1983). The
thickness of the Nikoro Group is at least 4000 m.

The Nikoro greenstone is composed of ultramafic cumulates, dolerite, basalt,
trachyte and alkali rhyolite. These alkali basaltic rocks are similar to mid-oceanic
ridge basalts in their Ti/V ratios rather than intraplate basalts and are con-
sidered to have originated from alkali basalt magmas generated at a hot spot
near an oceanic ridge (SAKAKIBARA et al., 1986). The Nikoro greenstone was
subjected to regional metamorphism ranging from the zeolite facies through the
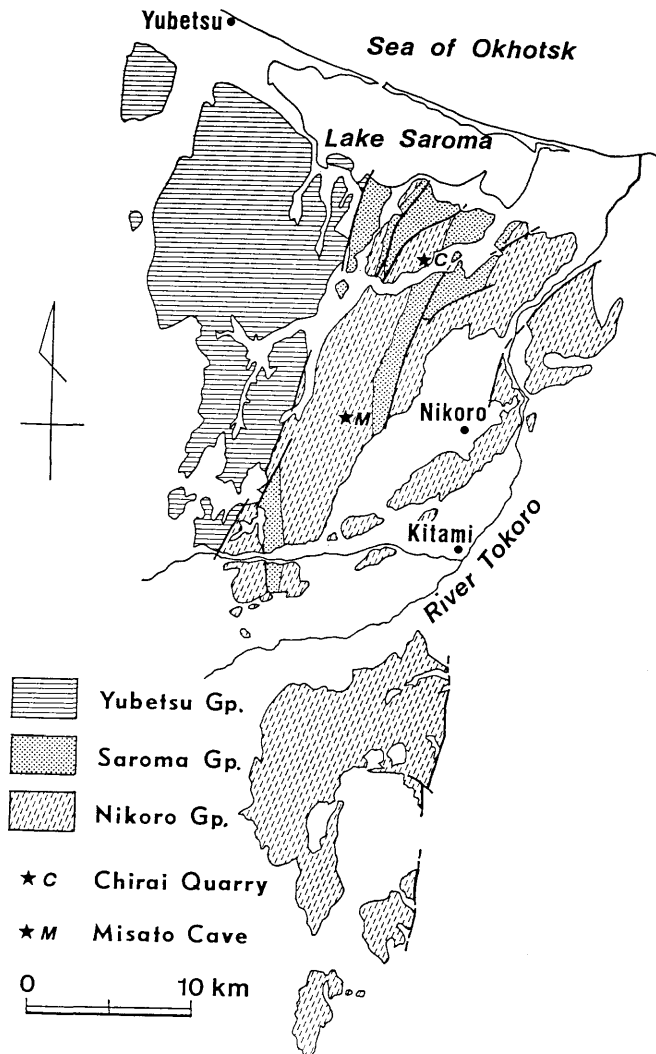prehnite-actinolite facies (SAKAKIBARA et al., 1986).

Fig. 2.   Geologic sketch map of the northern Tokoro Belt
    showing the position of the Chirai Quarry and the
    Misato Cave (modified from SAKAKIBARA *et al.*, 1986 and
    TAJIKA, 1988).

The Saroma Group, unconformably overlying the Nikoro Group, comprises conglomerate in the basal part, sandstone in the lower, alternation of sandstone and shale in the middle and mainly shale in the upper, attaining more than 2000 m in thickness. Sandstones are mostly turbidites and are rich in acidic to intermediate volcaniclastic debris (KIMINAMI and KONTANI, 1983; KONTANI *et al.*, 1986). Conglomerates contain clasts of andesitic (partly rhyolitic) and monzonitic rocks (SAKAKIBARA *et al.*, 1986).

Coniacian to Santonian radiolarians were reported from the Saroma Group (IWATA *et al.*, 1983). In addition, an inoceramid comparable to *Inoceramus*

schmidti MICHAEL of Campanian age was found in the lowermost part of the Saroma Group (SAKAKIBARA and TANAKA, 1986).

The Yubetsu Group is separated by faults from both the Nikoro and Saroma Groups and consists mostly of pelagic or hemipelagic shales, turbidite sandstones and conglomerates (TAJIKA, 1988). Exposed sequences are always separated from each other by reverse faults and individual sequences are tectonically repeated. Manganese spherules were found in red shales (SAKAKIBARA *et al.*, 1986; TAJIKA, 1988). Sandstones are rich in andesitic clasts (KONTANI and KIMINAMI, 1980). Gravels of conglomerates consist of chert, sandstone, andesite, basalt, granite and so on. The thickness of the Yubetsu Group appears to be more than 10 km, but the actual thickness of the Group is unknown owing to tectonic repetition. Radiolarian assemblages from the Yubetsu Group indicate an age of middle Campanian to early Maastrichtian (TAJIKA, 1988).

Tectonic and depositional environments of the Tokoro rocks are interpreted as follows, according to SAKAKIBARA *et al.* (1986) and TAJIKA (1988): The Nikoro Group is represented by oceanic sediments and seamount rocks formed near an oceanic ridge in Late Jurassic to Early Cretaceous time. The Nikoro seamount rocks were metamorphosed to some extent during subduction beneath the paleo-Okhotsk land. The Saroma Group unconformably covered the Nikoro Group as forearc basin deposits in Late Cretaceous time. Subsequently, the Yubetsu Group was formed as trench-fill deposits which were then incorporated into an accretionary prism.

III. Studied Sections

For the micropaleontological investigations of the Tokoro Belt, over 10 limestone localities were visited, but suitable sections for micropaleontological studies were found only at two sites, Chirai Quarry and Misato Cave, both in the Nikoro Group (Figs. 1, 2). Limestones from other localities were too strongly recrystallized.

Lithologic and stratigraphic features at Chirai and Misato are as follows:

1. Chirai Quarry

The Chirai Quarry is located about 6 km east of the town of Saroma, south of Lake Saroma (Figs. 2, 3). Excellent exposures are observable at the quarry operation area (Fig. 4), but outcrop conditions undergo continuous change due to quarrying. The quarry exposures are broken into blocks by faulting, but the original bedding is easily distinguished (Figs. 5, 6). Seven lithologic columns


Explanation of Plate 30

Thin-section photomicrographs of the micritic limestone from the Chirai Quarry.
Plane polarized light. Scale bar=1 mm.
Fig. 1. Calcite-veined, radiolaria-rich, gray-colored micrite. Sample T0-70.
Fig. 2. Calcite-veined, foram-common, radiolaria-rich, pink-colored micrite.
        Sample T3A-1.

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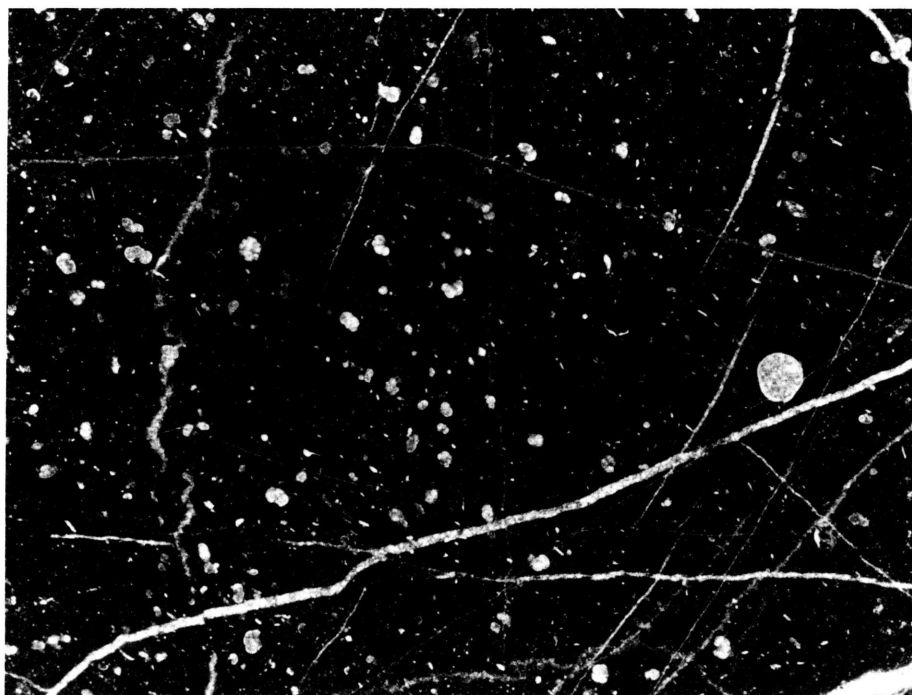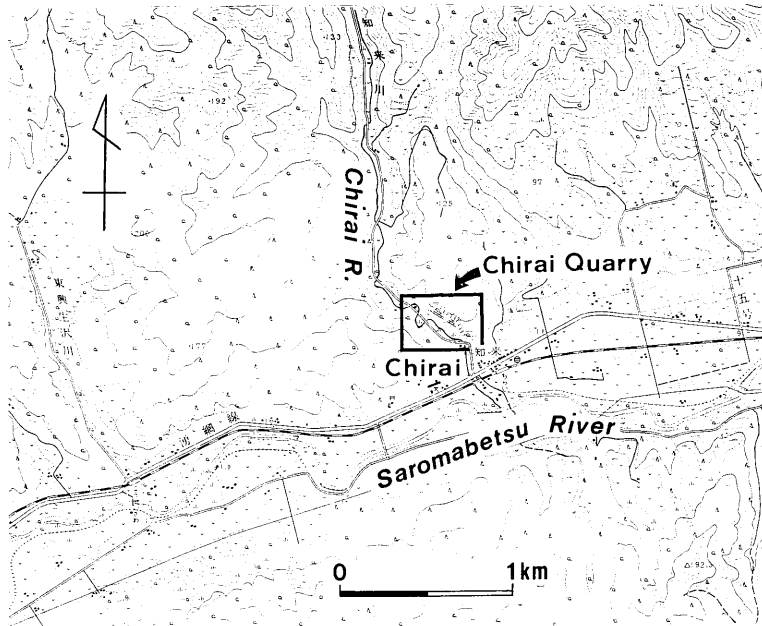
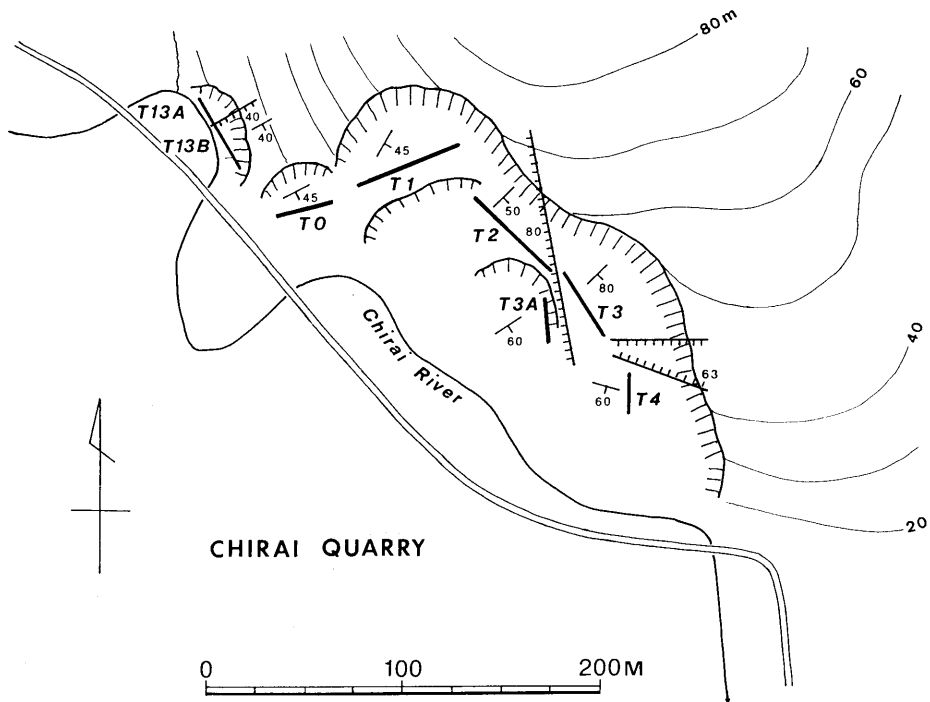Fig. 3. Index map showing the location of the Chirai Quarry.

Fig. 4. Chirai Quarry exposures showing the studied sections (thick lines).

Fig. 5. Outcrop of alternated micrite and chert at the top part of the
T 3 block of the Chirai Quarry.

Fig. 6. Photograph showing the occurrence of replacement chert
(dark-colored part) interbedded with micrite (light-colored part).
T 2A block of the Chirai Quarry.

were prepared for these blocks, as shown in Figs. 7 and 8. Gray to pink micritic
limestones (Pl. 30) are rhythmically interbedded with replacement chert in most
of the blocks. The limestone usually bears stylolitic structures and calcite veinlets
(Pl. 30), and is accompanied by red, bedded, radiolarian chert (5–10 cm-thick
bedded) sequences (T 0, T 3A). Bedded chert is sometimes intercalated with
films or thin layers of greenish tuff. The T 13A, B sections are characterized
by weathered, green, basic tuff at the base (Fig. 8). Replacement chert inter-
bedded with limestone beds is ribbon-like, lenticular, spheroidal and irregular in

shape (Fig. 6).

About 30 samples from sections T 0, T 3, T 3A, T 13A and T 13B were studied for radiolarians, foraminifers and calcareous nannofossils.

2. Misato Cave

The Misato Cave is situated about 12 km west of the town of Nikoro (Fig. 9). Two limestone bodies were investigated, which are T 12 and T 12A. The T 12 section is characterized by light gray micritic limestone (about 20 cm thick) interbedded with dark gray and red replacement chert (less than 15 cm thick). Near the top of the section T 12 beds of chert breccia are intercalated and are cemented with fine grained lime-mud (Fig. 10).

The section T 12A is also characterized by alternating beds of light gray micritic limestone and dark gray replacement chert, similar in lithology and mode of occurrence to those of the section T 12, but altered basalt is observed at the top of the section (Fig. 10).

About 10 samples from the sections T 12 and T 12A were examined for micropaleontology as mentioned in the Chirai sections.

IV. Paleontology

A. Radiolaria

1. Chirai Quarry

About 30 chert and limestone samples from the sections T 0, T 1, T 2, T 3, T 3A, T 4, T 13A, T 13B in the Chirai Quarry were examined for radiolarians. Generally speaking, the sections T 13A and 13B, which represent the lowest stratigraphic units in the quarry (Fig. 11), yield abundant radiolarians, but they are either rare in occurrence or poor in preservation in samples from other sections. Radiolarian assemblages only from the sections T 0, T 3A, T 13A and T 13B were successfully identified. The faunal characteristics in each section are described as follows:

a. Section T 0 (Fig. 7)

Samples T 0-50, -180~185 and -220 were examined, but radiolarian fossils are rather few in occurrence. Throughout these samples, the *Sphaerostylus lanceola* group is most common, and *Triactoma*(?) sp., *Cinguloturris* cf. *carpatica*, *Archaeodictyomitra* sp. are rarely found (Table 1).

b. Section T 3A (Fig. 7)

Seven samples T 3A-5, -15, -200, -300, -400, 500 and 630 were checked. From only two samples T 3A-15 and -200 radiolarian fossils were found. Identified species are as follows: in sample T-3A-15, *Zhamoidellum*(?) sp., *Sethocapsa*(?) sp., *Pseudodictyomitra*(?) sp. and so on; in sample T 3A-200, *Archaeospongoprunum*(?) sp., *Crucella*(?) sp., *Archaeodictyomitra* sp. etc. (Table 1).

c. Section T 13A (Fig. 8)

Three samples T 13A-80, -480 and 650 were examined, of which samples T 13A-480 and 650 contain abundant well-preserved radiolarians. In sample T 13A-80 radiolarians are rather few in occurrence, in which *Zhamoidellum*
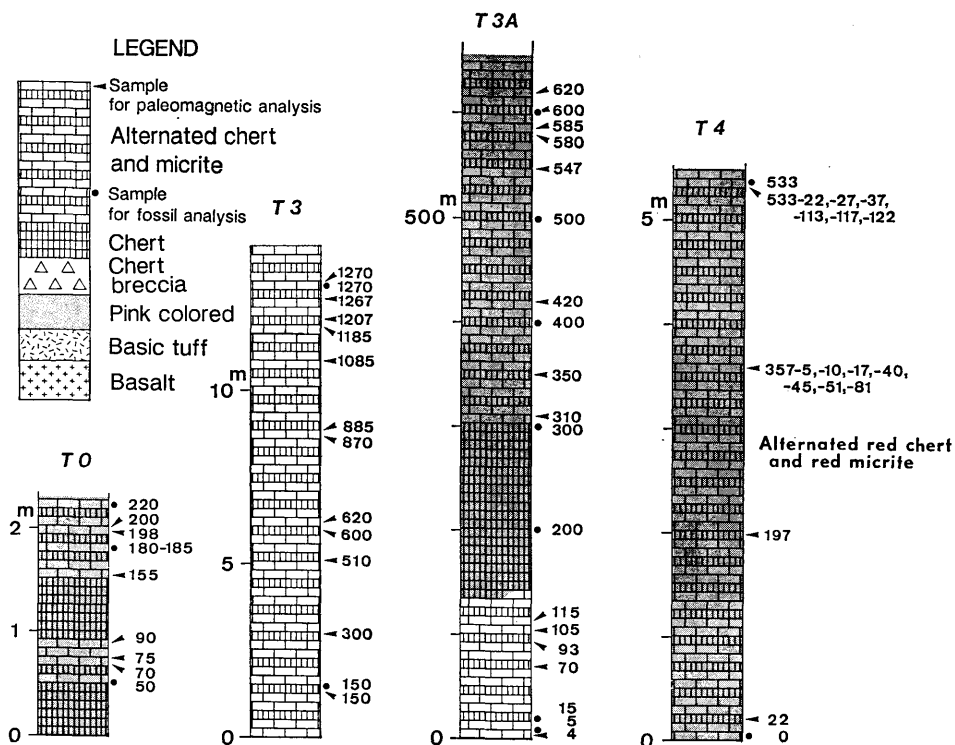
Fig. 7-1.

Fig. 7. Lithologic columns from the Chirai Quarry showing the stratigraphic positions of the examined samples. For the positions of the sections T 0, T 1, T 2, T 3, T 3A and T 4, refer to Fig. 4.

Table 1. Radiolarian assemblages from Sections T0 and T3A from the Chirai Quarry

sample number species	T0	T0 180 | 185	T0	T3 A	T3 A	T3 A
	50		220	15	200	300
Archaeodictyomitra sp.	+	+			+	
Archaeospongoprunum (?) sp.			+		+	+
Cinguloturris cf. *carpatica*		+				
Crucella (?) sp.					+	
Paronaella sp.	+	+				
Pseudodictyomitra (?) sp.				+		
Sethocapsa (?) sp.	+	+		+		
Sphaerostylus lanceola	+	+				
Triactoma (?) sp.	+	+				
Zhamoidellum (?) sp.	+	+		+		

T 1

• 315

m
30

2755
2735
2645
2595

2515

2375

2275

2045

20

1920
1890

1755
1730
1680

1588

1260

1100

10   950

500

200
• 100

0

m
30

2835
2735

2533

2393

2293

2185

2040

20   1850

1680

1080
10   1000

770

600
500

250

0   • 50

T 2
(continued)

m
60

• 5900
5900

5650

5480
5460
5360
5315
5285
5250

50

4550

4230
4205
4085
4055
4030

3895
3865
3845
3720
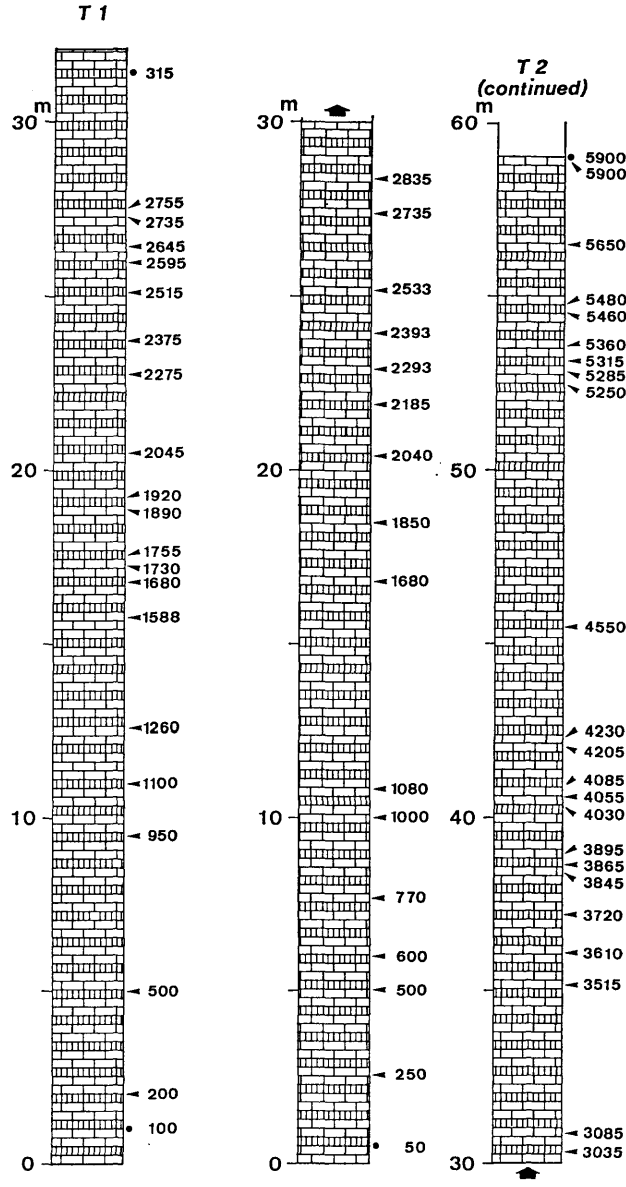40   3610
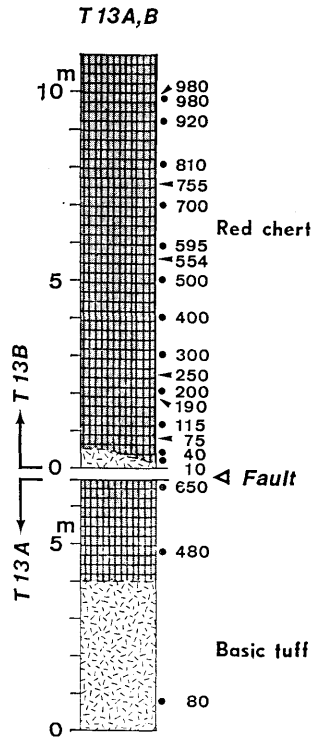3515

3085
3035
30

Fig. 7-2.

T 13A,B

Fig. 8. Lithologic columns of the sections
T 13A and B (refer to Fig. 4 for the po-
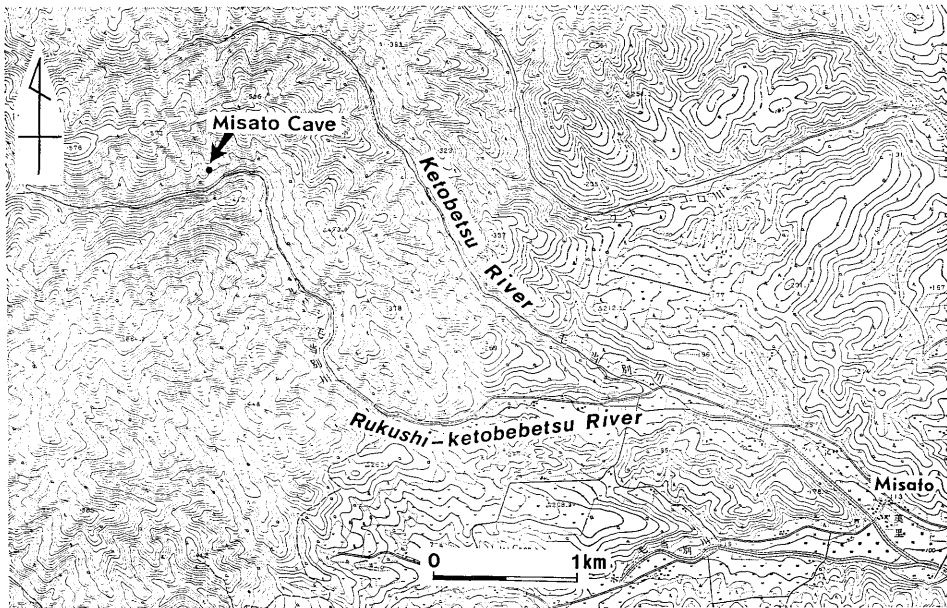sition of each section).

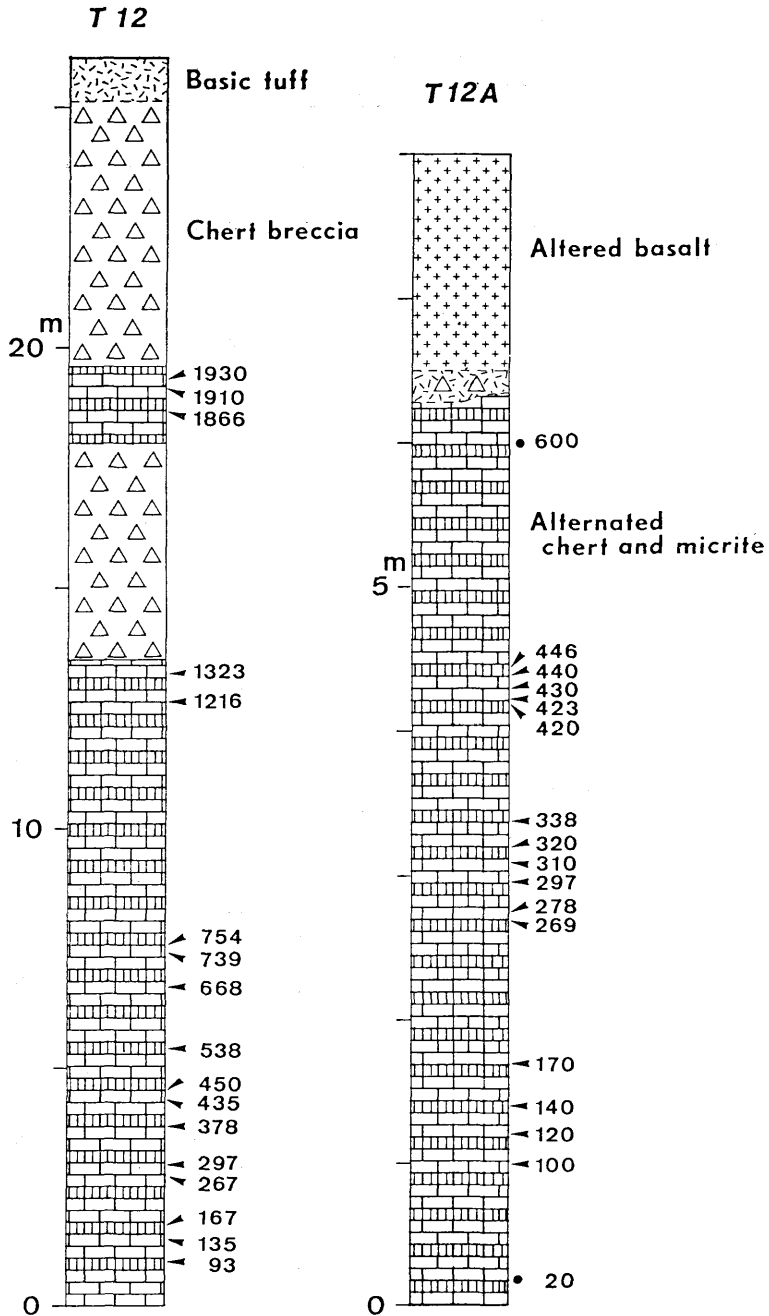Fig. 9.   Index map showing the location of Misato Cave.

Fig. 10. Lithologic columns from the Misato Cave showing the stratigraphic position of the examined samples.

Table 2.　Radiolarian assemblages from Sections T 13A and T 13B
from the Chirai Quarry

species / sample number	T 13 A 80	T 13 A 480	T 12 A 650	T 13 B 10	T 13 B 40	T 13 B 115	T 13 B 200
Alievium cf. *helenae*				+			
Amphipyndax durisaeptum		+	+				
Archaeodictyomitra sp. aff. *A. suzukii*		+	+	+	+		
Archaeodictyomitra sp.			+	+			+
Archaeospongoprunum cf. *imlayi*		+	+	+			
Archaeospongoprunum sp.						+	
Cinguloturris carpatica					+		
Cyrtocapsa (?) sp. aff. *C. kisoensis*		+					
Emiluvia cf. *orea*		+	+				
Eucyrtidiellum ptyctum		+	+	+			
Eucyrtidium (?) sp.			+	+			
Eucyrtis cf. *hanni*		+	+	+		+	
Haliodictya cf. *hojnosi*		+		+			
Hsuum cf. *brevicostatum*			+	+		+	
Hsuum (?) sp. aff. *H. stanleyensis*			+	+	+		
Lithelius (?) sp.			+	+			
Mirifusus cf. *guadalupensis*		+	+				
Mirifusus cf. *mediodilatatus*			+	+		+	
Obesacapsula morroensis			+				
Paronaella (?) *purisimaensis*			+				
Paronaella cf. *pygmaea*				+			
Parvicingula cf. *boesii*			+	+	+		
Parvicingula cf. *dhimenaensis*		+	+	+	+		
Protunuma sp.			+				
Ristola cf. *procera*						+	
Saitoum cf. *pagei*			+	+			
Sethocapsa sp.							+
Sethocapsa cf. *funatoensis*					+		
Spongocapsula cf. *palmerae*			+	+			
Spongocyclia (?) sp. aff. *S. trachodes*		+	+	+		+	
Spongodiscus (?) sp.			+	+			
Spongurus (?) sp.	+	+					
Stichocapsa cf. *decora*				+			
Stichocapsa naradaniensis		+		+			
Stichomitra (?) cf. *tairai*			+				
Triactoma blakei			+	+			
Triactoma cf. *jonesi*			+	+			
Triactoma sp.			+	+	+		
Tricolocapsa (?) sp.		+	+	+			
Zhamoidellum mikamense	+		+	+			

Table 3. Radiolarian assemblages from Section T12
from the Masato Cave

species / sample number	T12 20	T12 600
Amphipyndax tsunoensis	+	
Andromeda sp.	+	
Archaeodictyomitra cf. mirabilis	+	
Archaeodictyomitra cf. suzukii	+	
Archaeodictyomitra sp. aff. A. suzukii	+	
Archaeospongoprunum cf. imlayi	+	+
Crucella sp.	+	
Cyrtocapsa (?) cf. kisoensis	+	+
Diacanthocapsa sp.	+	
Eucyrtis (?) cf. hanni	+	
Eucyrtis cf. molengraaffi	+	+
Lithelius (?) sp.	+	
Obesacapsula morroensis	+	+
Paronaella cf. pygmaea	+	
Parvicingula cf. boesii		+
Parviciugula cf. dhimenaensis		+
Parvicingula (?) sp.	+	+
Patulibracchium sp.		+
Podobursa (?) sp.	+	+
Praeconocaryomma (?) sp.	+	
Ristola cf. procera		+
Sethocapsa funatoensis	+	
Spongocapsula cf. palmerae	+	
Spongocyclia (?) sp. aff. S. trachodes	+	+
Stichocapsa naradaniensis		+
Stichocapsa pseudodecora	+	+
Stichomitra (?) cf. tairai	+	
Stichomitra (?) takanoensis	+	
Tetratrabus cf. bulbosa		+
Theocorys (?) sp. aff. T. renzae		+
Tricolocapsa spp.	+	+

mikamense was identified (Table 2).

In sample T 13A-480, radiolarians are abundant and fairly well-preserved. Common radiolarian species include *Archaeospongoprunum* cf. *imlayi*, *Mirifusus* cf. *guadalupensis*, *Eucyrtidiellum ptyctum*, *Eucyrtis* cf. *hanni*, *Amphipyndax durisaeptum*, and *Archaeodictyomitra* sp. aff. *A. suzukii*.

Sample T 13A-650 contains very abundant and well-preserved radiolarians (Plates 31, 32), of which common species are *Archaeospongoprunum* cf. *imlayi*, *Triactoma* cf. *jonesi*, *Emiluvia* cf. *orea*, *Spongocyclia*(?) sp. aff. *S. trachodes*, *Lithelius*(?) sp., *Archaeodictyomitra* sp. aff. *A. suzukii*, *Eucyrtidiellum ptyctum*, *Eucyrtis* cf. *hanni*, *Hsuum* cf. *brevicostatum*, *Stichomitra*(?) *tairai*, *Mirifusus*

guadalupensis, Obesacapsulla morroensis, Zhamoidellum mikamense and others.
d. *Section T 13B* (Fig. 8)

12 samples from this section were analyzed for radiolarians, of which only four were rich in well-preserved radiolarians (Table 2).

Sample T 13B-10 contains well-preserved abundant radiolarians (Plates 31, 32). Important species include *Archaeospongoprunum* cf. *imlayi, Triactoma blakei, Haliodictya* cf. *hojnosi, Spongocyclia*(?) sp. aff. *S. trachodes, Saitoum* cf. *pagei, Hsuum* cf. *brevicostatum, Eucyrtidiellum ptyctum, Eucyrtis* cf. *hanni, Mirifusus mediodilatatus* group, *Spongocapsula* cf. *palmerae, Archaeodictyomitra* sp. aff. *A. suzukii,* and *Zhamoidellum mikamense.*

Sample T 13B-40 yields less abundant but well-preserved radiolarians. They include as dominant species *Sethocapsa* cf. *funatoensis, Archaeodictyomitra* sp. aff. *A. suzukii, Cinguloturris* cf. *carpatica, Parvicingula* cf. *dhimenaensis* and so on.

Sample T 13B-115 contains much less abundant but well-preserved radiolarians. They are chiefly *Archaeospongoprunum* sp., *Mirifusus mediodilatatus* groups, *Eucyrtis* cf. *hanni, Ristola* cf. *procera* and *Parvicingula* cf. *dhimenaensis.*

Sample T 13B-200 is rather poor in abundance and preservation of radiolarian fossils, in which *Archaeodictyomitra* sp. and *Sethocapsa* sp. were recognized.

To sum up, among the examined samples from the Chirai sections only four samples T 13A-480, T 13A-650, T 13B-10 and T 13B-40 presented well-preserved radiolarians. The faunal characteristics of radiolarians from these samples are almost similar to each other. That is, the faunal assemblages are characterized

Explanation of Plate 31

Scanning electron micrographs of radiolarians. Scale bar in all figures =100 μm.
Fig. 1. *Triactoma* cf. *T. jonesi* PESSAGNO
T 13B-10
Fig. 2. Actinommid gen. et sp. indet.
T 12-600
Fig. 3. *Emiluvia* cf. *E. orea* BAUMGARTNER
T 13A-650
Fig. 4. *Patulibracchium* sp.
T 12-600
Fig. 5. *Spongocyclia* (?) sp. aff. *S. trachodes* RENZ
T 13A-650
Fig. 6. *Spongodiscus* (?) sp.
T 13B-10
Fig. 7. *Lithelius* (?) sp.
T 12-600
Fig. 8. *Zhamoidellum mikamense* AITA
T 13A-650
Fig. 9. *Eucyrtidiellum ptyctum* (RIEDEL & SANFILIPPO)
T 13B-10
Fig. 10. *Obesacapsula morroensis* PESSAGNO
T 13A-650
Fig. 11. *Mirifusus* cf. *M. guadalupensis* PESSAGNO
T 13A-650

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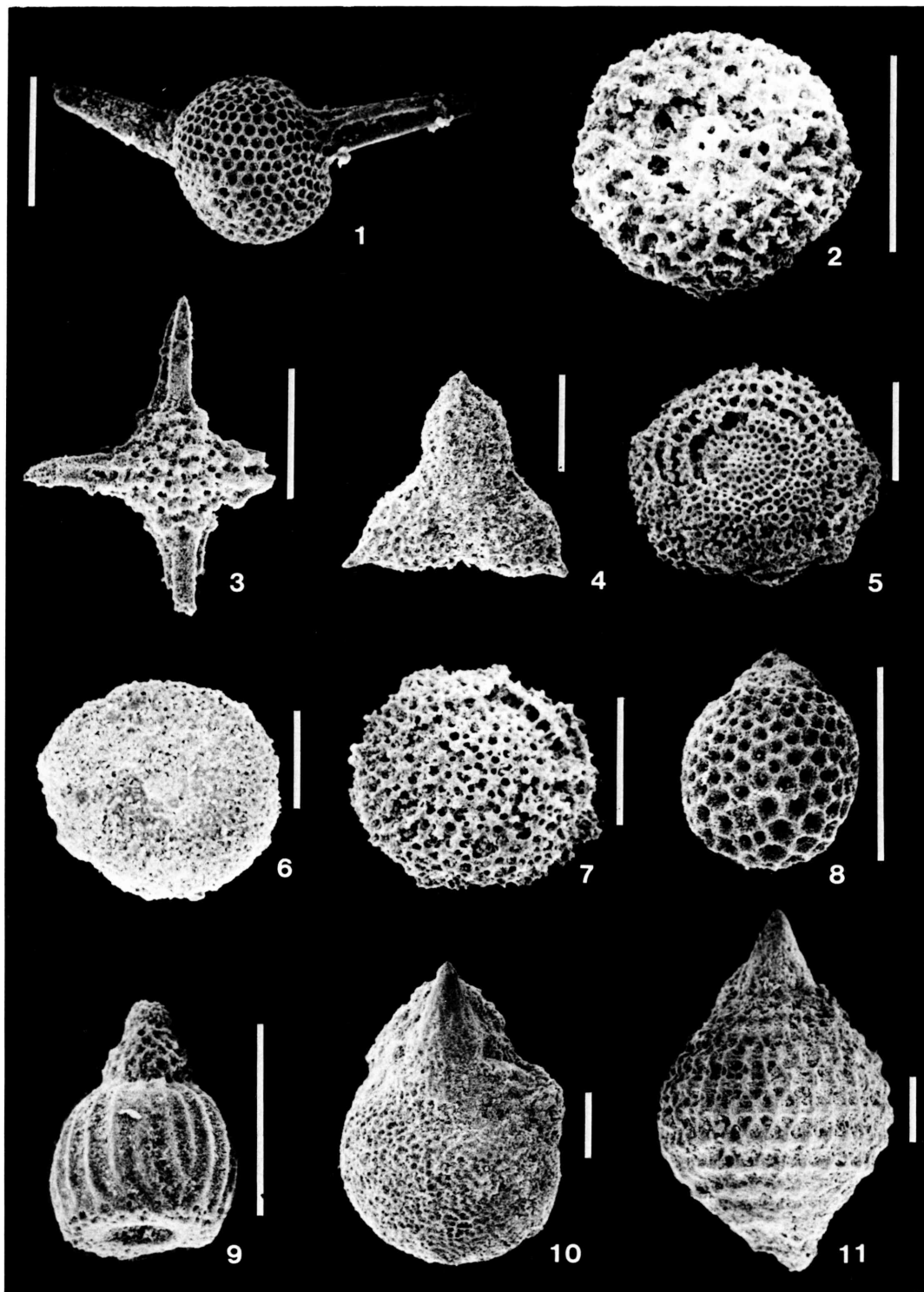
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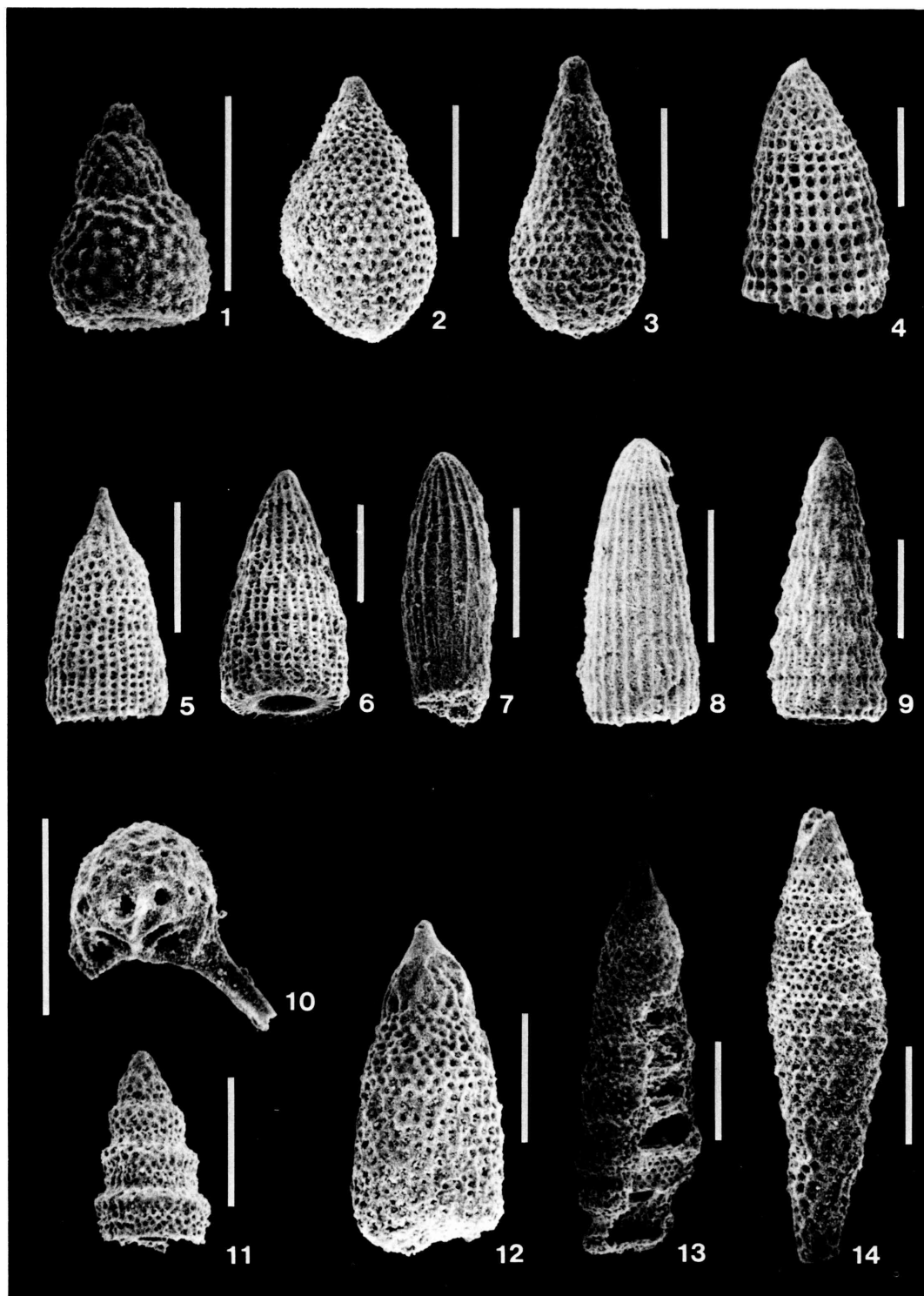
by *Archaeospongoprunum* cf. *imlayi*, *Eucyrtidiellum ptyctum*, *Hsuum* cf. *brevicostatum*, *Archaeodictyomitra* sp. aff. *A. suzukii*, *Spongocapsula* cf. *palmerae* and *Zhamoidellum mikamense*. This assemblage corresponds to the A0 to C2 Zones of the BAUMGARTNER's (1984) radiolarian zonation and to the *Archaeodictyomitra* (?) *mirabilis* Zone to *Zhamoidellum mikamense* Zone by AITA (1987). In addition to this, *Emiluvia orea* from T13A-480 and -650 characterizes Zones B and C2 of BAUMGARTNER (1984). Thus, the radiolarian assemblage indicates the age of the Late Oxfordian to Kimmeridgian or to Tithonian.

2. Misato Cave

About 30 samples were collected for radiolarian analysis from two sections at the Misato Cave (Figs. 9, 10). Two samples T 12A-20 and -600 yield abundant well-preserved radiolarian fossils (Table 3, Plates 31, 32).

Sample T 12A-20 is rich in well-preserved radiolarians. Dominant species are *Archaeospongoprunum* cf. *imlayi*, *Paronaella* cf. *pygmaea*, *Spongocyclia* (?) sp. aff. *S. trachodes*, *Lithelius* (?) sp., *Andromeda* sp., *Archaeodictyomitra* cf. *mirabilis*, *A.* cf. *suzukii*, *Obesacapsula morroensis*, *Stichomitra* (?) cf. *tairai* and so on.

Explanation of Plate 32

Scanning electron micrographs of radiolarians. Scale bar in all figures =100 μm.

Fig. 1. *Eucyrtidium* (?) sp.
          T 13A-650

Fig. 2. *Theocorys* (?) sp. aff. *T. renzae* SCHAAF
          T 12-600

Fig. 3. *Amphipyndax tsunoensis* AITA
          T 12-20

Fig. 4. *Hsuum* (?) sp. aff. *H. stanleyensis* PESSAGNO
          T 13A-650

Fig. 5. *Hsuum* (?) sp. aff. *H. stanleyensis* PESSAGNO
          T 13B-10

Fig. 6. *Hsuum* cf. *H. brevicostatum* BAUMGARTNER
          T 13A-650

Fig. 7. *Archaeodictyomitra* cf. *A. suzukii* AITA
          T 12-20

Fig. 8. *Archaeodictyomitra* sp. aff. *A. suzukii* AITA
          T 12-20

Fig. 9. *Hsuum* cf. *H. brevicostatum* BAUMGARTNER
          T 13A-650

Fig. 10. *Saitoum* cf. *S. pagei* PESSAGNO
          T 13A-650

Fig. 11. *Cinguloturris carpatica* DUMITRICA
          TO 180-185

Fig. 12. *Stichomitra* (?) cf. *S. tairai* AITA
          T 13A-650

Fig. 13. *Spongocapsula* cf. *S. palmerae* PESSAGNO
          T 13A-650

Fig. 14. *Eucyrtis* cf. *E. hanni* (TAN SIN HOK)
          T 13A-650

Sample T 12A-600 contains less abundant but well-preserved radiolarians. Among them *Archaeospongoprunum* cf. *imlayi*, *Obesacapsula morroensis*, *Stichocapsa naradaniensis*, *S. pseudodecora*, *Ristola* cf. *procera* and *Parvicingula* cf. *dhimenaensis* are important.

The radiolarian assemblage mentioned above is well correlatable to Zones A1 to C2 of BAUMGARTNER (1984) and to the *Amphipyndax tsunoensis* Zone to the *Zhamoidellum mikamense* Zone of AITA (1987). Thus, the geologic age of the studied section is Callovian to Kimmeridgian or to Tithonian.

B. Calcareous nannofossils

Two limestone samples collected from the Chirai Quarry and one sample from the Misato Cave yield common calcareous nannofossils. All of these nannofossils, however, are heavily overgrown, and their identification to any taxonomic levels are almost impossible except for several robust species. Occurrence of *Zeugrhabdotus embergeri* in samples T 3A-105 and T 12-25-30 indicates an age younger than Middle Kimmeridgian for both the Chirai and Misato limestone units (Table 4). The stratigraphic range of *Diazomatolithus lehmanii* is placed between Middle Jurassic and Albian (PERCH-NIELSEN, 1985), and rare specimens tentatively identified to this species occur in samples T 3A-105 and T 12-25-30. The possible age of Chirai and Misato limestone units judged by the poorly preserved nannofossils, therefore, is between Kimmeridgian and Albian. If the rare specimens resembling nannoconus are truly *Nannoconus* sp., the oldest

Table 4. List of calcareous nannofossils from limestones
from the Chirai Quarry and the Misato Cave

species \ sample number	T3A-15	T3A-105	T12-25-30
Cyclagelosphaera margerelii	C	C	C
Diazomatolithus sp. cf. *D. lehmanii*	—	R	R
Ellipsagelosphaera communis	—	F	F
Nannoconus? sp.	R	—	—
Watznaueria barnesae	A	A	A
Zeugrhabdotus embergeri	—	R	F

A: abundant, C: common, F: few, R: rare

Explanation of Plate 33

Optical micrographs (cross-polarized light) of calcareous nannoplankton. Scale bar for all figures =10 μm.

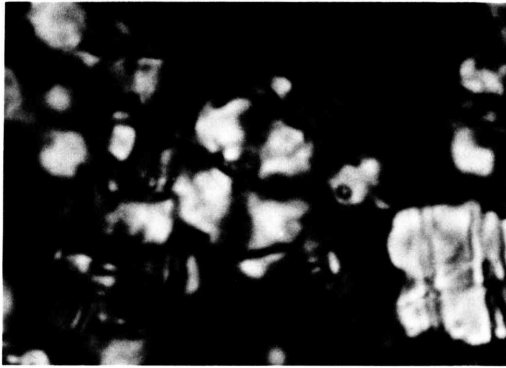Fig. 1. *Cyclagelosphaera margerelii* NOËL, sample T3A-105
Fig. 2. *Diazomatolithus* cf. *D. lehmanii* NOËL, sample T3A-105
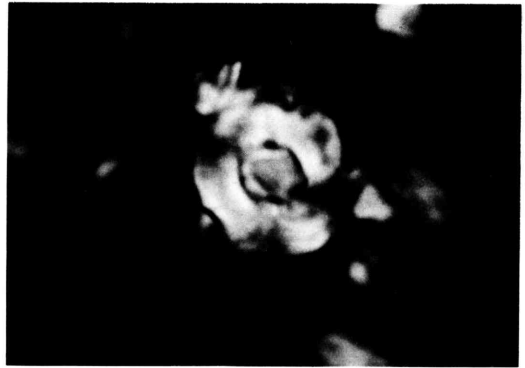Fig. 3. *Ellipsagelosphaera communis* (REINHARDT) PERCH-NIELSEN, sample T3A-105
Fig. 4. *Nannoconus?* sp., sample T3A-105
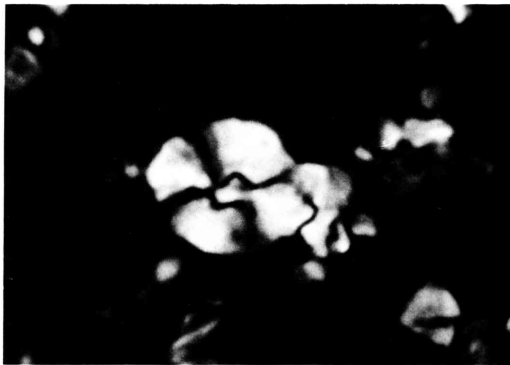Fig. 5. *Watznaueria barnesae* (BLACK) PERCH-NIELSEN, sample T3A-105
Fig. 6. *Zeugrhabdotus embergeri* (NOËL) PERCH-NIELSEN, sample T12-25-30
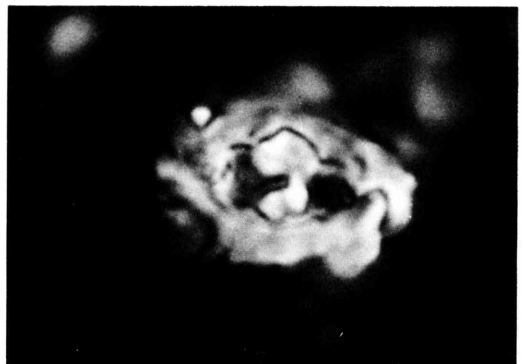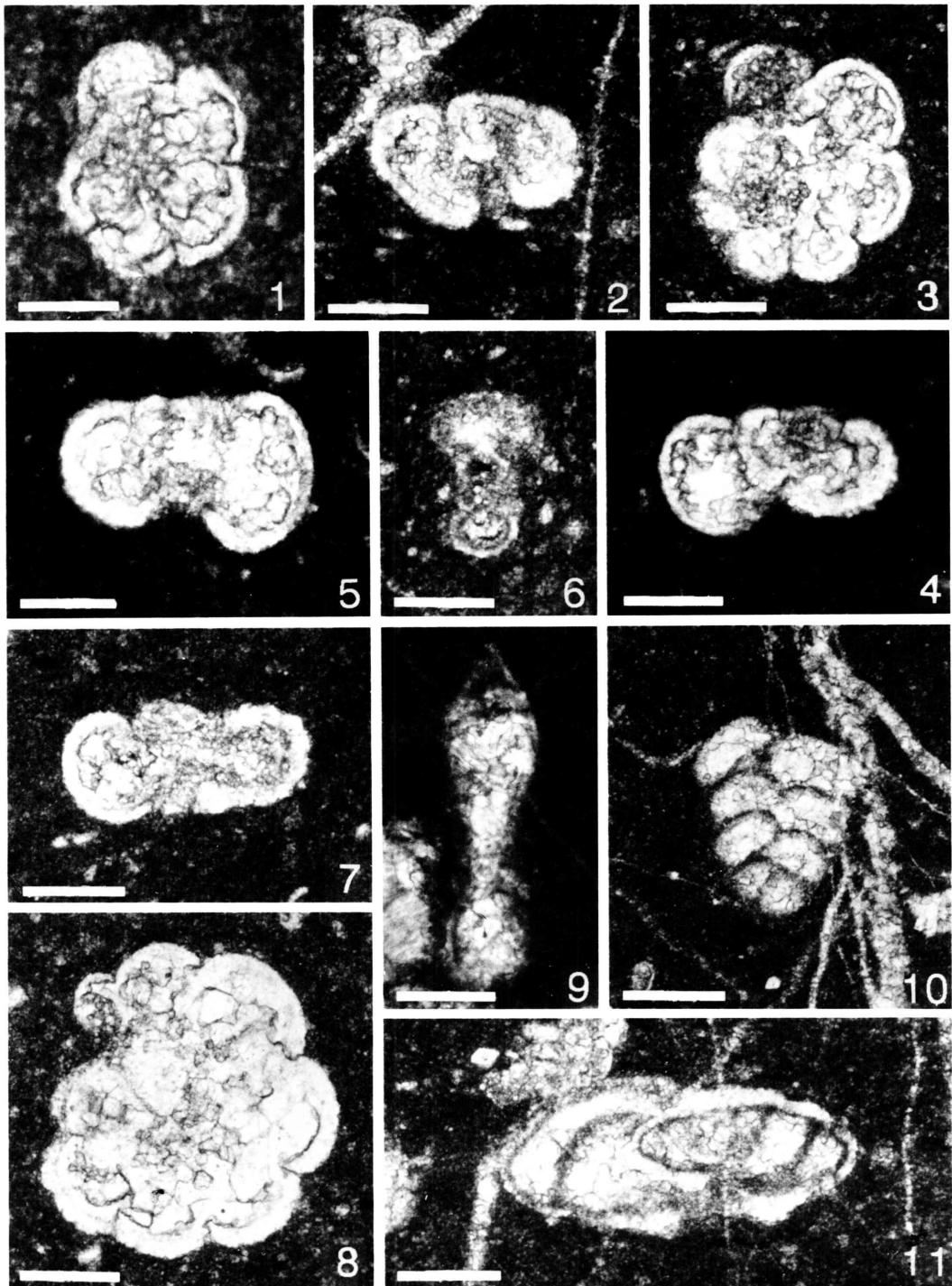
1

2

3

4

5

6

10 μm

H. Okada *et al.*:   Microfossil Assemblages from the Nikoro Pelagic Sediments

H. OKADA *et al.*:   Microfossil Assemblages from the Nikoro Pelagic Sediments

possible age for the Chirai unit could be late Tithonian.

C. Foraminifers

Planktic foraminifers of Aptian age are found in the reddish gray to medium gray stylolitic and veined micritic limestone interbedded with medium to dark gray chert at the Chirai Quarry. The faunas are low to moderately diverse and generally poorly preserved. The oldest samples are assigned to the *Globigerinelloides ferreolensis* Zone (KS 8) of SLITER (1989) and yield a middle Aptian age (about 116 Ma). This meager assemblage consists of *Globigerinelloides ferreolensis* (MOULLADE) and small hedbergellids such as *Hedbergella delrionensis* (CARSEY), *H. sigali* (MOULLADE) and *H. similis* LONGORIA.

Tectonically juxtaposed to these samples is a sequence of pelagic limestone and chert that contains a diverse assemblage of large, robust planktic foraminifers. The lower samples in this sequence belong to the *Hedbergella gorbachikae* Zone (KS 10) of late Aptian age (about 115 Ma). Foraminifers include *Hedbergella delrioensis*, *H. gorbachikae* LONGORIA, and *H. trocoidea* (GANDOLFI). The sequence extends upward into the *Ticinella bejaouaensis* Zone (KS 11) of latest Aptian age with the appearances of the nominal marker species. The early samples in this zone contain *Planomalina cheniourensis* SIGAL and thus indicate an age of about 114 Ma. The lack of this species in the uppermost beds assigned to Zone KS 11 suggests an age near the Aptian-Albian boundary at about 113 Ma.

The planktonic foraminiferal assemblages from the Chirai Quarry are identical to other coeval open-ocean assemblages. Most notable is the similarity to assemblages from topographic highs in the Pacific Basin such as the mid-Pacific Mountains, Magellan Rise, Ontong-Java Plateau and Manihiki Plateau,

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Explanation of Plate 34

Thin-section photomicrographs of planktonic foraminifers. Scale bar $= 100\,\mu$m for Figs. 2, 3, 4, 5, 6, 7, 8, 9, 11; $50\,\mu$m for Fig. 1; and $250\,\mu$m for Fig. 10.

Fig. 1. *Hedbergella delrioensis* (CARSEY), transverse section, sample T3A-11, Zone KS 11 (SLITER, 1989)

Fig. 2. *Hedbergella gorbachikae* LONGORIA, axial section, sample T3A-17, Zone KS 10 (SLITER, 1989)

Figs. 3, 4. *Hedbergella trocoidea* (GANDOLFI)
3. Transverse section, sample T3A-10, Zone KS 11 (SLITER, 1989)
4. Axial section, sample T3A-1, Zone KS 10 (SLITER, 1989)

Fig. 5. *Ticinella roberti* (GANDOLFI), axial section, sample T3A-13, Zone KS 11 (SLITER, 1989)

Fig. 6. *Globigerinelloides barri* BOLLI, LOEBLICH and TAPPAN, axial section, sample T3A-17, Zone KS 10 (SLITER, 1989)

Figs. 7–8. *Ticinella bejaouaensis* SIGAL, sample T3A-10, Zone KS 11 (SLITER, 1989)
7. Axial section
8. Transverse section

Fig. 9. *Planomalina cheniourensis* SIGAL, axial section, sample T2-5360, Zone KS 11 (SLITER, 1989)

Fig. 10. *Dorothia* sp., axial section, sample T3A-18

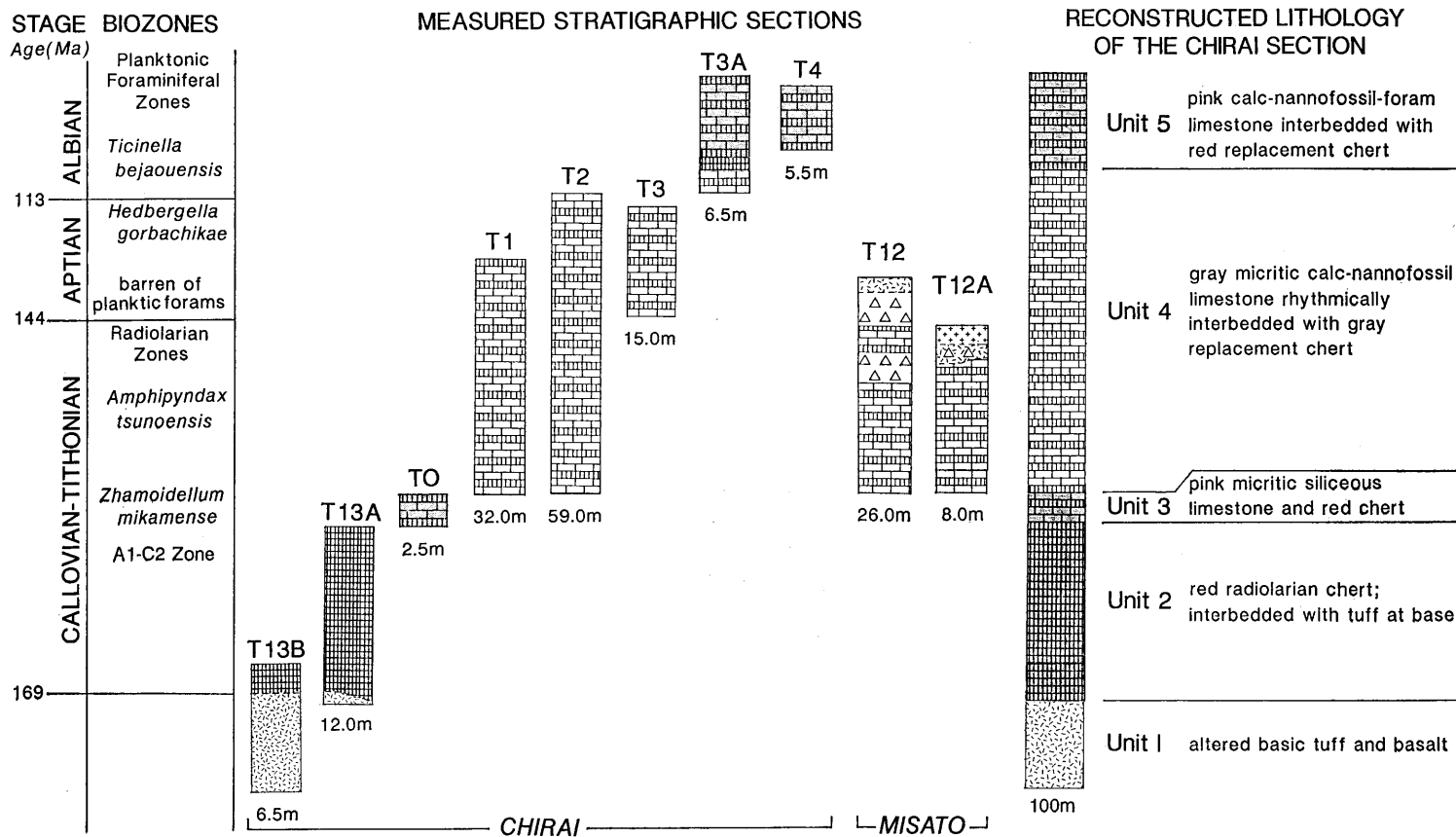Fig. 11. *Gavelinella* sp. axial section, sample T3A-11, Zone KS 11 (SLITER, 1989)

Fig. 11.   Correlation of the measured stratigraphic sections.   Planktonic foraminiferal zonation after SLITER (1989) and radiolarian zonation after BAUMGARTNER (1984) and AITA (1987).

and to pelagic limestone of the Franciscan Complex accreted to the western margin of the United States (SLITER, 1989, in press). In addition, the assemblages are strongly similar to those from pelagic limestone in Italy (ARTHUR and PREMOLI SILVA, 1982).

Benthic foraminifers from the limestone at the Chirai Quarry indicate bathyal water depths of about 1000 m and above the calcite compensation depth. Rare calcareous and agglutinated species are present and the assemblage is dominated by *Gavelinella* and *Dorothia* with lesser occurrence of *Dentalina*, *Gaudryina*, *Gyroidinoïdes*, *Lenticulina*, *Spiroplectammina* among others. Other biogenic material includes poorly preserved and recrystallized radiolarians, and occasional fish debris. The lack of shallow-water biogenic material indicates that the site of deposition was deeply submerged or far removed from a shallow source.

V. Concluding Remarks

A. Age and stratigraphy

The age of the Tokoro rocks has been studied by many workers. For the Nikoro Group, in particular, KIMINAMI *et al.* (1983) and IWATA *et al.* (1983) reported radiolarians denoting Late Jurassic (Kimmeridgian–Tithonian) to Early Cretaceous (Berriasian–Aptian). Our present study has also confirmed this notion about the age of the Nikoro Group, as summarized below.

Radiolarian assemblages from both the Chirai Quarry and Misato Cave sections show common features with each other, and that from the lower sequence of the Chirai section is correlatable with BAUMGARTNER's (1984) B to C2 Zone indicating the Late Oxfordian to Tithonian age. Furthermore, planktonic foraminifers from the upper sequence of the Chirai Quarry suggest a late Aptian to early Albian age.

Therefore, the studied section at the Chirai Quarry is reorganized into a composite stratigraphic sequence as shown in Fig. 11. This sequence consists of 5 units, I to V in ascending order. Unit I comprises altered basic tuff and basalt, Unit II is composed of red bedded chert, Unit III is represented by pink micritic siliceous limestone and red chert, Unit IV consists of gray micritic limestone rhythmically interbedded with gray replacement chert, and Unit V accommodates pink limestone interbedded with replacement chert.

The Misato section is correlated with the Chirai section as shown in Fig. 11. This stratigraphy implies that the sediments were deposited on the ocean floor under the influence of sedimentation on sea mounts.

B. Origin of oceanic sediments

Oceanic sediments exposed in the Tokoro Belt are represented by rhythmically interbedded micritic limestone and chert, both of which yield microfossils. The presence of nannofossils indicates that the limestone was originally calcareous nanno-ooze. The occurrence of limestone and the lack of either terrigenous debris or shallow-water bioclasts indicate that these sediments were initially deposited

in the deep ocean (above the CCD) far distant from continental margins. Benthic foraminifers from the limestone indicate bathyal environments of about 1000 m deep and above the CCD. Limestones from other localities in the Tokoro Belt, however, contain oolites and coralline debris (for example, some limestone bodies, south of Kunneppu), which indicate shallow-water environments. Thus, a seamount environment formed near an oceanic ridge as suggested for the Nikoro Complex by SAKAKIBARA *et al.* (1986), is consistent with our observation.

According to our paleomagnetic study of the Nikoro limestone and chert sections, the blocks show a mean inclination of I=3.4°, corresponding to a paleolatitude ranging from 5° N to 9° S for Callovian to Aptian times (168-112 Ma) (TARDUNO *et al.*, 1988).

Therefore, we suggest that the Nikoro rocks were formed in a seamount environment near a spreading ridge or a hotspot in the paleoequator region on the Izanagi Plate. Later northward migration of the Nikoro rocks may be explained according to the models of ENGEBRETSON *et al.* (1984) and HENDERSON *et al.* (1984). More detailed discussions on the plate tectonics interpretation of the Nikoro ophiolites will be given separately (TARDUNO *et al.*, in press).

A further similarity of the limestone in this area to that of the Franciscan Complex of northern California is found in the degree of stylolitization, recrystallization, chertification and veining that clearly differentiates these limestones from those from sites in the Pacific sites or from sections in Italy (SLITER, 1990, in press). This similarity suggests a like tectonic history for the Tokoro deposits that would involve the accumulation and disruption of a subduction complex. Indeed, the Tokoro deposits themselves, like those of the Franciscan Complex, presumably represent the obducted carbonate caps of Cretaceous plateaus that were originally deposited beneath a low-latitude paleoequatorial productive zone.

Acknowledgments

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