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Early Cretaceous melange in the Hida-Kanayama area, central Japan

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Abstract: The melange in the Hida-Kanayama area of the Mino terrane is characterized by numerous siliceous rock clasts which yield well-preserved radiolarians. The size, rock type, age, shape and distribution of clasts and the nature of matrix are investigated in detail to discuss the origin of the melange.

The melange is a chaotic mixture of rock clasts and shale matrix. The clasts, ranging in size from a millimeter to several kilometers, are composed of Middle Triassic to Late Jurassic chert, Middle Jurassic to earliest Cretaceous siliceous shale and massive sandstone, bedded turbidite and basalt of unknown age. Whereas the argillaceous parts of the melange yield early Late Jurassic to earliest Cretaceous radiolarians. The argillaceous parts consist of shale matrix and numerous siliceous shale clasts and fragments. Most of the radiolarians seem to be extracted from the siliceous shale clasts or fragments rather than from the shale matrix. Therefore, the age of the matrix is as young as or slightly younger than earliest Cretaceous. As the melange is unconformably overlain by Late Cretaceous rhyolites, the formation of the melange occurred during Early Cretaceous time.

Detailed field observations and micropaleontological investigations reveal that the Mazegawa Formation (MIZUTANI, 1981), one of the best studied siliceous shale sequences in the Mino terrane, is in fact one of the large blocks in the melange.

Well-preserved radiolarians, ranging in age from Middle Triassic to earliest Cretaceous, are obtained from siliceous shale clasts, chert clasts and argillaceous parts of the melange. The Middle Jurassic to earliest Cretaceous radiolarians belong to the following five assemblages: *Guexella nudata, Gongylothorax sakawaensis—Stichocapsa naradaniensis, Tricolocapsa yaoi, Pseudodictyomitra primitiva—Pseudodictyomitra* sp. A, and *Pseudodictyomitra* cf. *carpatica* Assemblages.

Following protolith succession is reconstructed from siliceous rock clasts of the melange in the Okukanayama route which is located in the central part of the study area :

(1) Triassic to Early Jurassic : gray to dark gray bedded chert
(2) late Middle Jurassic : pale purple bedded chert and light gray chert
(3) early Late Jurassic : white to light gray siliceous shale
(4) latest Jurassic : gray-dark gray massive (partly bedded) siliceous shale
(5) earliest Cretaceous : laminated siliceous shale with trace fossils, and siliceous siltstone

The reconstructed succession is lithologically similar to the succession of stacked coherent sequences of the Inuyama-Kamiaso area to the south, but the

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age of each rock type is very different between the Hida-Kanayama and Inuyama–Kamiaso areas. This shows that the melange of the Hida-Kanayama area was not produced by the collapse of the same normal coherent sequences as in the Inuyama–Kamiaso area.

The lateral extensions of the rocks of the Okukanayama route are distributed at Nakagiri and Funeno. Three different protoliths are reconstructed from clasts in the melange among the Okukanayama, Nakagiri and Funeno localities by investigation on the ages and lithology of siliceous rock clasts. These three different protoliths must have been dislocated from different rock bodies as large slabs and then broken into small clasts almost at the same time.

INTRODUCTION

Melanges and the related rock bodies are widely distributed in the sedimentary complex of the Mino terrane, central Japan (Fig. 1). Although the general character of the melanges is known as a result of recent several studies in the Mino terrane, a detailed analysis is required for specifying the processes and mechanism of the fragmentation and

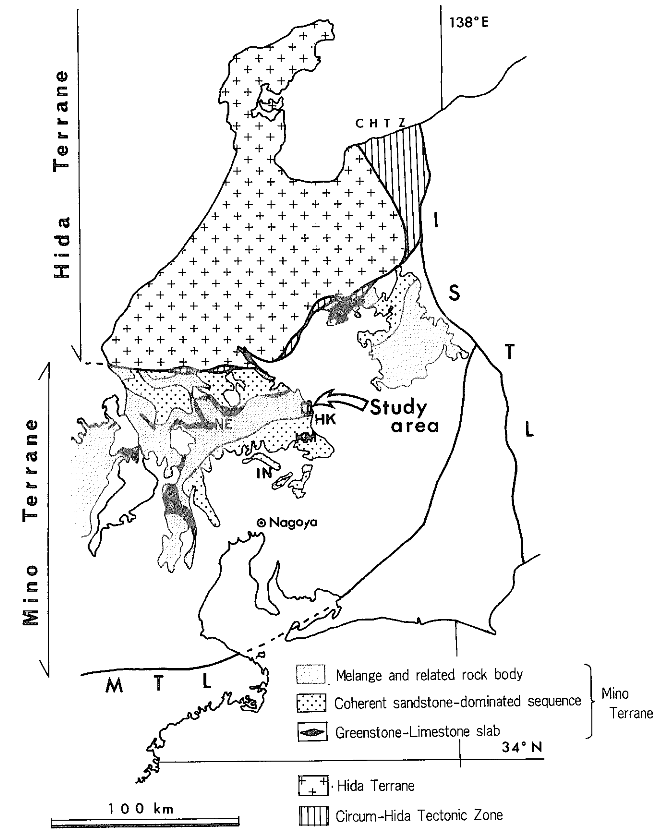

Fig. 1 Index map showing the study area. CHTZ : Circum-Hida Tectonic Zone, ISTL : Itoigawa–Shizuoka Tectonic Line, MTL : Median Tectonic Line, HK : Hida-Kanayama, NE : Neo, IN : Inuyama, KM : Kamiaso.

mixing.

Thick sedimentary sequences of the Mino terrane had been regarded as Carboniferous to Permian strata on the basis of fusulinids in lenticular bodies of limestone for a long time (e.g. KANUMA, 1958). When Triassic conodonts were discovered in bedded chert during the 1970's (e.g. KOIKE *et al.*, 1971), the sedimentary sequences were modified to be of late Paleozoic to Triassic age. Towards the late 1970's, radiolarian biostratigraphy became a key to reveal that most of the clastic rocks of the Mino terrane were deposited during Jurassic time (MIZUTANI *et al.*, 1981), and that the pre-Jurassic chert, limestone and greenstone are allochthonous blocks in the autochthonous clastic rocks (e.g. WAKITA, 1983, 1984; WAKITA and OKAMURA, 1982).

The admixtures of allochthonous blocks and Jurassic clastic rocks showing block-in-matrix texture were called "olistostrome" (ADACHI, 1976; KANO, 1979). However, their distribution, structure, mode of occurrence and origin are still very poorly understood. Therefore, non-genetic term, melange is adapted for such chaotic mixtures in this report instead of the olistostrome whose definition requires to be of sedimentary origin. It is important to investigate the nature of the melange and to describe it in detail in order to specify the process and mechanism of the fragmentation and mixing.

Until now the mode of occurrence of siliceous shale has not been made clear in the melanges of the Mino terrane. And major concern in the previous studies was placed on the age of formation of melanges, depending on the radiolarians obtained from the siliceous shale. Some authors suggested that Jurassic siliceous shale may occur in clasts ("olistoliths") of melange ("olistostrome") (MIZUTANI, 1981; WAKITA and OKAMURA, 1979; YAMAMOTO, 1985), but no one gave any evidence to prove that the siliceous shale occurs as clasts, nor showed the critical relationship between the siliceous shale and the melange ("olistostrome").

MIZUTANI *et al.* (1981) identified three radiolarian assemblages in the Mino terrane: the *Mirifusus baileyi* Assemblage of Late Jurassic age, and the *Dictyomitrella* (?) *kamoensis* — *Pantanellium foveatum* and the *Unuma echinatus* Assemblages of Middle Jurassic age. As the two Assemblages of Middle Jurassic age were reported from a sequence of siliceous shale at some localities, their stratigraphical relationship is well-known. However, no reports have shown that Late Jurassic siliceous shale occurs along with Middle Jurassic siliceous shale within a sequence. Therefore, the relationship between two types of siliceous shale of Middle and Late Jurassic ages is still ambiguous.

Well-preserved radiolarians of Late Jurassic age are obtained from a siliceous shale sequence (Mazegawa Formation: MIZUTANI, 1981) in the Hida-Kanayama area situated in the central part of the Mino terrane (Fig. 1). Various kinds of studies were done on the lithostratigraphy, biostratigraphy, paleomagnetism and isotope geochronology of the Mazegawa Formation. SHIBATA and MIZUTANI (1980) showed that whole rock samples of the siliceous shale of the Mazegawa Formation give a Rb-Sr isochron of 128 ± 3 Ma, and that K-Ar ages for these samples range from 125 to 133 Ma, except two much older ages. MIZUTANI (1981) described the lithostratigraphic and biostratigraphic characters of the Mazegawa Formation, and discussed the relationship between the age given by the fossils and the isotopic

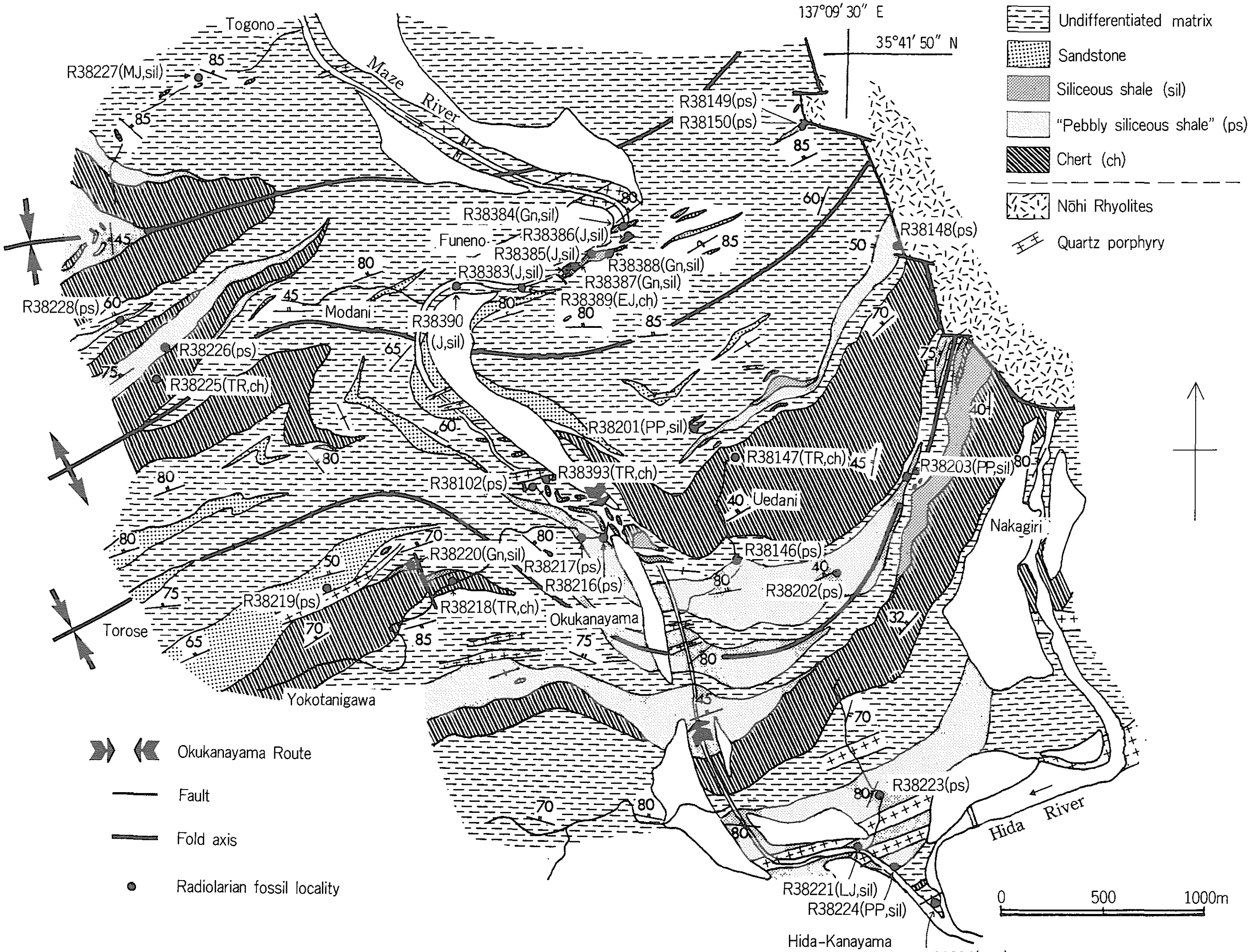

Fig. 2 Geologic map of the Hida-Kanayama area
R 38 ××× : Number of the registered samples (Geological Museum) from which diagnostic radiolarians are extracted
[Radiolarian assemblage and age] TR : Triassic, J : Jurassic, EJ : Early Jurassic, MJ : Middle Jurassic, LJ : Late Jurassic, Gn : *Guexella nudata* Assemblage, GS : *Gongylothorax sakawaensis—Stichocapsa naradaniensis* Assemblage, Ty : *Tricolocapsa yaoi* Assemblage, PP : *Pseudodictyomitra primitiva—Pseudodictyomitra* sp. A Assemblage, Pc : *Pseudodictyomitra* cf. *carpatica* Assemblage.
[Rock type] ms : Argillaceous parts of the melange, ps : "Pebbly siliceous shale", sil : Siliceous shale, ch : Chert, gs : Basalt.

Table 1 Radiolarian assemblages used in this paper and their correlation with those of MIZUTANI *et al.* (1981).

		This paper	MIZUTANI *et al.* (1981)
CRET.		*Pseudodictyomitra* cf. *carpatica*	
JURASSIC	Late	*Pseudodictyomitra primitiva* — *P.* sp. A	*Mirifusus baileyi*
		Tricolocapsa yaoi	
		Gongylothorax sakawaensis – *Stichocapsa naradaniensis*	
	Middle	*Guexella nudata*	*Dictyomitrella* (?) *kamoensis* — *Pantanellium foveatum*
		Unuma echinatus	*Unuma echinatus*
	Early	*Hsuum hisuikyoense*	
		Parahsuum sp. D	
		Parahsuum simplum	
TRIAS.		*Canoptum triassicum*	

ages. He also gave a paleontological description of the radiolarian fauna of the *Mirifusus baileyi* Assemblage (MIZUTANI *et al.* 1981), and concluded that the radiolarians of the Mazegawa Formation indicate Early (?) Tithonian. Paleomagnetic studies were also done on the Mazegawa Formation by HATTORI (1982), who suggested that this formation was deposited at a low latitude area. Although the Late Jurassic siliceous shale of the Mazegawa Formation itself has been investigated in detail as described above, the relationship of the formation to surrounding melange or to Middle Jurassic siliceous shale of other areas is poorly understood.

I have mapped and investigated the melange of the Hida-Kanayama area since 1984, focusing on the relationship between Middle Jurassic and Late Jurassic siliceous shales, occurrence of siliceous shale, and fabrics and ages of clasts and matrix of the melange. Recently, WAKITA (1987) reported earliest Cretaceous radiolarians from shale and siliceous shale of the melange in the Hida-Kanayama area. These radiolarians are not only younger than those of the Mazegawa Formation, but are the youngest in the fossils obtained from the sedimentary complex of the Mino terrane. The occurrence of earliest Cretaceous radiolarians suggests that

Late Jurassic siliceous shale like the Mazegawa Formation may occur as clasts of the melange, but causes more confusion about the timing of the formation of the melange, because earliest Cretaceous radiolarians are not obtained from true shale matrix but from siliceous shale clasts or fragments of microscopic size in the melange.

The primary objectives of this study are (1) to determine the relationship between siliceous shale and surrounding rocks, (2) to determine the relationship between Late Jurassic and Middle Jurassic siliceous shales, (3) to reconstruct protolith from which clasts in melange were derived, on the basis of radiolarians from siliceous rock clasts, and (4) to discuss the origin of the melange.

Mapping was done in an area of approximately 10 km^2 in the north of Hida-Kanayama (Fig. 2), and detailed field observation and sampling for radiolarians were carried out with special emphasis on the melange along the Okukanayama route (Figs. A-1—A-10).

In this study, the name and division of the radiolarian assemblages are in accordance with those given by YAO *et al.* (1982) and YAO (1986). The correlation of this division to that of MIZUTANI *et al.* (1981) is shown in Table 1.

GEOLOGIC SETTING

The Mino terrane is situated to the south of the Hida terrane and the Circum-Hida Tectonic Zone (Fig. 1).

The Hida terrane consists mainly of polymetamorphosed gneiss, amphibolite, crystalline limestone and granitic rocks. Radiometric age of the granitic rocks are mostly concentrated at approximately 180 Ma. SHIBATA and NOZAWA (1986), however, reported that the Rb–Sr model ages of some granites intruded into gneiss are about 1100, 700, or 300 Ma, indicating that the Hida terrane includes the gneiss of Precambrian age. Carboniferous fossils from crystalline limestone (HIROI, 1978) suggest that Paleozoic sequences also exist in the Hida terrane.

In the Circum-Hida Tectonic Zone, non-metamorphosed Ordovician to Permian shallow marine sedimentary rocks, chloritoid phyllite and schistose rocks (greenschist—glaucophane schist facies) of 300–400 Ma are tectonically squeezed and embedded in serpentinites. The Kuruma Group, Lower Jurassic molasse-type sediments, unconformably covers a part of the older rocks of the Circum-Hida Tectonic Zone. The pre-Jurassic rocks of the Hida terrane and the Circum-Hida Tectonic Zone and the Kuruma Group are unconformably overlain by Middle Jurassic to Early Cretaceous shallow marine to non-marine molasse-type sedimentary covers (the Tetori Group).

The sedimentary complex of the Mino terrane is composed chiefly of sandstone, shale, chert, greenstone and limestone. Melanges and the related rock bodies are widely distributed with a east–west trend in the middle belt of the Mino terrane (Fig. 1), and include clasts and slabs of sandstone, chert, siliceous shale, limestone and greenstone embedded in non-to weakly foliated shale matrix. On the both sides of the belt of melanges and related rock bodies, coherent sandstone-dominated sequences occur (Fig. 1). The southern coherent sequence consists of stacked slices each of which is composed of Triassic–earliest Jurassic cherts, Middle Jurassic siliceous shales and early Late (?) Jurassic massive sandstone with bedded turbidite in ascending order (e.g. YAO *et al.*, 1980; KIDO *et al.*, 1982) of the Inuyama–Kamiaso area (Fig. 1). The northern coherent sequence consists of Middle Jurassic massive sandstone and bedded turbidite associated with small amounts of chert blocks in the lower part.

The Hida-Kanayama area occupies the southeastern part of the belt of melanges and the related rock bodies, and is thoroughly underlain by the melange of the Mino terrane. In the east of the study area, the melange is unconformably overlain by the Late Cretaceous Nohi Rhyolites, and is intruded by quartz porphyry or granite porphyry dikes related to the same igneous activity as the Nohi Rhyolites.

MELANGE

The chaotic complexes of sedimentary rocks in the Mino terrane are characterized by lithologically heterogeneous bodies of harder rocks mixed and dispersed in a matrix of pelitic heterogeneous material. They are very similar to the olistostrome defined by FLORES (1955) or ABBATE *et al.* (1970). The chaotically mixed rock bodies of the Mino terrane, however, do not occur within normal stratigraphic sequences, and are of unknown origin. Therefore, they should be distinguished from the olistostromes of obviously sedimentary origin as mentioned in the previous chapter.

Although the term *melange* has been defined by many geologists (e.g. HSÜ, 1968 ; COWAN, 1974, 1985 ; RAYMOND, 1984), no consensus has been reached about the definition until now. But, there is a growing consensus that whatever the definition of a term is, it should be based on observable criteria rather than on presumed origin (RAYMOND, 1984). If the requirement of pervasively sheared fabric in matrix is eliminated in the definition of melange as RAYMOND (1984) proposed, the non-genetic term *melange* should be adapted for the chaotic complexes in the Mino terrane rather than olistostrome.

The definition of the term *melange* in this report is as follows :

Melange is a term describing a mappable (at 1 : 25000 or smaller scale), internally fragmented and mixed rock body containing a variety of clasts and blocks in a pelitic matrix.

The term *clast* refers to inclusions of all sizes and types in the melange in this report. The term *block* is used for massive clasts larger than 1 m in diameter, and the term *slab* implies a mappable sheet-like clast.

The melange of the Hida-Kanayama area consists of a chaotic mixture of clasts (Fig. 2), ranging from a millimeter to several kilometers in length, of various rock types in shale matrix which is not pervasively sheared but weakly foliated.

The structural trend of the melange is represented by the foliation of shale matrix and the elongation and arrangement of large slabs (Fig. 2). Two synforms and one antiform are recognized in the study area. The folds are tight, and have a wave length of approximately 2 km. The axes trend ENE-WSW and plunge to the west. Both limbs dip generally 70-85 degrees northward, so that the axial planes dip steeply northward. The traces of the axial planes are slightly curved (Fig. 2).

1. Matrix

The matrix of the melange consists largely of dark gray shale having weak, sometimes distinct, scaly foliation. The development of the foliation depends on that of myriad anastomosing cleavages subparallel to arrangement of white micas and elongated rock fragments in the shale matrix. Rock fragments of different kinds and sizes are found irregularly throughout the matrix.

The proportion of matrix to clasts is variable but generally low (Plate I-6). In most outcrops a small amount of hard clasts of sandstone, siliceous shale and chert which resist weathering are enclosed by argillaceous parts (Fig. 3). Although the argillaceous parts look like matrix at most of the outcrops, the argillaceous parts contain not only shale of matrix but numerous small clasts and fragments of siliceous shale and siltstone. Therefore, the portion of true matrix of the melange is much less in amount, and the proportion of the true matrix portion to the clasts is lower than that in appearance.

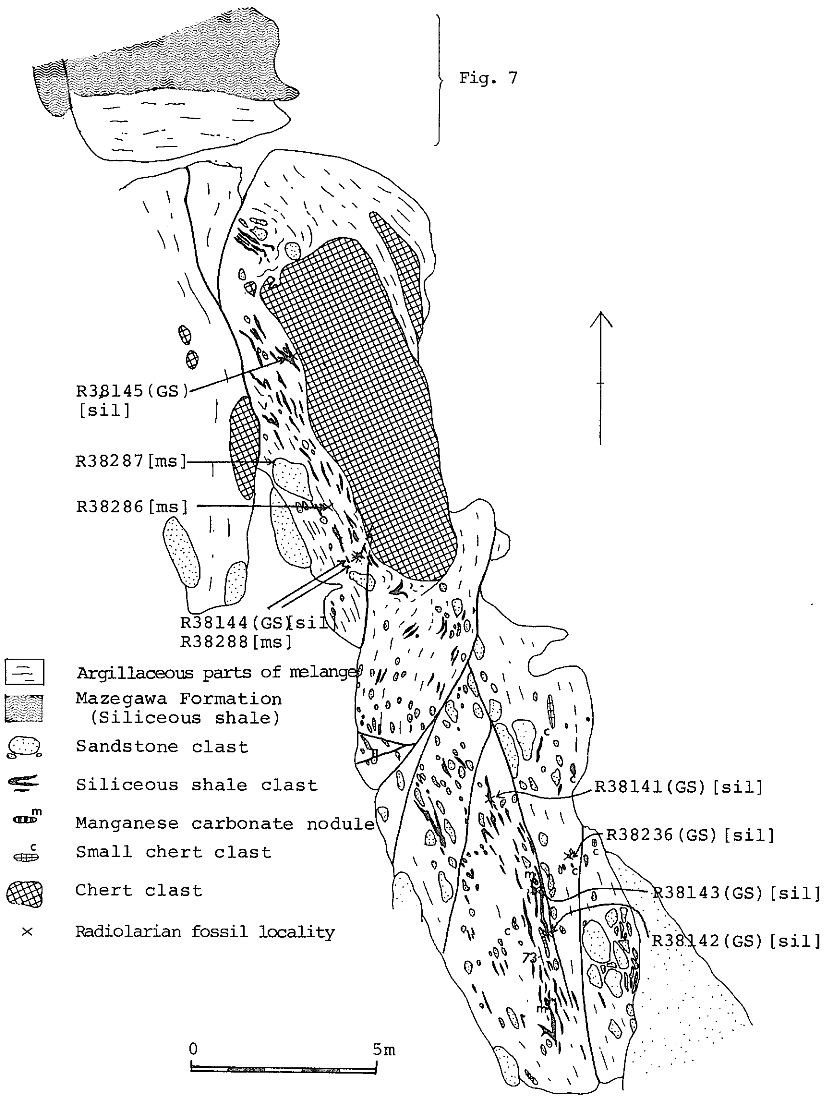

Fig. 3 Occurrence of the melange in the Okukanayama route (map showing a part of Fig. A-5). Symbols of rock types are the same as those in Fig. 2.

Some samples of argillaceous parts of the melange yield radiolarians of the *Gongylothorax sakawaensis* — *Stichocapsa naradaniensis, Pseudodictyomitra primitiva*—*Pseudodictyomitra* sp. A, and *Pseudodictyomitra* cf. *carpatica* Assemblages (Table 2), ranging in age from early Late Jurassic to earliest Cretaceous. The samples contain not only clayey part (true shale matrix) but also small clasts and fragments of siliceous shale, some of which can be observed only under the microscope. The siliceous shale clasts and fragments yield a number of well-preserved radiolarians. In thin section, radiolarians in shale matrix are also well-preserved, but are small in amount. The radiolarians in the argillaceous parts of the melange show a very close affinity to those of the siliceous shale clasts and slabs which are apparently enclosed in shale matrix, and so most of the radiolarians must have been extracted from siliceous shale clasts and fragments rather than from shale matrix. No diagnostic species indicating Late Cretaceous age is obtained from the argillaceous parts of the melange. Therefore, the age of true matrix of the melange must be earliest Cretaceous or slightly younger.

The shale matrix is found to be inject-

Table 2 Radiolarians from argillaceous parts of the melange (shale matrix including siliceous shale clasts and fragments) in the Hida-Kanayama area.

Sample number (GSJ R)	38272	38286	38288	38293	38107	38108	38285	38088	38084	38284	38083	38081	38087	38082	38283	38287	38281	38282	38112
Locality (Fig.)	2	3	3	A4	A7	A7	A3	A3	A3	A3	A3	A3	A3	A3	A3	3	A3	A3	A6
Radiolarian assemblage or age	LJ	Pc	LJ EC	PP Pc	GS PP	LJ	GS	LJ	LJ	LJ	PP	PP Pc	Pc	Pc	LJ EC	J	J	J	J
Archaeodictyomitra cf. *apiara* (RÜST)				○															
Archaeodictyomitra minoensis (MIZUTANI)		○	○	○	○									○					
Archaeodictyomitra cf. *rigida* PESSAGNO								○				○		○		○			
Archaeodictyomitra spp.																	○		
Cinguloturris carpatica DUMITRICA				○															
Cinguloturris sp. aff. *C. carpatica* DUMITRICA		○												○					
Eucyrtidiellum nodosum WAKITA					○			○											
Eucyrtidiellum ptyctum (RIEDEL and SANFILIPPO)	○				○			○				?							
Eucyrtidiellum pyramis AITA														○					
Eucyrtidiellum sp.																			○
Hsuum brevicostatum (OZVOLDOVA)					○														
Hsuum spp.					○						○								
Mirifusus sp.										○									
Parvicingula dhimenaensis BAUMGARTNER					○														
Parvicingula spp.						○		○		○									
Protunuma japonicus MATSUOKA and YAO					○							○	○						
Pseudodictyomitra cf. *carpatica* (LOZYNYAK)														○					
Pseudodictyomitra leptoconica (FOREMAN)												○							
Pseudodictyomitra primitiva MATSUOKA and YAO				○	○				?		○								
Pseudodictyomitra sp. aff. *P. primitiva* MATSUOKA and YAO													○						
Pseudodictyomitra(?) sp. *D.* MATSUOKA and YAO	○			○				○				○							
Pseudodictyomitra spp.						○		○	○	○				○					
Ristola altissima (RÜST)								○											
Sethocapsa sp. aff. *S. uterculus* (PARONA)												○							
Stichocapsa cf. *naradaniensis* MATSUOKA							○												
Stylocapsa catenarum MATSUOKA					○														
Tanarla conica (ALIEV)			○	○	○														
Tricolocapsa plicarum YAO																			○
Tricolocapsa spp.		○	○	○						○		○		○	○	○	○	○	
Williriedellum cf. *crystallinum* DUMITRICA				○								○		○	○				
Xitus gifuensis MIZUTANI		○				○		?			○								

[Radiolarian assemblage and age]
J : Jurassic, LJ : Late Jurassic, EC : earliest Cretaceous, GS : *Gongylothorax sakawaensis—Stichocapsa naradaniensis* Assemblage, PP : *Pseudodictyomitra primitiva—Pseudodictyomitra* sp. A Assemblage, Pc : *Pseudodictyomitra* cf. *carpatica* Assemblage.

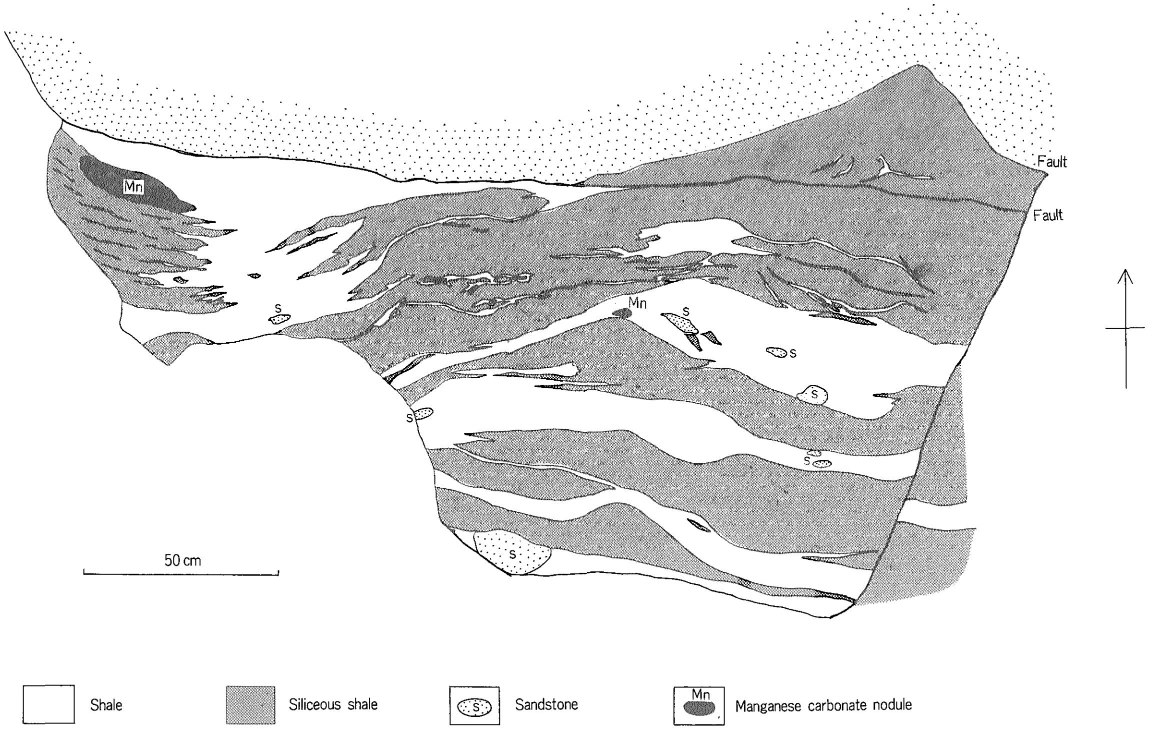

Fig. 4 Shale injections into a siliceous shale clast. The injections cut the lamination of the siliceous shale with sharp boundaries (Plate I–4).

ed into cracks and fractures in the outer part of the clasts, thus giving an impression of extreme mobility (Fig. 4). Some clasts of sandstone and siliceous shale were "frozen" in the process of breaking up into smaller fragments.

Shale is injected especially into siliceous shale clasts, is usually accompanied with relatively smaller inclusions of sandstone and chert, and cuts the lamination and bedding of siliceous shale at a slightly oblique angle (Plate I–4).

2. Clast

The clasts consist mainly of sandstone, siliceous shale and chert with minor basalt. They exhibit a wide range of size from a millimeter to several kilometers, and have diverse shapes such as lenticular, rhombic, hexagonal and subrounded (Fig. 5). Most of the clasts are elongated parallel to the foliation of the matrix. Some of sandstone and siliceous shale clasts show pinch-and-swell structure, prominent necking and wispy termination (Fig. 5). Although clasts are mixed and dispersed in matrix, mappable siliceous shale clasts tend to be arranged almost at the same horizon, from Nakagiri through Okukanayama to Funeno (Fig. 2).

Siliceous rock clasts such as chert and siliceous shale are very common in the melange. Their size varies from one centimeter to several kilometers. Most of the km-order slabs are composed of both chert and siliceous shale.

Chert consists essentially of microcrystalline quartz with radiolarian skeletons, and is mostly light to dark gray,

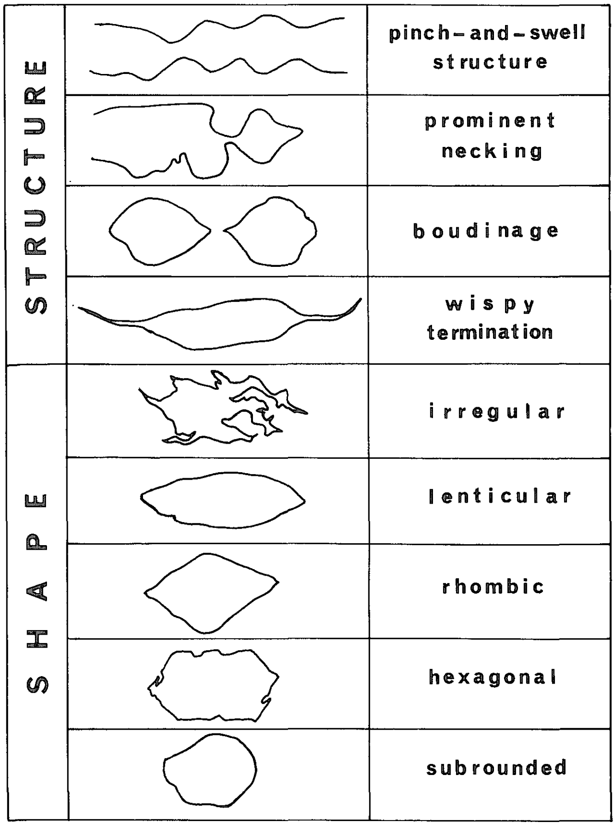

Fig. 5 Shapes and structures of clasts in the melange. The clasts in the melange of the study area have diverse shapes. Common shapes and structures are figured.

sometimes pale green, pale purple or reddish brown in color. The chert formations are rhythmically bedded with shale partings, and partly interbedded with white dolostone. Bedded chert sometimes shows isoclinal foldings whose wave length is several meters. Chert in clasts yields diagnostic radiolarians (Table 3). These radiolarians include: *Archaeospongoprunum* (?) *hellenicum* DE WEVER, *Triassocampe* spp. and *Capnuchosphaera* (?) sp. with a range of Middle to Late Triassic age; *Parahsuum* cf. *simplum* YAO, *Katroma* spp. and *Bagotum* (?) sp. of Early Jurassic age; *Hsuum* cf. *hisuikyoense* ISOZAKI and MATSUDA, *Guexella nudata* (KOCHER), and *Dicolocapsa conoformis* MATSUOKA of Middle Jurassic age.

Siliceous shale is one of the most common clast-type in the melange. The rock type described here as siliceous shale includes various siliceous to argillaceous rocks which contain a various amount of radiolarian tests (Table 4–7). Size and shape of the siliceous shale clasts are also variable. Common shapes are lenticular, irregular, laminae and very thin layer with wispy termination. The age of siliceous shale ranges from late Middle Jurassic (*Guexella nudata* Assemblage) to earliest Cretaceous (*Pseudodictyomitra* cf. *carpatica* Assemblage).

Clasts of sandstone are as common as those of siliceous shale and chert. Sandstone, gray to dark gray in color, is composed essentially of ill-sorted angular grains of quartz, K-feldspar, plagioclase, rock fragments and clayey matrix with a small amount of heavy minerals. Most of the quartz grains show wavy extinction. Dominant rock fragments are acidic tuff, basalt, chert, shale, acidic hypabyssal rocks and sericite-quartz schist. Commonly observed heavy minerals are muscovite, biotite, zircon, tourmaline and opaques. Some grains of quartz, plagioclase, K-feldspars and micas and some rock fragments are replaced by calcite or sericite. Most of the sandstones have more or less calcite cement. The calcite cementation is characteristic of sandstone clasts

Table 3 Middle-Late Triassic to Late Jurassic radiolarians from chert clasts in the melange of the Hida-Kanayama area.

Sample number (GSJ R)	38206	38218	38393	38225	38147	38126	38389	38128	38133	38106	38139	38140	38104	38129	38294	38292	38127	38130	38291	38290	38236	38105
Locality (Fig.)	6	2	2	2	2	A7	2	A6	A4	A7	A3	A3	A9	A6	2	A8	A7	A6	A5	A5	3	A9
Rock type	GB	GB	GB	RB	GB	GB	GB	LG	GB	LV	PB	PB	LG	LB	LG	LG	LG	LG	LV	LV	LV	LG
Radiolarian assemblage or age	TR	TR	TR	TR	TR	TR	EJ	EJ	EJ	EJ	MJ	J	J	J	J	J	Gn	Gn	Gn	Gn	Gn	LJ
Archaeodictyomitra cf. *apiara* (RÜST)																				○		
Archaeodictyomitra cf. *rigida* PESSAGNO										○												
Archaeodictyomitra spp.															○				○			○
Archaeospongoprunum (?) hellenicum DE WEVER					○																	
Archaeospongoprunum spp.							○															
Bagotum (?) sp.							○															
Capnuchosphaera sp.					?	?																
Canoptum triassicum YAO				○																		
Dicolocapsa conoformis MATSUOKA																	○					
Eucyrtidiellum cf. *ptyctum* (RIEDEL and SANFILIPPO)																○						
Eucyrtidiellum pustulatum BAUMGARTNER																					○	
Eucyrtidiellum unumaense (YAO)											○						○				○	
Eucyrtidiellum spp.				?							○							○	○			
Guexella nudata (KOCHER)																		○				
Hsuum brevicostatum (OZVOLDOVA)																		○			○	
Hsuum cf. *hisuikyoense* ISOZAKI and MATSUDA										○												
Hsuum maxwelli PESSAGNO																	○			○	○	
Hsuum sp.											○	○		○								
Katroma spp.							○															
Pachus sp.					○																	
Palaeosaturnalis sp.						○																
Parahsuum simplum YAO							○															
Parahsuum spp.							○	○	○		○											
Parvicingula dhimenaensis BAUMGARTNER																					○	
Praeoconocaryomma sp.													?		○							
Poulpus (?) sp. A YAO *et al.*				○																		
Protunuma turbo MATSUOKA											?						○					
Protunuma (?) ochinensis MATSUOKA																		○				
Stichocapsa cf. *robusta* MATSUOKA																						○
Stylocapsa catenarum MATSUOKA																					○	
Stylocapsa oblongula KOCHER																	○		○		○	
Stylocapsa tecta MATSUOKA																					○	
Triasocampe spp.	○	○																				
Tricolocapsa conexa MATSUOKA																	○	○		○		
Tricolocapsa sp. aff. *T. fusiformis* YAO																	○					
Tricolocapsa plicarum YAO										○									○		○	
Tricolocapsa spp.									○			○		○				○				
Trillus sp.							○		?													
Tripocyclia sp.			○																			
Xitus sp.																						○

[Radiolarian assemblage and age]
TR : Triassic, J : Jurassic, EJ : Early Jurassic, MJ : Middle Jurassic, LJ : Late Jurassic, Gn : *Guexella nudata* Assemblage
[Rock type]
GB : Gray bedded chert, LB : Light gray bedded chert, PB : Pale purple bedded chert, RB : Reddish brown bedded chert, LG : Light gray chert in small clasts, LV : Light gray highly siliceous shale in small clasts.

particularly in the "pebbly siliceous shale".

Sandstone clasts are mostly less than 1 m in diameter, but there are some larger blocks and slabs more than 1 km long composed of massive sandstone or bedded turbidite which show pinch-and-swell structure, boudinage and slump folding in some cases. At Torose, massive coarse-grained sandstone is interbedded with thick laminated shale. Some sandstone beds show distinct sedimentary structures such as graded bedding, sole markings, and parallel or cross lamination.

Sandstone clasts less than 1 m in diameter have various shapes such as hexagonal, rhombic or lenticular. Some

Table 4 Late Middle Jurassic (*Guexella nudata* Assemblage) to early Late Jurassic (*Gongylothorax sakawaensis—Stichocapsa naradaniensis* Assemblage) radiolarians from siliceous shale clasts in the melange of the Hida-Kanayama area.

Sample number (GSJ R)	38220	38384	38387	38388	38153	38138	38276	38143	38275	38278	38144	38392	38145	38157	38142	38141
Locality (Fig.)	2	2	2	2	A2	A3	A3	3	A3	A3	3	A2	3	A3	3	3
Rock type	GM	GF	GF	GF	LL	LL	GM	LL	GM	BS	LL	LL	LL	GM	LL	LL
Radiolarian assemblage	Gn	Gn	Gn	Gn	GS	GS	GS	GS	GS	GS	GS	GS	GS	GS	GS	GS
Archaeodictyomitra cf. *apiara* (RÜST)										○			?			
Archaeodictyomitra cf. *rigida* PESSAGNO		○	○					○			○	○	○		○	
Archaeodictyomitra spp.				○										○		
Archaeospongoprunum spp.												○	○			
Canoptum spp.	○	○						○								○
Cinguloturris carpatica DUMITRICA			○				○	?	○							
Cyrtocapsa sp. A MATSUOKA												○	○	○		
Dictyomitrella (?) cf. *kamoensis* MIZUTANI and KIDO		○		○									○			
Eucyrtidiellum nodosum WAKITA		○			○		○	○						○		○
Eucyrtidiellum ptyctum (RIEDEL and SANFILIPPO)					○			○							○	○
Eucyrtidiellum pustulatum BAUMGARTNER													○			
Eucyrtidiellum unumaense (YAO)		○		?												
Eucyrtidiellum spp.			○	○					○	○	○	○			○	
Foremanella sp.						○										
Gongylothorax sakawaensis MATSUOKA														○		
Hsuum brevicostatum (OZVOLDOVA)	○				○	○	○	○		○				○		
Hsuum maxwelli PESSAGNO					○		○	○	○	○		○	○	○	○	○
Hsuum spp.				○		○						○				
Mirifusus baileyi PESSAGNO															○	
Mirifusus fragilis BAUMGARTNER						○	○		○							○
Parahsuum spp.													○			○
Parvicingula dhimenaensis BAUMGARTNER								○	○	?		○	○			○
Parvicingula cf. *mashitaensis* MIZUTANI														○		○
Podobursa spp.										○		○				
Praeoconocaryomma spp.												○				
Protunuma spp.			○		○										○	
Protunuma (?) *ochinensis* MATSUOKA				○									○			
Pseudodictyomitra (?) sp. D MATSUOKA and YAO								○					○		○	○
Pseudoeucyrtis spp.												○		○		
Stichocapsa naradaniensis MATSUOKA									○	○		?			?	?
Stylocapsa catenarum MATSUOKA													○	○		
Stylocapsa tecta MATSUOKA		?														
Stylocapsa (?) *spiralis* MATSUOKA												○	○			
Triactoma blakei (PESSAGNO)																○
Tricolocapsa conexa MATSUOKA	○		○								○					
Tricolocapsa plicarum YAO			○		○	○	○	○		○				○	?	
Tricolocapsa spp.												○				
Williriedellum sp. A Group MATSUOKA							○	○	○		○				○	○
Zhamoidellum sp.							○									

[Radiolarian assemblage]
Gn : *Guexella nudata* Assemblage, GS : *Gongylothorax sakawaensis—Stichocapsa naradaniensis* Assemblage
[Rock type]
GF : Gray laminated siliceous shale at Funeno, GL : Gray laminated siliceous shale yielding trace fossils, GM : Gray massive siliceous shale, LL : Light gray siliceous shale in lenticular clasts, BS : "Blended siliceous shale".

Table 5 Middle Late Jurassic (*Tricolocapsa yaoi* Assemblage), latest Jurassic (*Pseudodictyomitra primitiva—Pseudodictyomitra* sp. A Assemblage) and earliest Cretaceous (*Pseudodictyomitra* cf. *carpatica* Assemblage) radiolarians from siliceous shale clasts in the melange of the Hida-Kanayama area.

Sample number (GSJ R)	38207	38208	38209	38205	38212	38213	38214	38203	38204	38210	38295	38135	38114	38090	38224	38201	38215	38152	38211	38080	38134
Locality (Fig.)	6	6	6	6	6	6	6	2	6	6	A2	A4	A5	A3	6	2	6	A3	6	A3	A4
Rock type	GR	GR	GR	GR	GR	GR	GR	GM	GR	GR	GM	GM	AS	BS	LS	GL	GR	GL	GR	LS	GL
Age	Ty	Ty	Ty	Ty	PP	PP	PP	PP	PP	PP	PP	PP	PP	PP	PP	PP	Pc	Pc	Pc	Pc	Pc
Acaeniotyle spp.									○												
Amphibrachium sp.		○																			
Archaeodictyomitra cf. *apiara* (RÜST)													○							○	
Archaeodictyomitra minoensis (MIZUTANI)					○		○	○				○	○		○		○	?	○	○	○
Archaeodictyomitra cf. *rigida* PESSAGNO																					○
Archaeodictyomitra spp.	○	○						○													
Archaeospongoprunum imlayi PESSAGNO					○	○		○	○	○				○							
Archaeospongoprunum sp.		○																			
Cinguloturris carpatica DUMITRICA	?	○	○	○	○	○			○	○			○	○		?					
Cinguloturris sp. aff. *C. carpatica* DUMITRICA																	○		○	○	○
Dictyomitrella (?) sp. aff. *D(?). kamoensis* MIZUTANI and KIDO													○								
Emiluvia spp.						○	○														
Eucyrtidiellum nodosum WAKITA	○			○																	
Eucyrtidiellum pyramis AITA																		○	○	○	○
Eucyrtidiellum sp. aff. *E. pyramis* AITA																				○	
Eucyrtidiellum ptyctum (RIEDEL and SANFILIPPO)	○			○		○	○	○	○		○	○	○	○							
Hsuum maxwelli PESSAGNO	○			○																	
Hsuum spp.										○			○								
Mirifusus baileyi PESSAGNO					○	○	○	○	○	○		○	○	○	○	○	○		○		
Mirifusus mediodilatatus (RÜST)	○			○	○					○									○		
Mirifusus sp.											○										
Pantanellium sp.				○									○								
Parvicingula dhimenaensis BAUMGARTNER					○	○			○	○			○								
Parvicingula mashitaensis MIZUTANI	○	○	○		○	○	○	○	○	○			○		○		○			○	○
Podobursa spp.	○	○	○		○	○		○					○		○				○		
Protunuma japonicus MATSUOKA and YAO					○	○	○	?		○	○	○	○	○	○	○			○		
Pseudodictyomitra cf. *carpatica* (LOZYNYAK)																			○		
Pseudodictyomitra leptoconica (FOREMAN)																	○				?
Pseudodictyomitra okamurai MIZUTANI						○	○	○	○	○	○	○									
Pseudodictyomitra primitiva MATSUOKA and YAO									○	○						○		○		○	○
Pseudodictyomitra spp.	○		○		○													○	○	○	
Pseudodictyomitra (?) sp. D MATSUOKA and YAO		○	○	○									○		○					○	
Pseudoeucyrtis reticularis MATSUOKA												○									
Pseudoeucyrtis spp.								○		○									○		
Ristola altissima (RÜST)					○				○								○				
Sethocapsa sp. aff. *S. uterculus* (PARONA)																				○	
Solentryma (?) sp.												○	○								
Spongocapsula spp.								○			○				○					○	
Thanarla cf. *conica* (ALIEV)												○	○							○	
Thanarla cf. *pulchra* (SQUINABOL)																			○		
Thanarla spp.																			○	○	○
Triactoma blakei (PESSAGNO)					○	○			○	○		○			○						
Tricolocapsa cf. *yaoi* MATSUOKA	○																				
Tricolocapsa spp.		○	○	○						○		○	○							○	
Williriedellum sp. A Group MATSUOKA	○			○																	
Williriedellum cf. *crystallinum* DUMITRICA													○		○						
Xitus gifuensis MIZUTANI					○	○			○	○			○			○				○	
Xitus sp.				○																	

[Radiolarian assemblage]
Ty : *Tricolocapsa yaoi* Assemblage, PP : *Pseudodictyomitra primitiva—Pseudodictyomitra* sp. A Assemblage, Pc : *Pseudodictyomitra* cf. *carpatica* Assemblage
[Rock type]
AS : A small gray siliceous shale clast in shale injection, GR : Gray bedded siliceous shale, GL : Gray laminated siliceous shale yielding trace fossils, GM : Gray massive siliceous shale, LS : Light gray siliceous siltstone in lenticular clasts, BS : "Blended siliceous shale".

Table 6 Radiolarians from "pebbly siliceous shale" in the melange of the Hida-Kanayama area.

Sample number (GSJ R)	38228	38226	38219	38099	38100	38101	38102	38202	38223	38216	38217	38148	38150	38149	38098	38123	38109	38146	38124
Locality (Fig.)	2	2	2	A9	A8	A8	2	2	2	2	2	2	2	2	A10	A8	A7	2	A4
Radiolarian assemblage or age	GS	LJ	LJ	LJ	LJ	J	J	LJ	LJ	PP	PP	J	PP Pc	Pc	LJ	J	J	LJ	J
Archaeodictyomitra minoensis (MIZUTANI)								O						O					
Archaeodictyomitra spp.															O	O	O		O
Canoptum sp.					O														
Cinguloturris carpatica DUMITRICA													O						
Cyrtocapsa sp. A MATSUOKA		?																	
Dictyomitrella (?) sp. aff. *D(?). kamoensis* MIZUTANI and KIDO														O					
Eucyrtidiellum ptyctum (RIEDEL and SANFILIPPO)			O	O															
Eucyrtidiellum pyramis AITA and OKADA														O					
Eucyrtidiellum sp.					O	O										O			
Hsuum brevicostatum (OZVOLDOVA)				?	O			O											
Hsuum sp.						O	O												
Mirifusus baileyi PESSAGNO					O				O	O									
Mirifusus mediodilatatus (RÜST)					O														
Orbiculiforma(?) kanayamaensis MIZUTANI											O								
Parvicingula dhimenaensis BAUMGARTNER			O		O														
Parvicingula sp. aff. *P. cosmoconica* (FOREMAN)													O						
Podobursa spp.					O														
Protunuma japonicus MATSUOKA and YAO														O					
Pseudodictyomitra okamurai MIZUTANI											O								
Pseudodictyomitra primitiva MATSUOKA and YAO													O						
Pseudodictyomitra spp.				?										O	?				
Pseudodictyomitra(?) sp. D MATSUOKA and YAO														O				O	
Stichocapsa cf. *naradaniensis* MATSUOKA		O																	
Stylocapsa(?) spiralis MATSUOKA	O																		
Thanarla sp.														O					
Tricolocapsa plicarum YAO or *T. conexa* MATSUOKA						O	O	O				O							
Tricolocapsa spp.										O					O		O	O	O
Williriedellum cf. *crystallinum* DUMITRICA							?							O					
Xitus gifuensis MIZUTANI										O	O			O					

[Radiolarian assemblage and age]
J : Jurassic, LJ : Late Jurassic, GS : *Gongylothorax sakawaensis—Stichocapsa naradaniensis* Assemblage, PP : *Pseudodictyomitra primitiva—Pseudodictyomitra* sp. A Assemblage, Pc : *Pseudodictyomitra* cf. *carpatica* Assemblage.

of the clasts are oriented parallel to the trends of elongated siliceous shale clasts or the foliation of the matrix.

Basalt clasts are much less common than clasts of the other rock type in the melange, and are found mostly near the Mazegawa Formation (Fig. A-3). Most of them are small (less than 1 m across) ; the largest one (3 m across) is associated with a small chert inclusion. The basalt lava clasts are usually lenticular or subrounded, whereas tuff clasts are irregular in shape and elongate subparallel to the foliation of the melange matrix. The basalt lavas consist of groundmass and microphenocrysts of plagioclase and olivine (?). Olivine (?) is fully altered and replaced by chlorite, occurring as hexagonal pseudomorphs. Rock fragments of basalt of microscopic size are also found in the melange matrix at some other localities in the Okukanayama route.

RELATIONSHIP BETWEEN AGE AND LITHOLOGY OF SILICEOUS ROCK CLASTS

Numerous well-preserved radiolarians were obtained from siliceous rock clasts in the study area (Table 3-7). The depositional age of the siliceous rocks was determined by these radiolarians, referring to the Mesozoic radiolarian biostratigraphy recently developed.

Table 7 Jurassic radiolarians from the siliceous shale clasts in the melange of the Hida-Kanayama area.
They could not be correlated with any assemblages because of their poor preservation and lack of diagnostic species.

Sample number (GSJ R)	38383	38385	38386	38390	38227	38274	38113	38137	38154	38155	38221
Locality (Fig.)	2	2	2	2	2	A3	A5	A3	A2	A2	2
Rock type	GF	GF	GF	GF	LL	LL	BS	BS	BS	GL	LL
Age	MJ	MJ	MJ	LJ	MJ	J	LJ	LJ	LJ	LJ	LJ
Archaeodictyomitra cf. *rigida* PESSAGNO	○										○
Archaeodictyomitra spp.			○								
Canoptum sp.					○						
Cinguloturris carpatica DUMITRICA											○
Eucyrtidiellum ptyctum (RIEDEL and SANFILIPPO)				○				○			
Eucyrtidiellum pustulatum BAUMGARTNER					○						
Eucyrtidiellum unumaense (YAO)	○				○						
Eucyrtidiellum spp.		○	○			○	○				
Hsuum brevicostatum (OZVOLDOVA)						○					
Hsuum spp.	?			○		○					
Parvicingula dhimenanensis PESSAGNO					○						
Pseudodictyomitra primitiva MATSUOKA and YAO										○	
Pseudodictyomitra spp.								○			
Pseudodictyomitra (?) sp. D MATSUOKA and YAO							○				
Stichocapsa sp. cf. *robusta* MATSUOKA						○					
Tanarla sp.									○		
Tricolocapsa sp. aff. *T. fusiformis* YAO		○	○		○					○	
Tricolocapsa plicarum YAO		?		○		○					
Tricolocapsa spp.				○			○			○	
Unuma sp. or *Protunuma* sp.		○									
Williriedellum sp. A Group MATSUOKA											○
Xitus sp.									○		

[Age] J : Jurassic, MJ : Middle Jurassic, LJ : Late Jurassic
[Rock type] GF : Gray laminated siliceous shale at Funeno, GL : Gray laminated siliceous shale yielding trace fossils, GM : Gray massive siliceous shale, LL : Light gray siliceous shale in lenticular clasts, BS : "Blended siliceous shale".

1. Okukanayama route

The relationship between the age and lithology of siliceous rock clasts in the Okukanayama route is as follows (Table 8) :

Triassic and Early Jurassic clasts

Triassic and Early Jurassic siliceous rock clasts consist of bedded chert. The chert is gray or dark gray and is composed of microcrystalline quartz with abundant radiolarian skeletons. The chert shows the least mud-contents among the siliceous rock clasts, and this gives a very clear appearance in thin section (Plate II-1). The structures of the radiolarian skeletons such as shapes of pores, spines and beams are completely destroyed.

late Middle Jurassic clasts

Late Middle Jurassic siliceous rock clasts are also composed of bedded chert. The chert yields radiolarians of the *Guexella nudata* Assemblage (Table 3). The chert slightly differs from that of Triassic to Early Jurassic age in color and texture under the microscope. There are two types of late Middle Jurassic chert clasts in the Okukanayama route. One is a pale purple bedded chert clast and the others are light gray variety. Only faint clay seams bound the radiolarian spheres, which are replaced by slightly coarser microcrystalline quartz than in the older cherts (Plate II-2). The shape of pores, ornamentation of shells and spines of some radiolarian skeletons are preserved.

White to light gray chert occurs in forms of small fragments, one to several centimeters in diameter. These rocks

Table 8 Geologic age and lithology of siliceous rock clasts of the melange in the Okukanayama route.

Age	Rock type	Color	Mode of occurrence	Shape or form	Abundance of radiolarians	Preservation of radiolarians	Diagnostic species or Radiolarian Assemblage
Triassic	Chert	gray - dark gray	interbedded with thinner shale	blocks(>1m)	Rock forming	Poor	*Paleosaturnalis* sp. *Capnuchosphaera(?)* sp.
Early Jurassic	Chert	gray - dark gray	interbedded with thinner shale	blocks(>1m)	Rock forming	Poor	*Parahsuum* sp. *Hsuum* cf. *hisuikyoense*
late Middle Jurassic	Chert	pale purple	interbedded with thinner shale	blocks(>1m)	Rock forming	Well	*Guexella nudata* Assemblage
late Middle Jurassic	Chert	white - light gray	massive	small (<10cm) clasts	Rock forming	Well	*Guexella nudata* Assemblage
early Late Jurassic	Siliceous shale	white - light gray	massive	irregular shaped small clasts(<30cm)	Abundant	Very well	*Gongylothorax sakawaensis* - *Stichocapsa naradaniensis* Assemblage
latest Jurassic	Siliceous shale	gray - dark gray	massive, partly bedded	blocks(>1m)	Common	Very well	*Pseudodictyomitra primitiva* - *Pseudodictyomitra* sp. A Assemblage
earliest Cretaceous	Siliceous shale	gray - dark gray	laminated(yielding trace fossils)	blocks(>1m)	Common	Very well	*Pseudodictyomitra* cf. *carpatica* Assemblage
earliest Cretaceous	Siliceous siltstone	gray	massive	lenticlular clasts	Rare	Very well	*Pseudodictyomitra* cf. *carpatica* Assemblage

Abundance of radiolarians: Rock forming = 90-100%, Abundant = 20-90%, Common = 5-20%, Rare = <5%.

consist essentially of radiolarian tests which float in the matrix composed of microcrystalline quartz and clay minerals (Plate II-3). The tests are not in contact with each other. About 20% of the radiolarian remains are well-preserved, and the tests are filled with microcrystalline quartz and mud. The shells and fillings of the other radiolarians are replaced by coarser grains of quartz, and the shape of the pores and the ornamentation of the shells are obscured.

One of the samples of light gray chert may be of Late Jurassic age, because it yields *Stichocapsa* cf. *robsta* Matsuoka and *Xitus* sp. It occurs as a small clast covered with light gray siliceous shale which is similar to the early Late Jurassic siliceous shale clasts in the Okukanayama route. The texture under the microscope is very close to that of the Triassic to Early Jurassic bedded chert. This is an exception of the siliceous rock clasts in the study area.

early Late Jurassic clasts

The early Late Jurassic radiolarians of the *Gongylothorax sakawaensis*—*Stichocapsa naradaniensis* Assemblage are contained in white to light gray siliceous shale (Table 4). The siliceous shale clasts are swirled and mixed with black argillite or with dark gray siliceous shale in the melange (Plate I-1) or in larger siliceous shale clasts. These clasts are characterized by their small size (less than 30 cm in diameter), light color and lenticular or irregular forms. The proportion of radiolarian remains is over 50% in the shale matrix (Plate II-4). The shale matrix often contains detrital grains such as quartz, feldspars and mica flakes. Radiolarian skeletons are well-preserved and filled with microcrystalline quartz and mud. Chlorite occupies the veins in siliceous shale.

latest Jurassic clast

Latest Jurassic radiolarians of the *Pseudodictyomitra primitiva—Pseudodictyomitra* sp. A Assemblage are found in dark gray to gray massive siliceous shale with intercalations of bedded siliceous shale (Table 5). This rock type constitutes the main part of the Mazegawa Formation and some other siliceous shale clasts. The siliceous shale consists of clay and clastic grains of quartz, feldspars and micas together with radiolarian remains, which form less than 10% of the rock (Plate II-5). Radiolarian skeletons are generally well-preserved. The clastic grains are smaller than 0.04 mm in diameter.

earliest Cretaceous clast

The upper part of the Mazegawa Formation is composed of gray to dark gray laminated siliceous shale with trace fossils (Plate I-3). A number of clasts of this rock type are distributed in the Okukanayama route. Earliest Cretaceous radiolarians (*Pseudodictyomitra* cf. *carpatica* Assemblage) occur in some of them (Table 5). The siliceous shale is composed mostly of clay and coarser clastic grains (0.02-0.08 mm) than Jurassic siliceous shale (Plate II-6). The lamination depends on the size of clastic grains. Radiolarian remains form about 10% in volume of the sediment. Some of the radiolarian tests are well-preserved, but the rests are more or less deformed.

One of the lenticular clasts of gray siliceous siltstone also yields earliest Cretaceous radiolarians of the *Pseudodictyomitra* cf. *carpatica* Assemblage (Table 5). This clast consists of disrupted massive siliceous siltstone with trace fossils. This rock type is composed mainly of detrital grains of 0.02-0.08 mm in diameter. It contains somewhat smaller amount (about 1%) of radiolarian remains than the above-mentioned laminated siliceous shale.

A large amount of muddy dark gray siliceous shale occurs in the melange matrix. The shale resembles shale of matrix but slightly differs from the matrix in that the shale clasts are coarser in grain size and lighter in color than clayey parts of the matrix. Although the age is unknown, this rock type may be younger than the Jurassic siliceous shale.

Judging from the above-mentioned microscopic observation on the siliceous shale whose ages are well-known by radiolarians, the siliceous rock clasts in the Okukanayama route show a gradual increase of the amount of clay minerals and detrital mineral fragments as their age becomes younger (Plate II).

2. Nakagiri and Funeno

The relationship between age and lithology is also examined at Nakagiri and Funeno.

At Nakagiri, bedded chert and bedded siliceous shale form a large composite slab in the melange (Fig. 2). One sample of the dark gray bedded chert yields Middle to Late Triassic radiolarians. Bedded chert gradually changes into gray bedded siliceous shale towards the stratigraphically higher position (Fig. 6). The bedded siliceous shale near the boundary between chert and siliceous shale yields middle Late Jurassic radiolarians of the *Tricolocapsa yaoi* Assemblage. The siliceous shale also yields latest Jurassic radiolarians of the *Pseudodictyomitra primitiwa—Pseudodictyomitra* sp. A Assemblage and earliest Cretaceous radiolarians of the *Pseudodictyomitra* cf. *carpatica* Assemblage in the stratigraphically higher position. Latest Jurassic to earliest Cretaceous bedded siliceous shale also occurs as a block in the melange (Fig. 6).

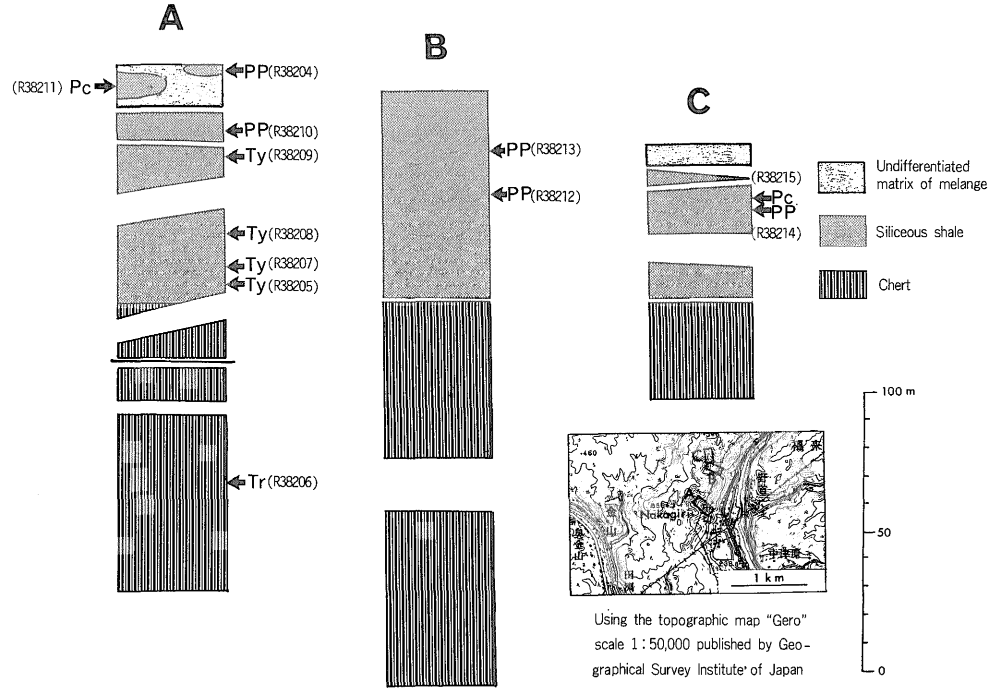

Fig. 6 Columnar sections in a large allochthonous slab at Nakagiri. The slab consists of bedded chert and bedded siliceous shale. In the A section, bedded chert gradually changes into bedded siliceous shale of middle Late Jurassic.
[Radiolarian assemblage and age]
Tr : Triassic, Ty : *Tricolocapsa yaoi* Assemblage, PP : *Pseudodictyomitra primitiva—Pseudodictyomitra* sp. A Assemblage, Pc : *Pseudodictyomitra* cf. *carpatica* Assemblage.

At Funeno, laminated siliceous shale occurs as blocks in the melange. It contains nodules or disrupted layers of manganese carbonate. The siliceous shale looks very similar to the upper part of the Mazegawa Formation, but contains obviously older radiolarians (Guexella nudata Assemblage of late Middle Jurassic, and undivided Late Jurassic) than those of the Mazegawa Formation (Tables 4, 7).

3. "Blended siliceous shale" and "Pebbly siliceous shale"

There are two types of large siliceous shale bodies in which several types of siliceous shales are mixed under unconsolidated state. They are namely "blended siliceous shale" and "pebbly siliceous shale", and occur as clasts in the melange of the study area.

"Blended siliceous shale"

"Blended siliceous shale" is a mixture of various kinds of siliceous shales ranging in color from light to dark gray. It occurs in the Okukanayama route (Figs. A-3, A-5). The mixture consists of dark gray siliceous shale with thin graded beds of gray to dark gray siliceous siltstone and intercalation of white, light gray or light brownish gray more siliceous shale lenses. The white to light gray siliceous shale is lenticular and irregularly shaped, yielding radiolarians of early Late Jurassic (*Gongylothorax sakawaensis—Stichocapsa naradaniensis* Assemblage). This rock unit exhibits variously disrupted layering and folding probably due to the soft sediment deformation.

"Pebbly siliceous shale"

"Pebbly siliceous shale" is widely distributed in the whole study area (Fig. 2), besides the Okukanayama route (Figs. A-6—A-10). It is characterized by containing sandstone clasts of 1 mm–1 m in diameter scattered in dark gray laminated siliceous shale. The siliceous shale also includes some manganese carbonate nodules. Dark gray to black shale and siltstone are often observed on surroundings of the sandstone clasts as if they were "tails" or "pressure shadows". In some places, lenticular shale with small sandstone inclusions are intervened in siliceous shale. Lenses and layers of dark gray to black shale frequently contain siliceous shale fragments. The shale layers cut the original stratification of the host siliceous shales with sharp boundaries.

The textures of this rock type are very similar to the margin of siliceous shale clasts where the shale matrix of the melange is injected. These features suggest that this rock type represents disrupted beds of siliceous shale with anastomosing subparallel injections of melange matrix which consists of dark gray shale and a small amount of sandstone clasts. Many of the thin shale injections less than 1 cm in width are deformed into lenses during compaction.

This rock type yields radiolarians of the *Gongylothorax sakawaensis—Stichocapsa naradaniensis*, *Pseudodictyomitra primitiva—Pseudodictyomitra* sp. A, and *Pseudodictyomitra* cf. *carpatica* Assemblages (Table 6), ranging in age from early Late Jurassic to earliest Cretaceous.

DISCUSSION

1. Occurrence of siliceous shale

With the progress of the radiolarian studies since the late 1970's, it became evident that Middle to Late Jurassic radiolarians from siliceous shale and manganese carbonate nodules abundantly occur in the Mino terrane (e.g. MIZUTANI *et al.*, 1981). Lithostratigraphic and biostratigraphic studies revealed that Permian limestones and Triassic cherts are allochthonous clasts or slabs in younger clastic strata, in which Middle to Late Jurassic siliceous shales are intercalated (WAKITA, 1983, 1984; WAKITA and OKAMURA, 1982). Thus, the depositional age of the sedimentary complex in the Mino terrane was thought to be Jurassic age.

Are the siliceous shales in the Mino terrane autochthon? A number of siliceous shale are distributed in the melanges. Although MIZUTANI (1981), WAKITA and OKAMURA (1982), YAMAMOTO (1985) and WAKITA (1983, 1987) inferred that the siliceous shale might occur as clasts, the mode of occurrence of siliceous shale in the melanges has been obscure.

This study has revealed that some of siliceous shale strata apparently occur as clasts in the melange matrix, as they are easily observable to be enclosed in shale matrix of the melange along the Okukanayama route (e.g. Fig. A-3). But it is not easy to identify a clast in the melange if its size is larger than the outcrop. How can we regard so large siliceous shale bodies as independent clasts? The best way for the investigation seems to be the detailed observation of the boundaries between siliceous shales and shale matrix of the melange.

In the following, an example of the examination of the large siliceous shale to check whether it is a clast or not is given.

The Mazegawa Formation in the study area is one of the best studied siliceous shale sequences in the Mino terrane. Mizutani (1981) reported abundant, well-preserved tests of radiolarians, and defined the *Mirifusus baileyi* Assemblage (*Pseudodictyomitra primitiva—Pseudodictyomitra* sp. A Assemblage in this paper ; Table 1). He inferred that the Mazegawa Formation might be a clast in the surrounding melange matrix. Wakita (1987) discovered the earliest Cretaceous radiolarians in the siliceous shale clasts and argillaceous parts of the melange surrounding the Mazegawa Formation.

Mizutani (1981) showed that the top of the Mazegawa Formation is southward by observing the graded bedding of the siliceous shale. Occurrence of radiolarians of the *Pseudodictyomitra* cf. *carpatica* Assemblage at the southern part of the Formation (Fig. A-4) is consistent with the observation of Mizutani (1981). The Mazegawa Formation is in fault contact with the underlying bedded chert. The contact between the top of the Mazegawa Formation and the overlying shale of the melange matrix is not depositional, but caused by injections of shale matrix of the melange into the top of the formation (Fig. 7). Late Jurassic to earliest Cretaceous siliceous shale occurs not only in the Mazegawa Formation, but also in small clasts which are thoroughly surrounded by shale matrix of the melange in the Okukanayama route. These lines of evidence strongly suggest that the Mazegawa Formation is one of the large clasts in the melange.

It is shown in this report that siliceous shale occurs as clasts in the melange, and thus the age of the formation of melange cannot be decided by the age of siliceous shale as in the previous works in the Mino terrane. In the study area, well-preserved radiolarians were obtained from 19 samples of the argillaceous parts of the melange (Table 2). Although the argillaceous parts of the melange which look like the matrix yields early Late Jurassic to earliest Cretaceous radiolarians, the argillaceous parts consist of shale matrix and numerous siliceous shale clasts and fragments. Most of the radiolarians seem to have been extracted from the siliceous shale clasts or fragments rather than from shale matrix. Therefore, the age of shale matrix is as young as or slightly younger than earliest Cretaceous. As the melange is unconformably overlain by Late Cretaceous rhyolites, the formation of the melange occurred during Early Cretaceous time.

2. Origin of melange

The origin of the melange in this area was first discussed by Kano (1979). He called the melange "olistostrome" and gave an account of the relationship between the "olistostrome" (melange) of the Hida-Kanayama area and the thick strata in the Inuyama-Kamiaso area adjacent to the south ; in his opinion the "olistostrome" is the products of the collapse of the front of advancing "Decken" of the Inuyama-Kamiaso area.

The coherent sandstone-dominated sequence is distributed in the Inuyama-Kamiaso area (Fig. 1). The lithostratigraphy and biostratigraphy of the strata of the Inuyama-Kamiaso area was determined by Yao *et al.* (1980), Yao (1982), Mizutani and Koike (1982), Kido (1982), Kido *et al.* (1982) and Sato (1974). These studies show that the strata are com-

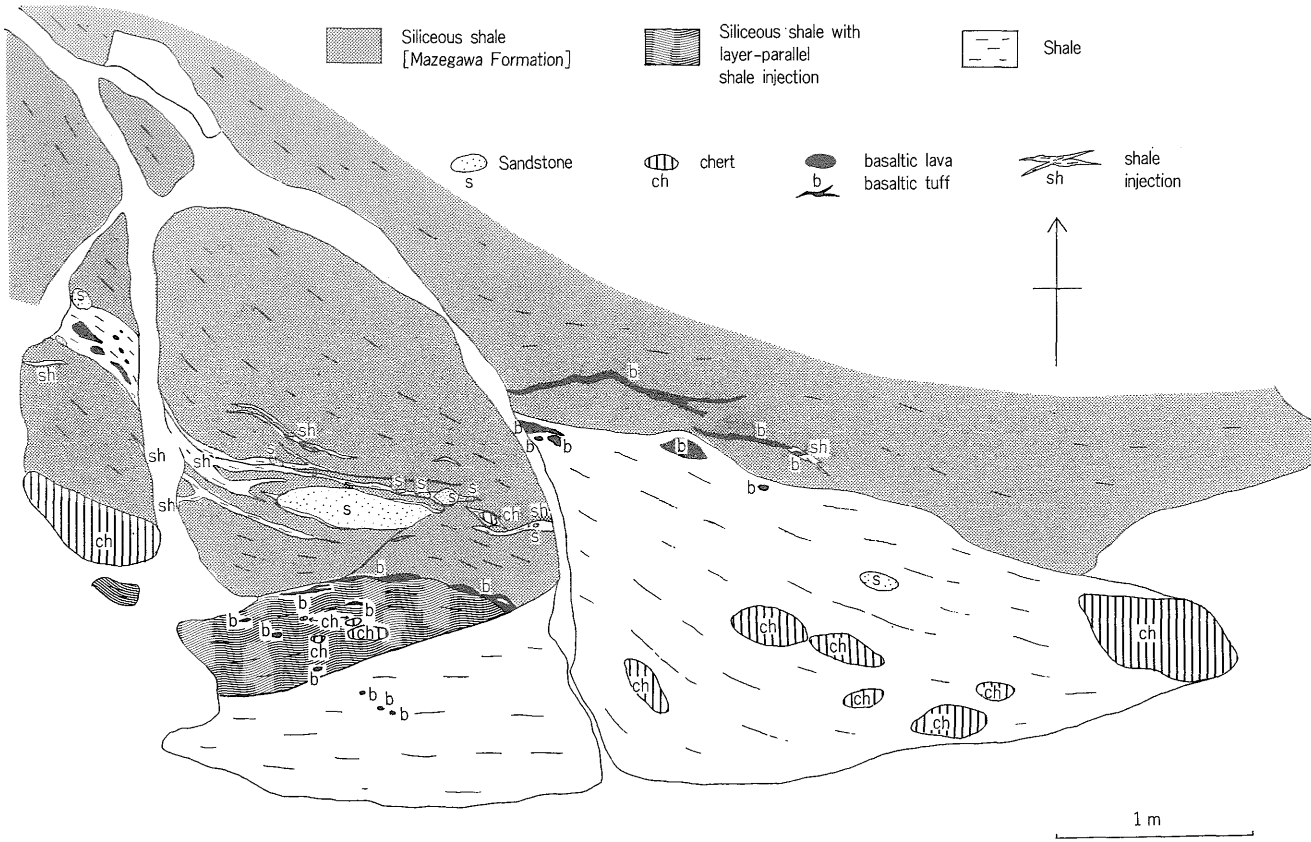

Fig. 7 Siliceous shale of the top part of the Mazegawa Formation and the overlying shale matrix of the melange at Okukanayama (see Figs. 3 and A-5).

posed of stacked slices, each of which has a common succession in ascending order as follows :

1. —chert
   of Middle Triassic to Early Jurassic age,
2. —siliceous shale
   of Middle Jurassic age,
3. —shale
   of late Middle Jurassic age
4. —massive sandstone and bedded turbidite of late Middle to early Late Jurassic age

On the other hand, the following succession is reconstructed on the basis of the lithology and age of the siliceous rock clasts in the Okukanayama route of the study area (Fig. 8).

(1) gray to dark gray bedded chert of Triassic to Early Jurassic age

(2) pale purple bedded chert and light gray chert of late Middle Jurassic age

(3) white to light gray siliceous shale of early Late Jurassic age

(4) gray to dark gray massive (partly bedded) siliceous shale of latest Jurassic age

(5) laminated siliceous shale yielding trace fossils and dark gray siliceous siltstone of earliest Cretaceous age

I believe that this is the original succession of the protolith from which the clasts in the melange were derived. The lithology from base to top exhibits a trend from siliceous to argillaceous within the succession. The microscopic observation of the siliceous rock clasts reveals that the terrigenous influence increases toward the top of the reconstructed succession ; coarser clastic grains become more common, as the age of siliceous rock clasts becomes younger (Plate II).

In the Mino terrane, most of the basaltic rocks are accompanied with Permian limestone and chert, and several examples of Triassic to Early Jurassic basalt exist (Hattori and Yoshimura, 1983 ; Wakita, 1983, 1984). As there are no criteria to distinguish Permian basalts from Mesozoic ones, it is difficult to determine the age of basalt without limestone and chert yielding fossils. Consequently it is ambiguous whether the basalt in clasts of the study area originally formed a succession with the other rock types in the clasts or not. This is the reason why the basalt is obliterated from the succession of the protolith (Fig. 8).

The succession reconstructed from the clasts in the Okukanayama route is lithologically similar to the succession of stacked coherent sequences of the Inuyama-Kamiaso area, but the age of each rock type is very different between the Hida-Kanayama area and Inuyama-Kamiaso areas (Fig. 8). This shows that the melange of the Hida-Kanayama area was not produced by collapse of the same coherent sequences as in the Inuyama-Kamiaso area.

Mizutani *et al.* (1981) reported the occurrence of radiolarians of Middle and Late Jurassic ages in siliceous shale strata of the Mino terrane. Middle Jurassic siliceous shale is widely distributed in the Mino terrane, but the distribution of the Late Jurassic one is limited to the middle part of the Mino terrane (Adachi, 1982). Although the Late Jurassic siliceous shale coexists with Middle Jurassic siliceous shale in the Neo area (Yamamoto, 1985) situated about 50 km to the west of the Hida-Kanayama area (Fig. 1), the relationship between Late Jurassic siliceous shale and Middle Jurassic one is still unknown.

Roughly speaking, the melange of the study area includes Middle Jurassic sili-

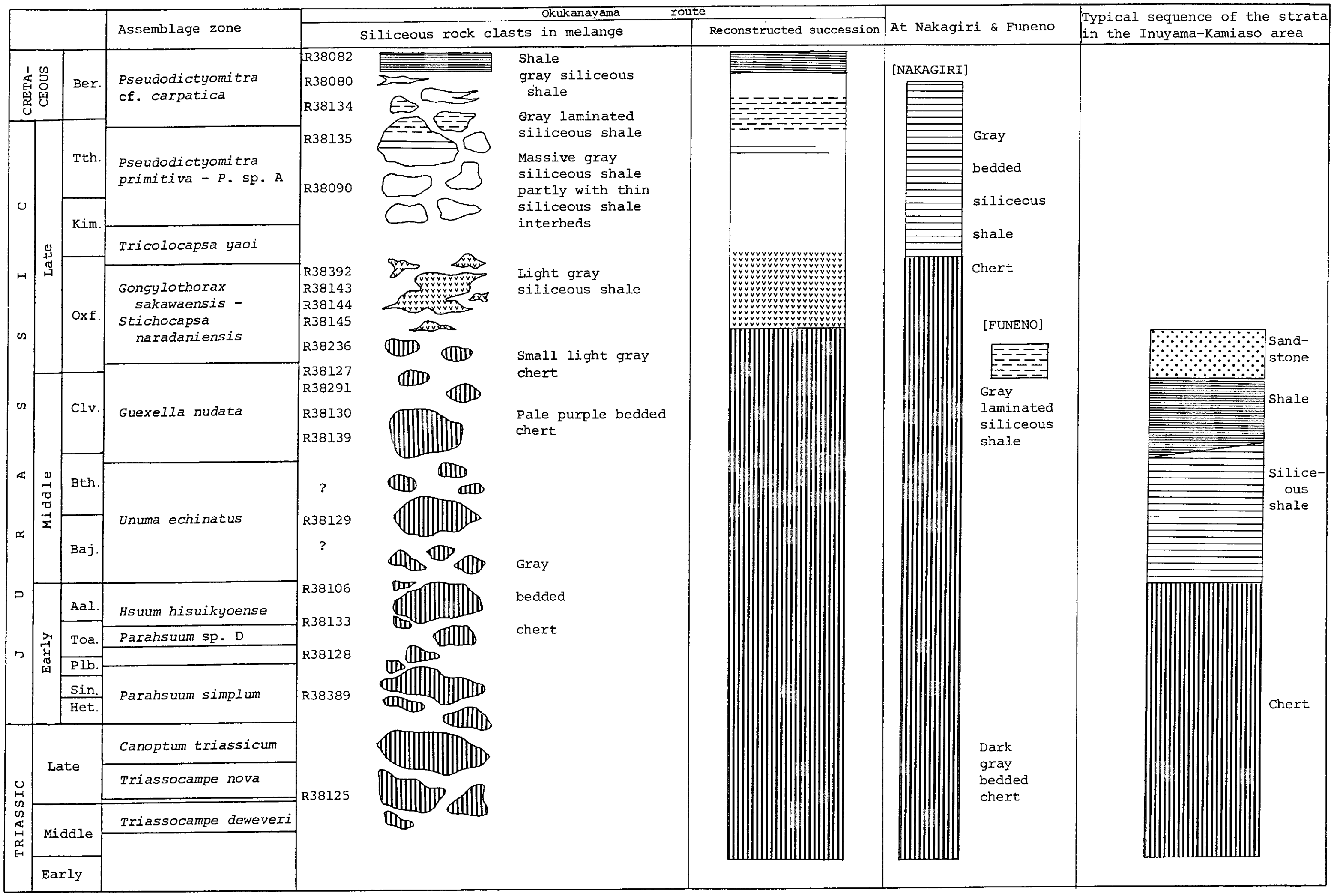

Fig. 8 Reconstruction of protolith of siliceous rock clasts of the melange.

ceous shale and Late Jurassic to earliest Cretaceous siliceous shale. But, Middle and Late Jurassic siliceous shales do not coexist at the same localities.

Late Jurassic to earliest Cretaceous siliceous shale clasts are distributed at Nakagiri, north of Uedani, and in the Okukanayama route, while those of Middle Jurassic age occur at Funeno and to the west of Okukanayama (Fig. 2).

Late Jurassic to earliest Cretaceous siliceous shale clasts do not occur together with Middle Jurassic siliceous shale clasts but with Middle Jurassic chert clasts in the Okukanayama route. On the other hand, no Late Jurassic siliceous shale clast was detached in the melange at Funeno where the clasts of Middle Jurassic siliceous shale and Early Jurassic chert occur.

The Middle Jurassic siliceous shale at Funeno is lithologically similar to that of latest Jurassic–earliest Cretaceous age. It is gray to dark gray in color, and laminated or massive (partly bedded). The shale matrix of the melange at Funeno is not so different from that of the Okukanayama route. Thus, the age of the siliceous shale clasts is different between these two localities (Fig. 8), although the lithologic features are very similar to each other in the melange at Funeno and in the Okukanayama route.

Even in the Late Jurassic siliceous shale, the rock types are diverging between at Nakagiri and in the Okukanayama route. At Nakagiri, Late Jurassic to earliest Cretaceous siliceous shale is interbedded with thinner shale. The sedimentary structures of the bedded siliceous shale are different from those of the Late Jurassic massive siliceous shale and earliest Cretaceous laminated siliceous shale of the Okukanayama route.

If the large slabs of chert or sandstone can be used as key beds or horizon markers, the Middle Jurassic siliceous shale clasts of Funeno and the Late Jurassic ones of Nakagiri and Okukanayama route are located almost at the same horizon in the melange (Fig. 2). There is no discontinuity and difference in shale matrix among three portions. These lines of evidence suggest that there were at least three different protoliths for the clasts in the melange. These protoliths must have been dislocated from different sites as large rock bodies and then broken into small clasts almost at the same time.

SUMMARY

(Ⅰ) The melange of the Hida-Kanayama area is a chaotic mixture of shale matrix and rock clasts, which consist of Middle Triassic to Late Jurassic chert, Middle Jurassic to earliest Cretaceous siliceous shale, and massive sandstone, bedded turbidite and basalt of unknown age.

(Ⅱ) The Mazegawa Formation (Mizutani, 1981) composed of latest Jurassic to earliest Cretaceous siliceous shale is one of the large clasts in the melange judging from the contact features to the surrounding rocks and the fossil evidence.

(Ⅲ) Numerous well-preserved radiolarians, ranging in age from Middle Triassic to earliest Cretaceous, are obtained from siliceous shale clasts, chert clasts and argillaceous parts (shale matrix containing siliceous shale clasts and fragments). Most of the radiolarians belong to the following five assemblages : *Guexella nudata, Gongylothorax sakawaensis*—*Stichocapsa naradaniensis, Tricolocapsa yaoi, Pseudodictyomitra primitiva*—*Pseudodictyomitra* sp. A, and

Pseudodictyomitra cf. *carpatica* Assemblages.

(IV) The following protolith succession is reconstructed from siliceous rock clasts of the melange in the Okukanayama route which is located in the central part of the study area :

(1) Triassic to Early Jurassic : gray to dark gray bedded chert
(2) late Middle Jurassic : pale purple bedded chert and light gray chert
(3) early Late Jurassic : white to light gray siliceous shale
(4) latest Jurassic : gray-dark gray massive (partly bedded) siliceous shale
(5) earliest Cretaceous : laminated siliceous shale with trace fossils, and siliceous siltstone

(V) The succession of the protolith, reconstructed from the siliceous rock clasts in the Okukanayama route of the Hida-Kanayama area, is lithologically similar to the sequence of the Inuyama-Kamiaso area to the south, but the age of each rock type is very different between the Hida-Kanayama and Inuyama-Kamiaso areas (Fig. 8). This shows that the melange of the Hida-Kanayama area was not produced by collapse of the same coherent sequences as in the Inuyama-Kamiaso area.

(VI) The lateral extensions of the rocks in the Okukanayama route are distributed at Nakagiri and Funeno. Three different protoliths are reconstructed from the clasts of the melange among the Okukanayama, Nakagiri and Funeno localities by their ages and lithology of siliceous rock clasts. These three distinct protoliths must have been dislocated from different sites as large rock bodies and then broken into small clasts almost at the same time.

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飛騨金山地域の白亜紀前期のメランジ

脇 田 浩 二

要 旨

美濃帯中央部の飛騨金山地域には泥質基質に砂岩・珪質頁岩・チャートなどの岩塊を含むメランジが広く分布している．本地域に従来報告されていたジュラ紀後期の馬瀬川層（珪質頁岩層）は，周囲の岩石との関係や産出化石から判断して，メランジ中の孤立岩塊であることが明らかになった。馬瀬川層の分布する奥金山において詳細なルートマップを作成するとともにメランジ中の珪質岩塊や泥質部から数多くの放散虫化石を抽出し，メランジをもたらした原岩の層序を復元した．復元された層序は，三畳紀-ジュラ紀中期のチャート及びジュラ紀後期-白亜紀最前期の珪質頁岩からなり，隣接する犬山-上麻生地域の地層とは地質年代に大きな隔たりがある．従って，本地域のメランジは犬山-上麻生地域の地層群が崩壊して形成されたのではないことが判明した．

奥金山とほぼ同層準に位置する中切や舟野においては奥金山とは岩相ないし時代の異なる珪質頁岩岩塊がメランジ中に含まれている．このことは，原岩の層序が若干異なる複数のスラブが移動してきて集まり，そののちに分裂してメランジを形成したことを反映している．珪質頁岩岩塊や珪質頁岩の岩塊を含む泥質部には白亜紀最前期の放散虫化石を産し，本地域のメランジが白亜紀後期の濃飛流紋岩類に不整合に覆われているので，メランジの形成年代は白亜紀前期と推定できる．

（受付：1987年10月14日；受理：1988年1月28日）

Appendix I

Route maps along the Okukanayama route

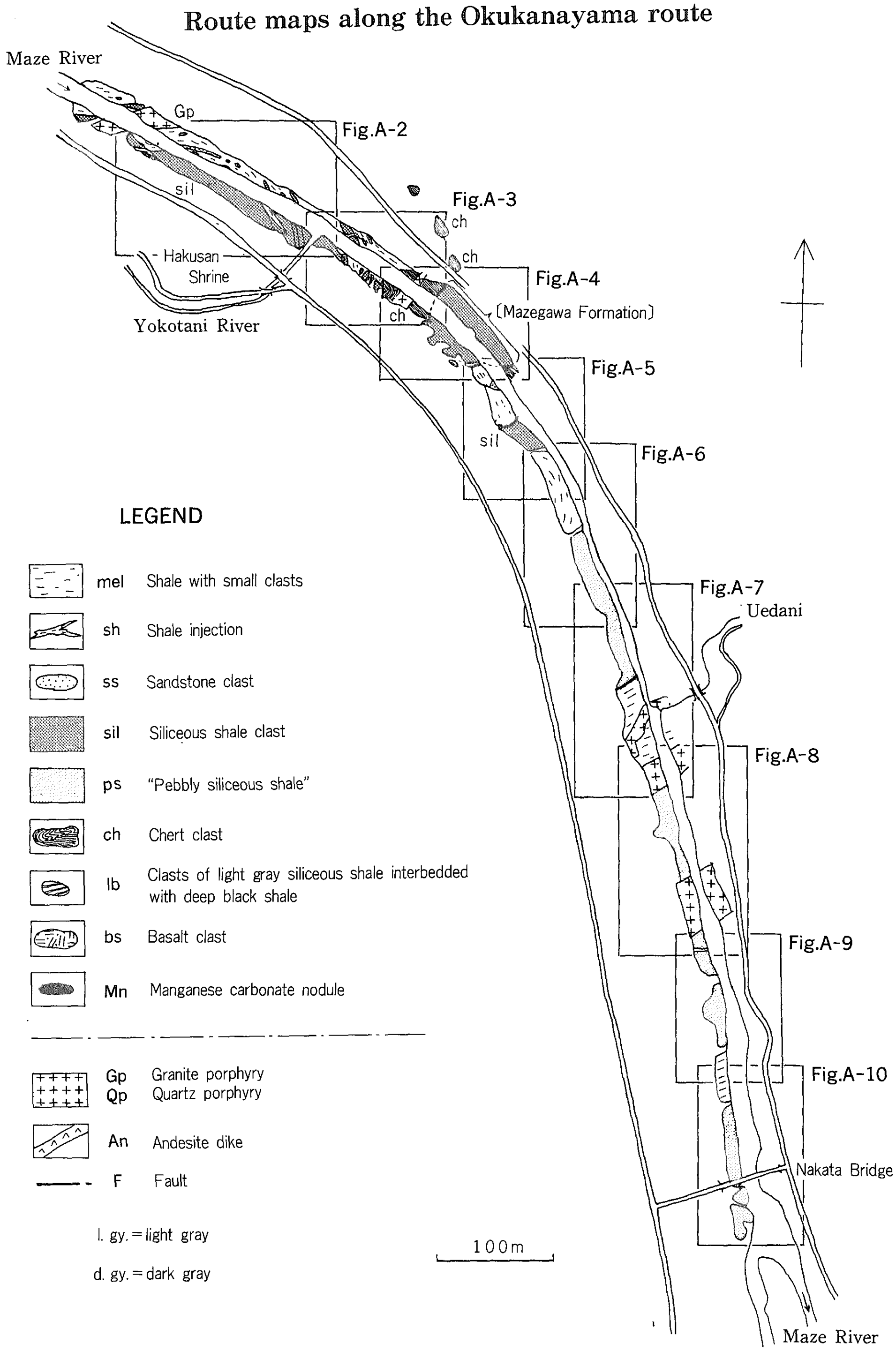

Fig. A-1 Index map showing route maps (Figs. A-2—A-10) along the Okukanayama route. For location of the route see Fig. 2.

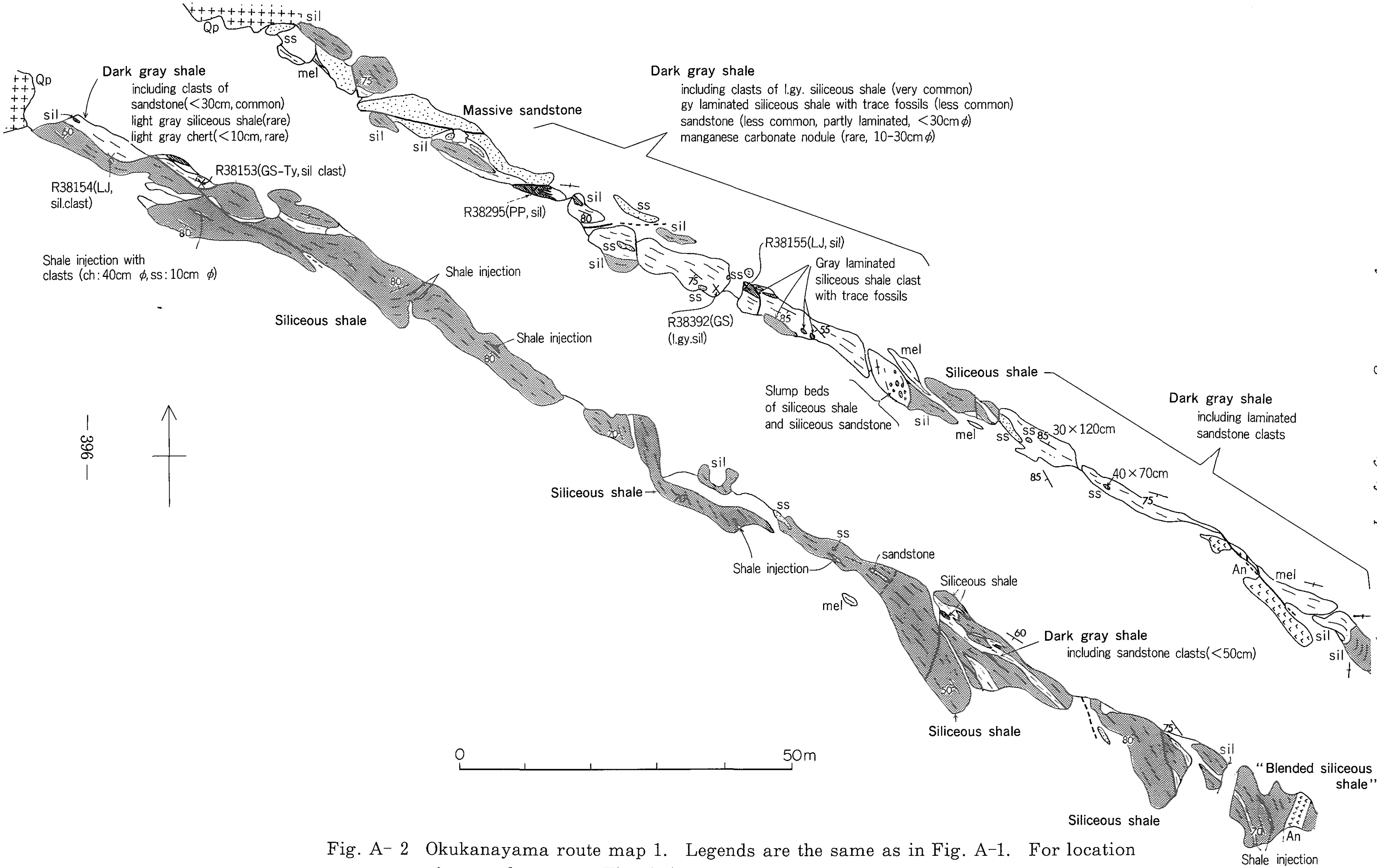

Fig. A- 2 Okukanayama route map 1. Legends are the same as in Fig. A-1. For location of mapped area, see Fig. A-1.

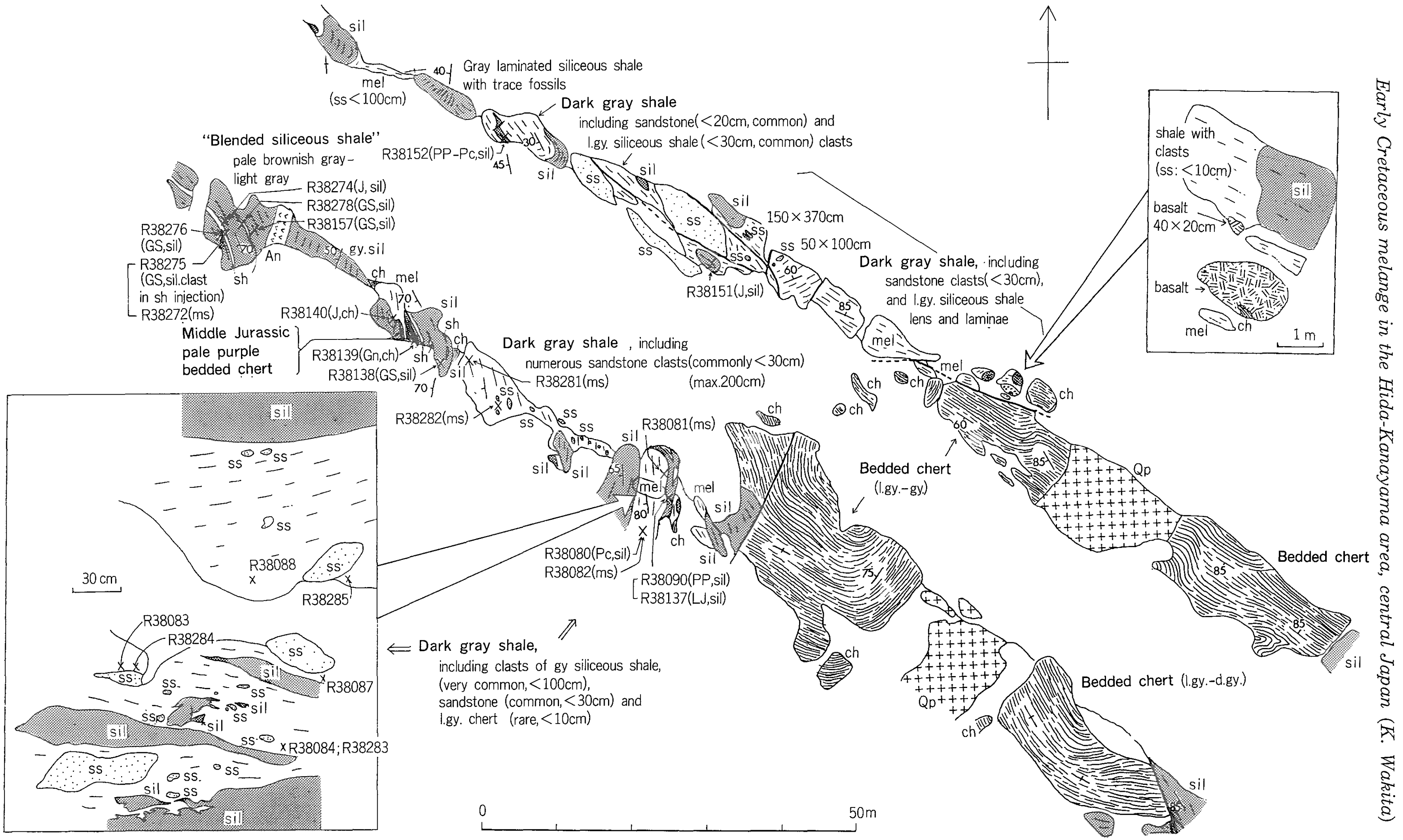

Fig. A- 3 Okukanayama route map 2. Legends are the same as in Fig. A-1. For location of mapped area, see Fig. A-1.

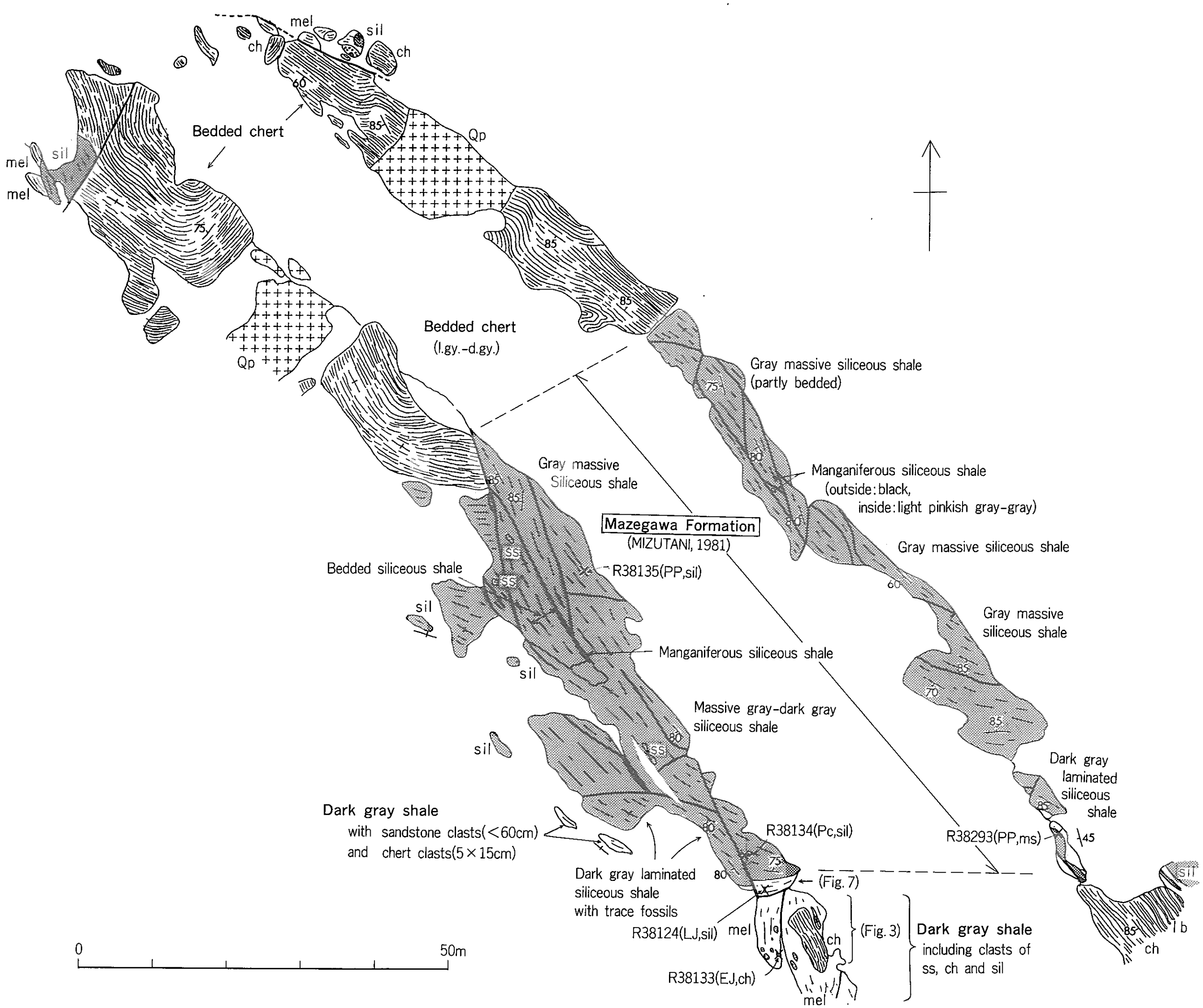

Fig. A- 4 Okukanayama route map 3. Legends are the same as in Fig. A-1. For location of mapped area, see Fig. A-1.

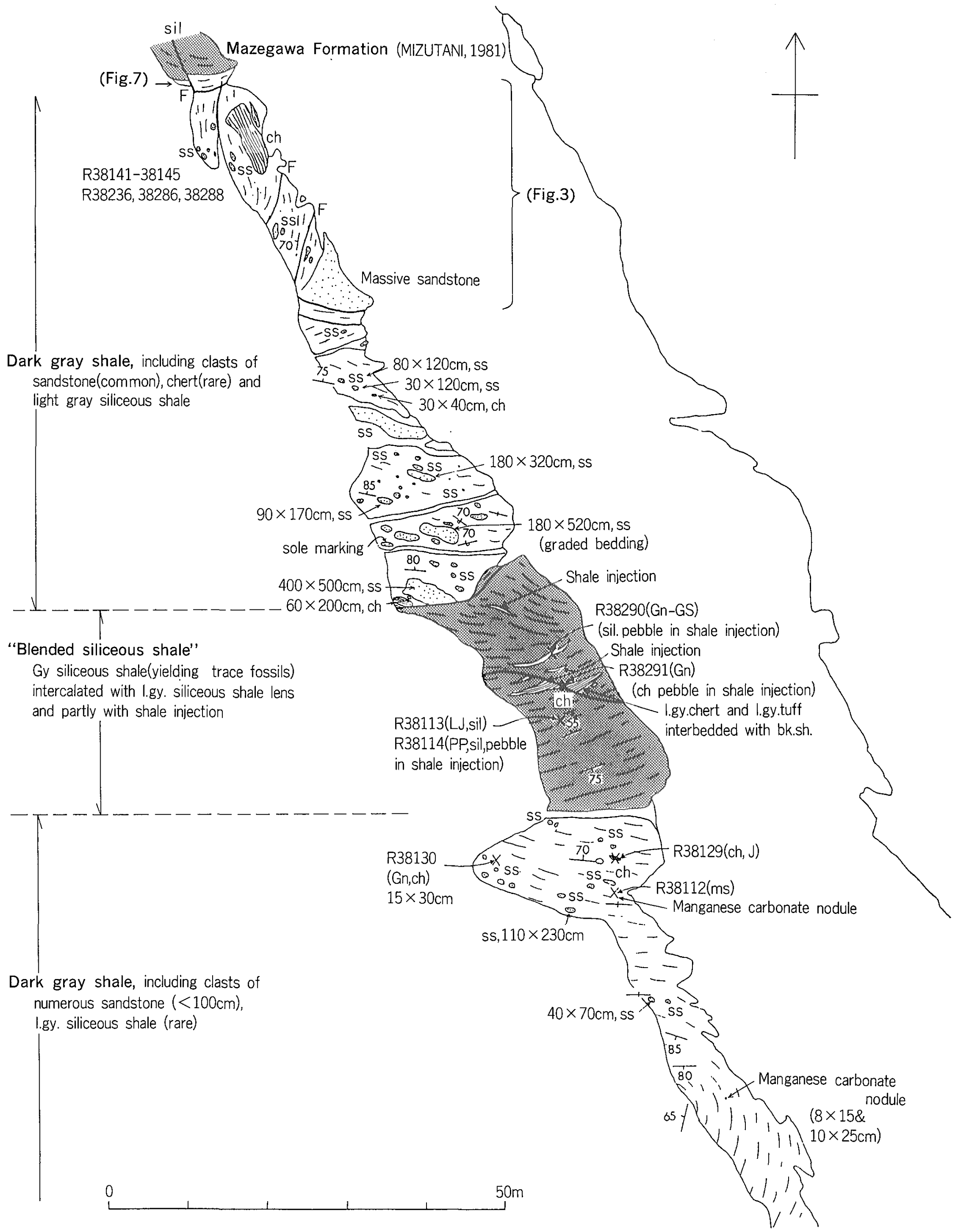

Fig. A- 5 Okukanayama route map 4. Legends are the same as in Fig. A-1. For location of mapped area, see Fig. A-1.

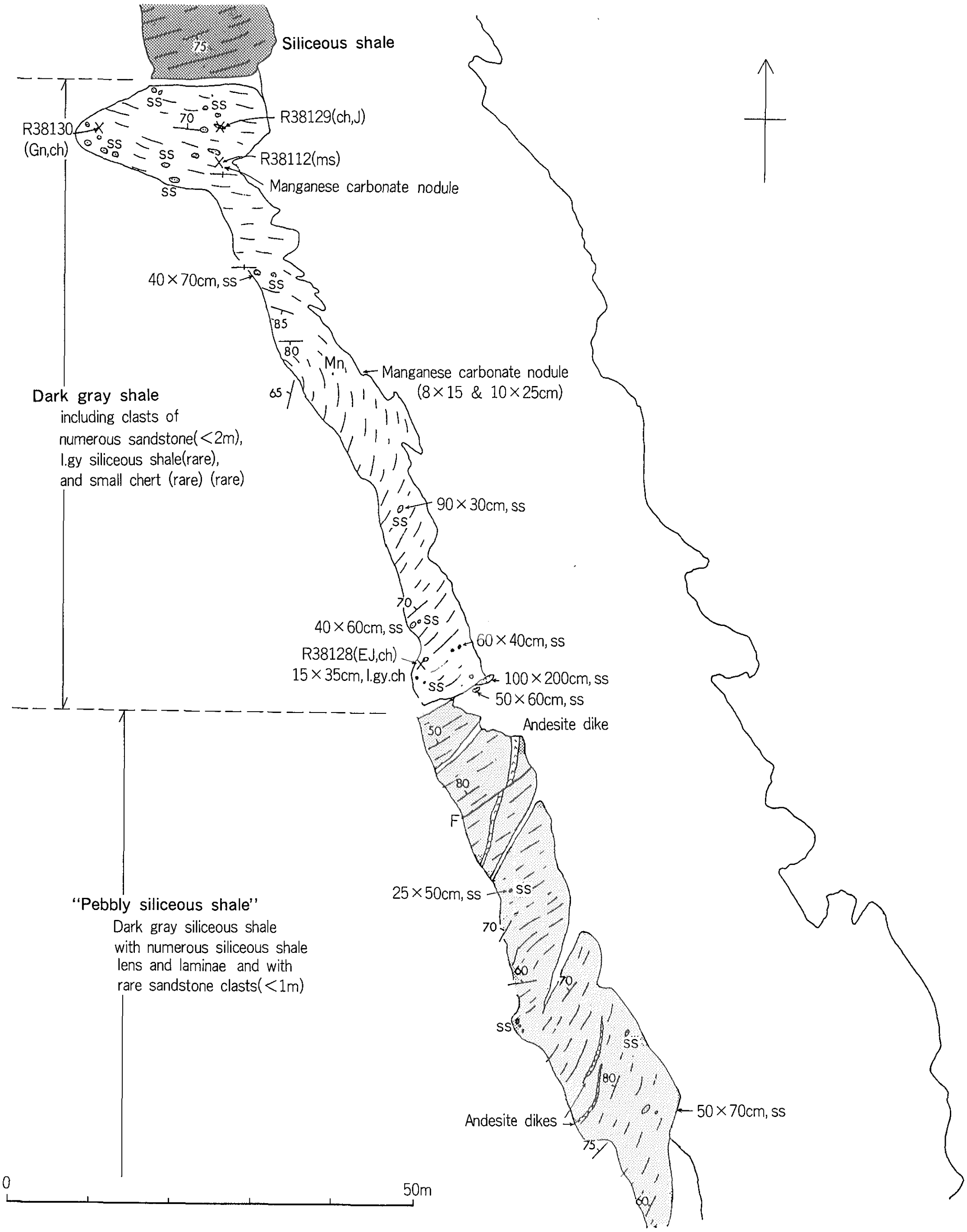

Fig. A- 6 Okukanayama route map 5. Legends are the same as in Fig. A-1. For location of mapped area, see Fig. A-1.

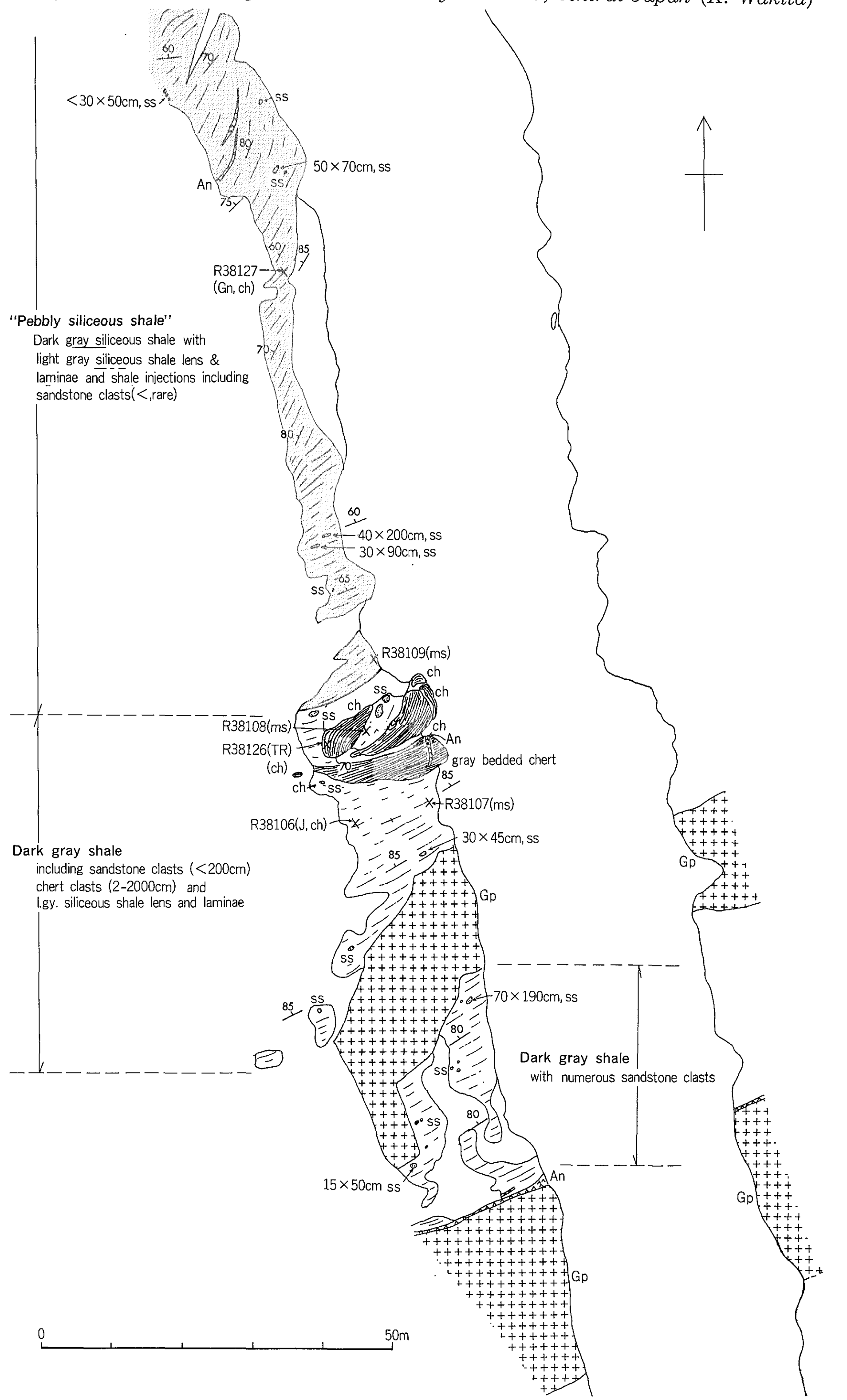

Fig. A- 7 Okukanayama route map 6. Legends are the same as in Fig. A-1. For location of mapped area, see Fig. A-1.

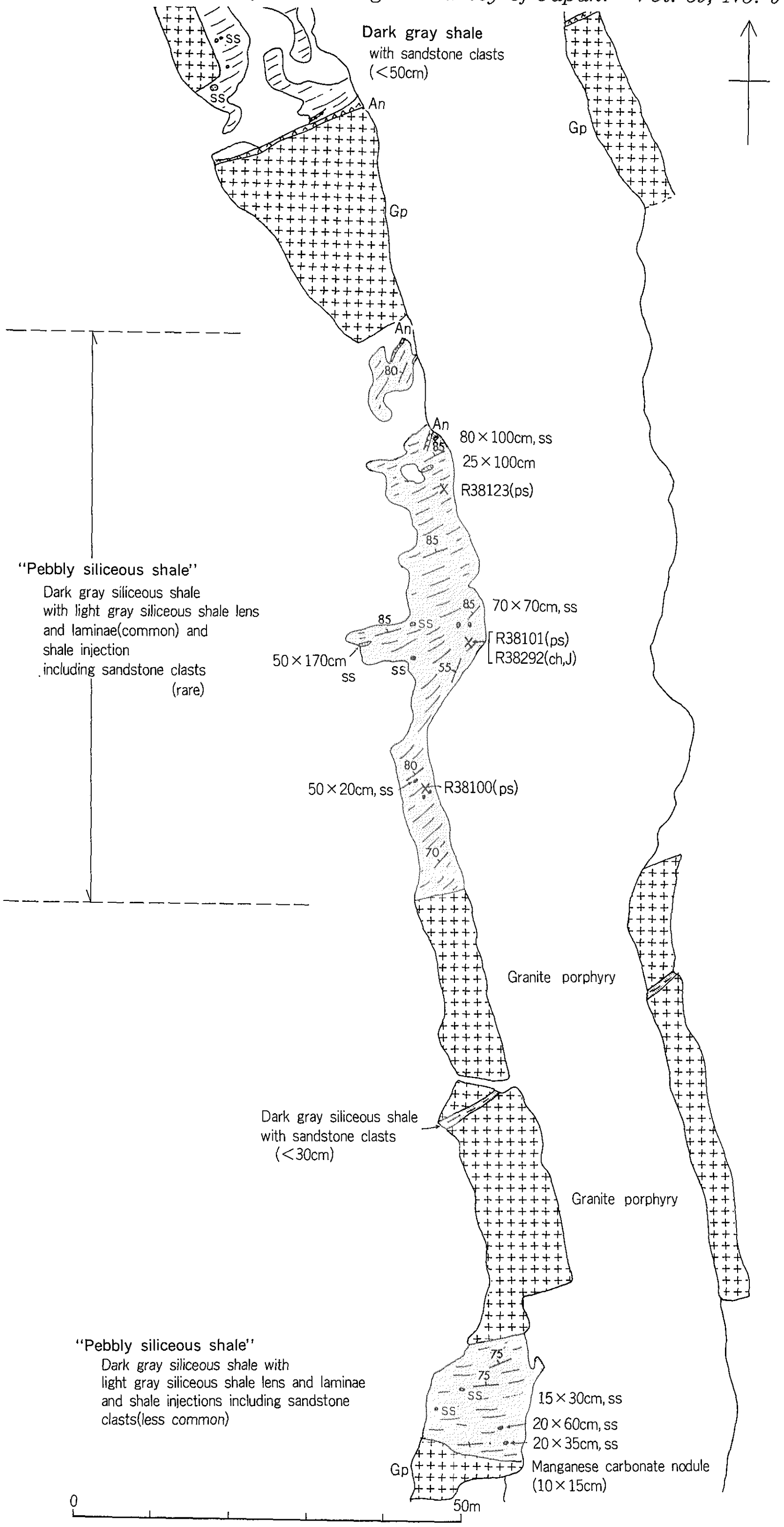

Fig. A- 8 Okukanayama route map 7. Legends are the same as in Fig. A-1. For location of mapped area, see Fig. A-1.

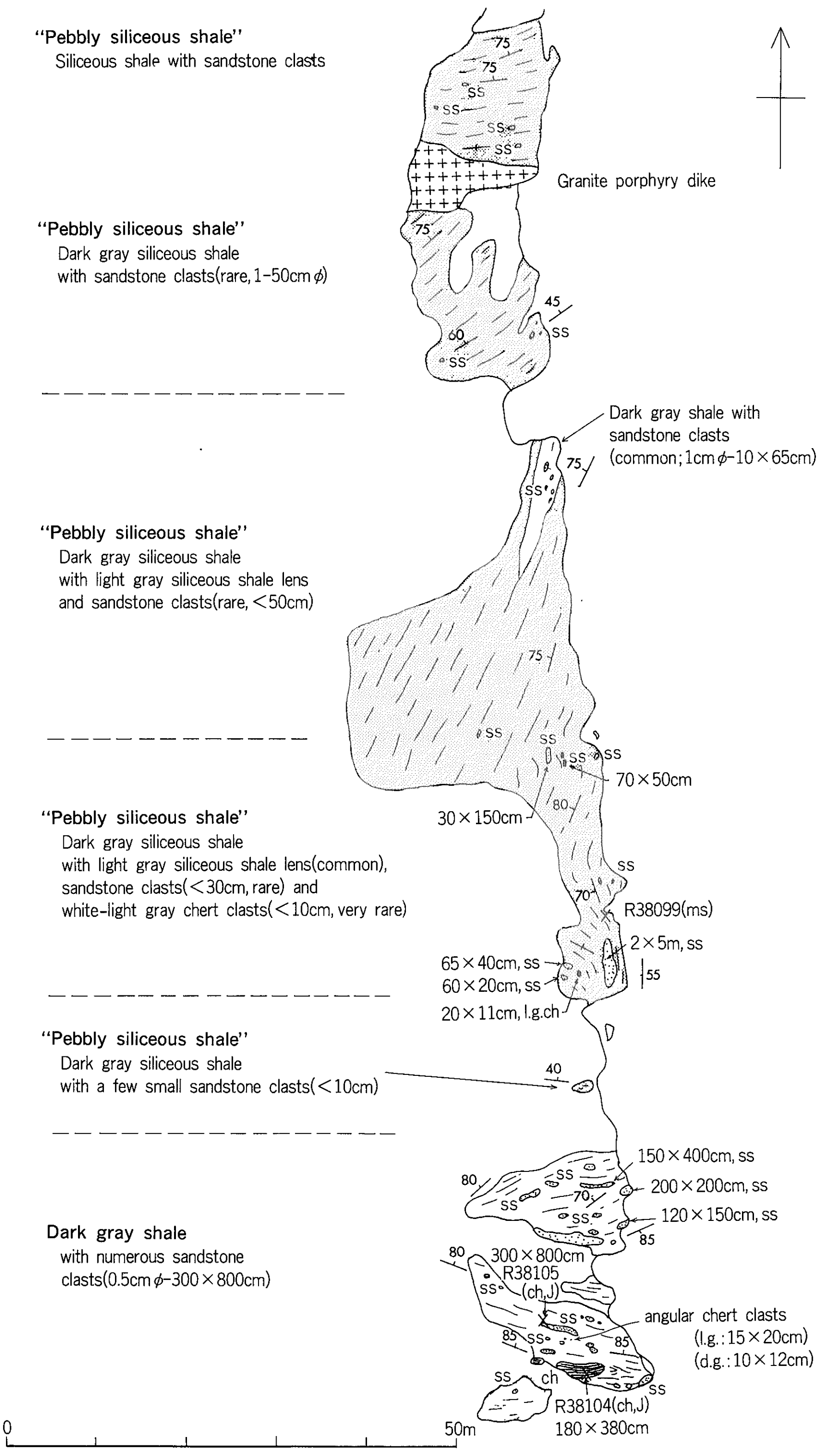

Fig. A- 9 Okukanayama route map 8. Legends are the same as in Fig. A-1. For location of mapped area, see Fig. A-1.

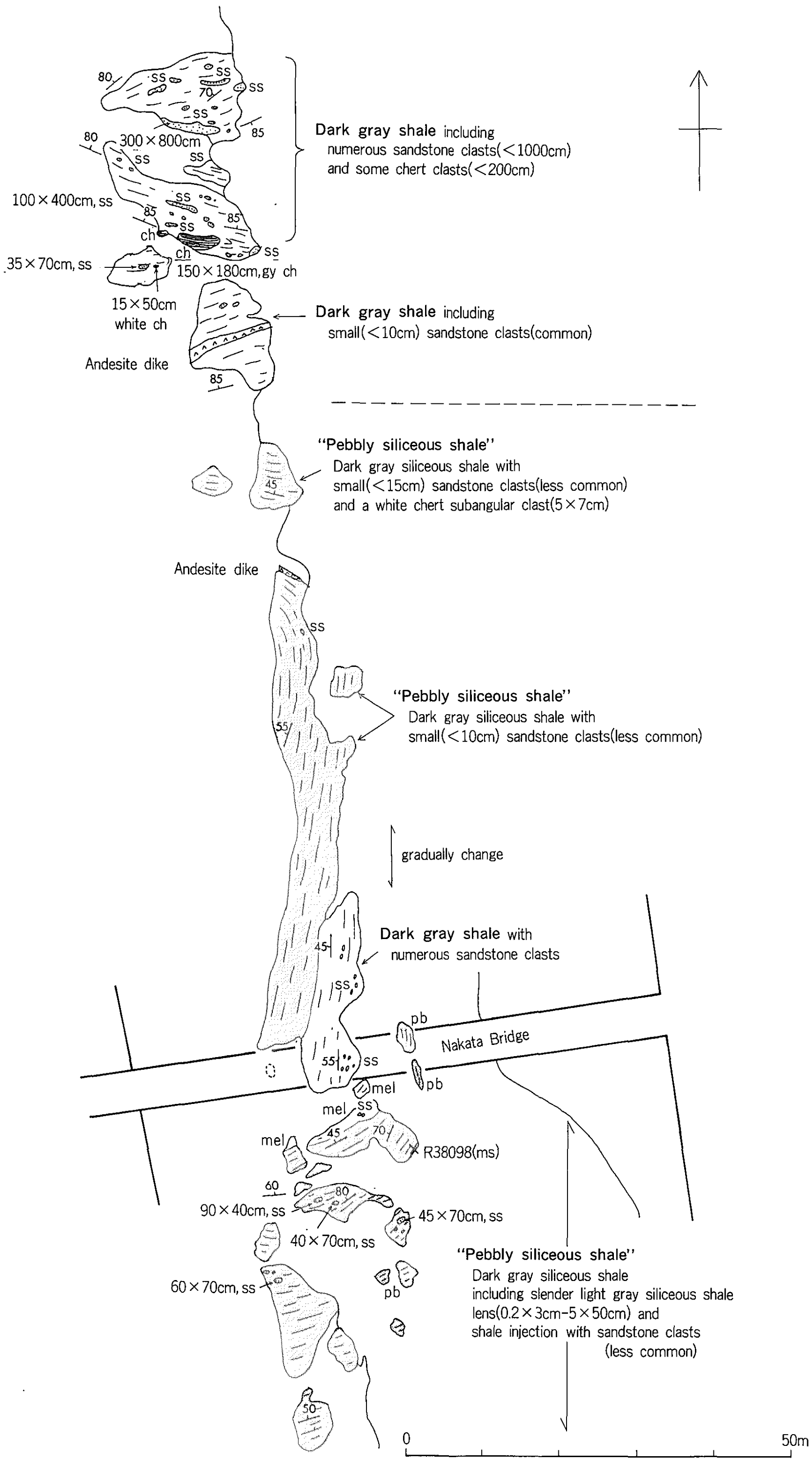

Fig. A-10 Okukanayama route map 9. Legends are the same as in Fig. A-1. For location of mapped area, see Fig. A-1.

Appendix II

RADIOLARIAN BIOSTRATIGRAPHY

In order to achieve exact information about the ages of the different components, detailed sampling and processing were conducted, using the method described by PESSAGNO and NEWPORT (1972). Most of the samples were collected in the Okukanayama route (Figs. A-1—A-10). Some others were sampled at scattered outcrops in the study area (Fig. 2).

Numerous radiolarians are obtained from chert, siliceous shale and shale (Table 2-7). The ages shown by these radiolarians range from Middle Triassic to earliest Cretaceous. Many samples of chert and siliceous shale yield well-preserved and highly diverse faunas of five assemblages ranging in age from late Middle Jurassic to earliest Cretaceous.

Triassic to Early Jurassic faunas are listed and five late Middle Jurassic to earliest Cretaceous radiolarian assemblages are briefly described. The subdivision (Table 1) is in accordance with those given by YAO *et al.* (1982) and YAO (1986).

Triassic and Early Jurassic radiolarians occur mostly in chert clasts. They are listed in Table 3. The genus *Triassocampe* is known from the Middle to Late Triassic (NAKASEKO and NISHIMURA, 1979). *Canoptum triassicum* and *Capnuchosphaera* sp. are characteristic faunal elements of the Late Triassic *Canoptum triassicum* Assemblage (YAO *et al.*, 1982). *Archaeospongoprunum* (?) *hellenicum* DE WEVER occurs in Late Triassic limestones of Greece (DE WEVER *et al.*, 1979).

Parahsuum cf. *simplum* YAO is diagnostic for the Early Jurassic (*Parahsuum simplum* Assemblage, YAO *et al.*, 1982). *Katroma, Bagotum* and *Laxtrum* are genera restricted to the Early Jurassic.

Hsuum cf. *hisuikyoense* ISOZAKI and MATSUDA is also diagnostic for the *Hsuum hisuikyoense* Assemblage (YAO, 1986) of the early Middle Jurassic.

Guexella nudata Assemblage

Pale brown bedded chert blocks and light gray small chert clasts of the melange in the Okukanayama route yield radiolarians of this assemblage (Table 3). Some fossils from laminated siliceous shale of R 38384, R 38387 and R 38388 (collected at Funeno) might belong to this assemblage (Table 4).

The assemblage is characterized by *Guexella nudata* (KOCHER) (Plate III-13), *Dicolocapsa conoformis* MATSUOKA (Plate III-14), *Eucyrtidiellum pustulatum* BAUMGARTNER, *E. unumaensis* (YAO) (Plate III-15), *Protunuma turbo* MATSUOKA, *Protunuma* (?) *ochiensis* MATSUOKA (Plate III-20), *Stylocapsa oblongula* (KOCHER) (Plate III-16), *Tricolocapsa conexa* MATSUOKA and *Dictyomitrella* (?) *kamoensis* MIZUTANI and KIDO.

Radiolarians of the sample, R 38236 might belong to the *Gongylothorax sakawaensis—Stichocapsa naradaniensis* Assemblage because of the occurrence of *Stylocapsa catenarum* MATSUOKA. These radiolarians are included in this report, however, in the *Guexella nudata* Assemblage by the occurrence of *Stylocapsa oblongula* MATSUOKA and by the lack of other diagnostic species for the *Gongylothorax sakawaensis—Stichocap-*

sa naradaniensis Assemblage. Whichever it belongs to, the age indicated by the radiolarians of the sample R 38236 must be close to the boundary between the two assemblages.

MATSUOKA (1983) assumed that this assemblage is younger than the *Unuma echinatus* assemblage. YAMAMOTO *et al.* (1985) reported some of the species of the *Guexella nudata* Assemblage including *Guexella nudata* from the sample of DSDP leg. 76 at the Blake Bahama Basin. As this core sample also contains Callovian nannofossils, the range of this assemblage is likely to include Callovian age at least.

***Gongylothorax sakawaensis—Stichocapsa naradaniensis* Assemblage**

Radiolarians of this assemblage (Table 4) occur in two types of siliceous shale clasts : gray massive siliceous shale and light gray siliceous shale. Diagnostic species for the *Gongylothorax sakawaensis—Stichocapsa naradaniensis* Assemblage are :
Gongylothorax sakawaensis MATSUOKA (Plate IV-14), *Stylocapsa* (?) *spilaris* MATSUOKA (Plate IV-19), *Stylocapsa catenarum* MATSUOKA (Plate IV-20), *Stichocapsa* cf. *naradaniensis* MATSUOKA (Plate IV-18), *Mirifusus fragilis* BAUMGARTNER (Plate IV-23), and *Cyrtocapsa* sp. A MATSUOKA (Plate IV-17).

This assemblage also contains *Hsuum maxwelli* PESSAGNO (Plate IV-4, 5), *H. brevicostata* BAUMGARTNER (Plate IV-6) and *Parvicingula dhimenaensis* BAUMGARTNER (Plate IV-10) which occur also in the older assemblage, as well as *Cinguloturris carpatica* DUMITRICA (Plate IV-16), *Eucyrtidiellum nodosum* n. sp. (Plate IV-29), *E. ptyctum* (RIEDEL and SANFILIPPO) (Plate IV-28), *Pseudodictyomitra* (?) sp. D MATSUOKA and YAO (Plate IV-12), and *Williriedellum* sp. A Group MATSUOKA (Plate IV-22) which are contained even in the younger assemblage.

***Tricolocapsa yaoi* Assemblage**

Light gray to dark gray bedded siliceous shale in the siliceous shale slab at Nakagiri (Fig. 2, 6) yields radiolarians of this assemblage (Table 5). This assemblage is characterized by the occurrence of *Tricolocapsa* cf. *yaoi* MATSUOKA (Plate V-18), and co-occurrence of *Hsuum maxwelli* PESSAGNO (Plate V-11), *Williriedellum* sp. A Group MATSUOKA, *Eucyrtidiellum nodosum* n. sp. (Plate V-16), *E. ptyctum* (RIEDEL and SANFILIPPO), *Cinguloturris carpatica* DUMITRICA (Plate V-8), *Parvicingula mashitaensis* MIZUTANI (Plate V-6), *Pseudodictyomitra* sp. D MATSUOKA and YAO and *Mirifusus mediodilatatus* (RÜST) in the study area. This radiolarian assemblage shows a close affinity with that of the Togano Group in Shikoku, Southwest Japan (MATSUOKA, 1986).

***Pseudodictyomitra primitiva—Pseudodictyomitra* sp. A Assemblage**

Various types of siliceous shale such as gray massive, gray laminated, light gray lenticular and gray bedded siliceous shale yield radiolarians of this assemblage (Table 5). The assemblage is marked by the first appearance of *Archaeodictyomitra minoensis* (MIZUTANI), *Archaeospongoprunum imlayi* PESSAGNO, *Protunuma japonicus* MATSUOKA and YAO (Plate V-13), *Pseudodictyomitra primitiva* MATSUOKA and YAO (Plate V-3), *P. okamurai* MIZUTANI (Plate V-5), *Ristola altissima* (RÜST) (Plate V-14), *Solentryma* (?) sp. (Plate V-10) and *Xitus gifuensis* MIZUTANI (Plate V-9) in the study area. *Eucyrtidiellum ptyctum* (RIEDEL and SANFILIPPO) (Plate V-17) and *Cinguloturris carpatica*

DUMITRICA have their last occurrence in this assemblage. *Mirifusus baileyi* PESSAGNO (Plate V-15), *M. mediodilatatus* PESSAGNO, *Parvicingula mashitaensis* MIZUTANI, *Pseudodictyomitra* (?) sp. D MATSUOKA and YAO (Plate V-4) and *Triactoma blakei* (PESSAGNO) (Plate V-23) also occur in the *Tricolocapsa yaoi* Assemblage. Most of the species in this assemblage were reported from many samples of the Mazegawa Formation by MIZUTANI (1981) which is one of the siliceous shale clasts in the melange of the Hida-Kanayama area, from several areas in the Mino terrane (ADACHI, 1982) and from the Torinosu Group in Shikoku, Southwest Japan (MATSUOKA and YAO, 1985).

Pseudodictyomitra cf. *carpatica* Assemblage

Radiolarians of this assemblage occur in gray laminated siliceous shale blocks, a small lenticular clast of gray siliceous shale and argillaceous parts of the melange (Table 2, 5). The assemblage is marked by the first appearance of *Eucyrtidiellum pyramis* AITA and OKADA (Plate VI-21, 22, 23), *Cinguloturris* sp. aff. *C. carpatica* DUMITRICA (Plate VI-14), *Pseudodictyomitra leptoconica* (FOREMAN) (Plate VI-3), *P.* cf. *carpatica* (LOZYNYAK) (Plate VI-8) and *P.* sp. aff. *P. primitiva* MATSUOKA and YAO (Plate VI-4, 5). *Eucyrtidiellum pyramis* is a marker for the *Ditrabs sansalvadorensis* Interval Zone (AITA, 1985; AITA and OKADA, 1986) which can be correlated with the *Pseudodictyomitra* cf. *carpatica* Assemblage (YAO, 1986).

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Appendix III

SYSTEMATIC PALEONTOLOGY

Following specific description is based on specimens from samples which contain well-preserved radiolarians of the *Gongylothorax sakawaensis — Stichocapsa naradaniensis* Assemblage and the *Tricolocapsa yaoi* Assemblage.

Type specimens are registered and deposited in the Geological Museum of the Geological Survey of Japan. In the systematic description and explanation of plates, the GSJ F number refers to the specimens in that museum.

Subclass RADIOLARIA MÜLLER 1858

Superorder POLYCYSTINA EHRENBERG 1838, emend. RIEDEL 1967

Order NASSELLARIA EHRENBERG 1875

Genus *EUCYRTIDIELLUM* BAUMGARTNER 1984

Eucyrtidiellum nodosum n. sp.
(Plate IV–29, Plate V–16)

1986 *Eucyrtidiellum* sp. aff. *E. unumaense* (YAO)—MATSUOKA, p. 113, Plate 2—9.

Description.–Cephalis small, spherical with a small apical horn. Thorax with irregular small nodes. Whole portion of abdomen with relatively regular ornamentation consisting of larger nodes than those of thorax.

Measurements (in μm, based on 9 specimens) : height of cephalis, thorax and abdomen, 93–120 (mean 108); height/width of thorax, 27–45 (mean 34)/37–53 (mean 47) ; height/width of abdomen, 53–80 (mean 66)/80–100 (mean 92)

Remarks.–This species differs from *E. unumaensis* (YAO) by having a nodose abdomen and from *E. pustulatum* BAUMGARTNER by having larger and more regular nodes which cover the whole abdomen.

Derivatio nominis : nodosus (lat.) = nodose

Type-specimens : Holotype, GSJ F 10631–25 a (Plate IV–29), Paratype, GSJ F 10695–44 c (Plate V–16)

PLATES

AND

EXPLANATIONS

(with 6 Plates)

Plate I Photographs of the outcrops along the Okukanayama route.

1 Light gray siliceous shale clasts yielding early Late Jurassic radiolarians (*Gongylothorax sakawaensis—Stichocapsa naradaniensis* Assemblage). Note the irregular swirled form. Scale is 4 × 5 cm.

2 Bedded siliceous shale part in the massive siliceous shale clast (Mazegawa Formation), yielding latest Jurassic radiolarians of the *Pseudodictyomitra primitiva—Pseudodictyomitra* sp. A Assemblage. Hammer head is 20 cm long.

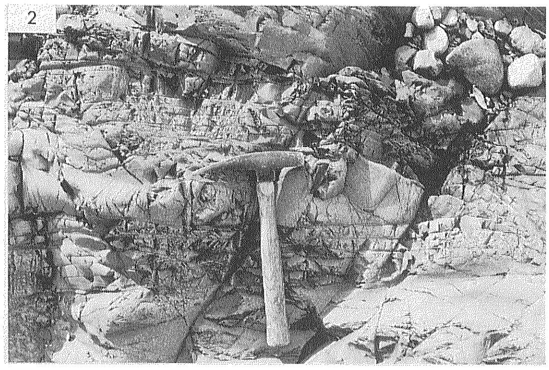
3 Dark gray laminated siliceous shale of earliest Cretaceous, yielding radiolarians of the *Pseudodictyomitra* cf. *carpatica* Assemblage. This rock type is characterized by laminations and trace fossils. Marker is 14.2 cm long.

4 Shale injection cut into a siliceous shale clast. Note the sharp boundaries between the injection and siliceous shale. The laminations of the siliceous shale are cut by the injection. Marker is 13.2 cm long.

5 Dark gray shale matrix of the melange is injected into the disrupted alternation of sandstone and shale. The injection took place after the disruption of the alternation. Marker is 14.2 cm long.

6 Matrix of the melange in the Hida-Kanayama area. Note the proportion of the clasts to the matrix. Most of the clasts consist of gray siliceous shale and sandstone. Marker is 14.2 cm long.


1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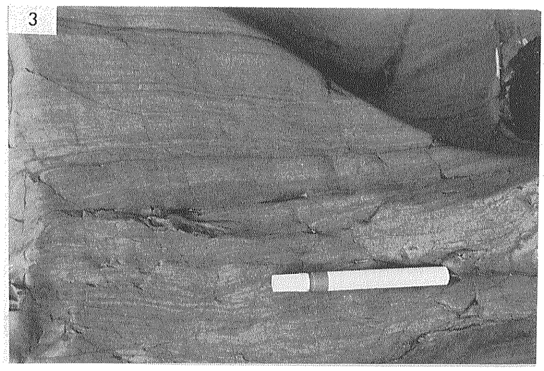
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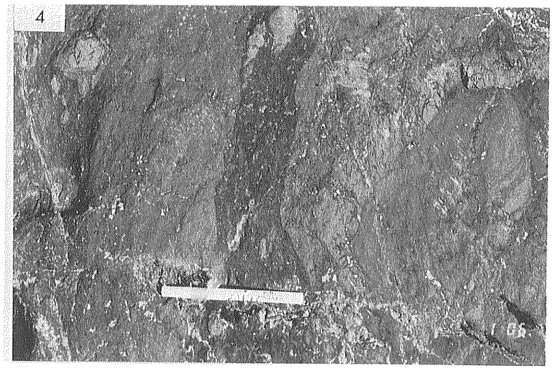
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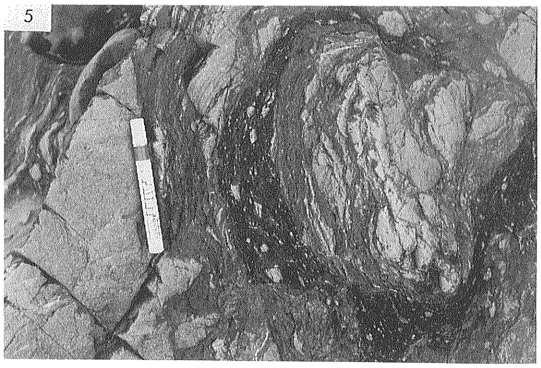
5


6

Plate II Photomicrographs of thin sections of chert and siliceous shale of the clasts in the melange along the Okukanayama route. Lower polar only. 10 mm wide.

1 Gray Triassic bedded chert (GSJ R 38126).

2 Pale purple late Middle Jurassic bedded chert (GSJ R 38139) yielding radiolarians of the *Guexella nudata* Assemblage.

3 Light gray late Middle Jurassic chert (GSJ R 38130) which occurs as a small clast and yields radiolarians of the *Guexella nudata* Assemblage.

4 Light gray early Late Jurassic siliceous shale (GSJ R 38145) showing irregularly swirled form (Plate I-1). This sample yields radiolarians of the *Gongylothorax sakawaensis—Stichocapsa naradaniensis* Assemblage.

5 Massive gray siliceous shale (GSJ R 38135) yielding latest Jurassic radiolarians of the *Pseudodictyomitra primitiva—Pseudodictyomitra* sp. A Assemblage.

6 Gray laminated siliceous shale (GSJ R 38134) yielding earliest Cretaceous radiolarians of the *Pseudodictyomitra* cf. *carpatica* Assemblage.

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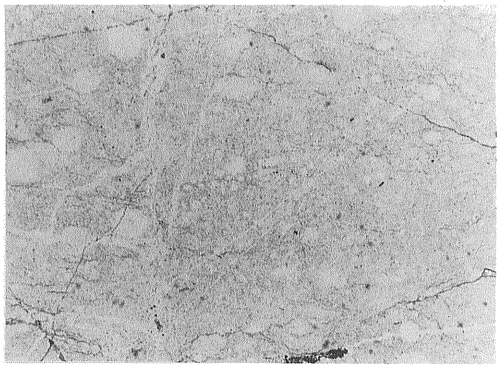

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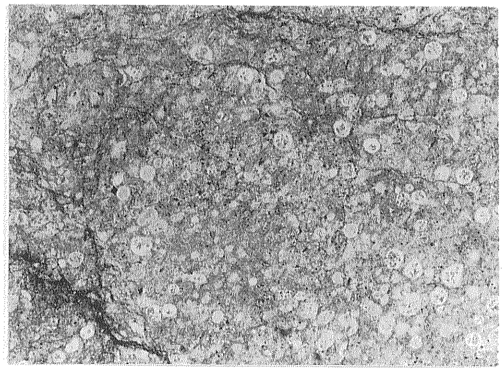

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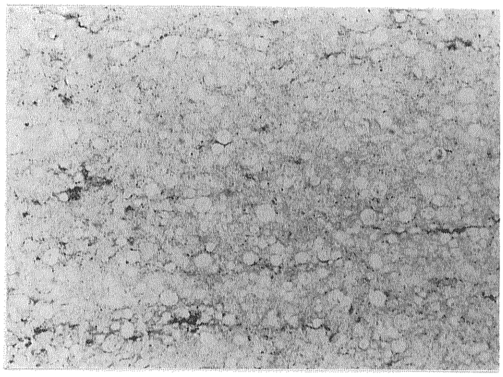

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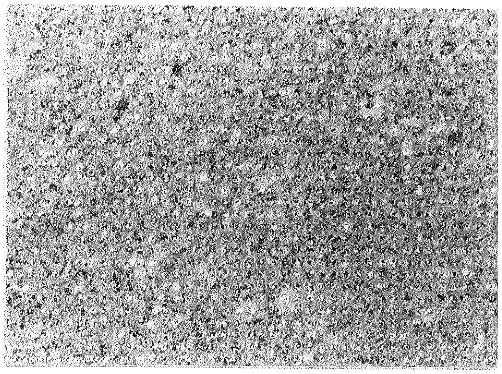

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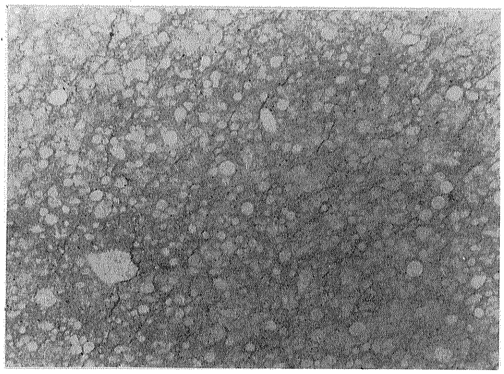

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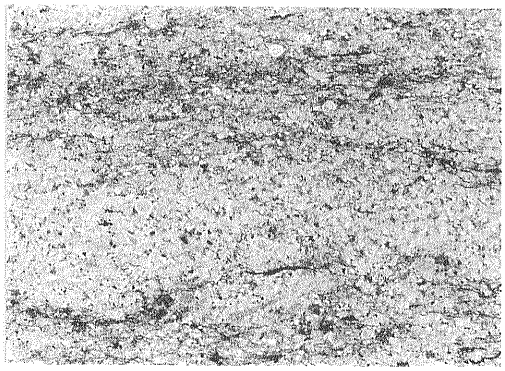

Plate III Triassic (1–5), Early Jurassic (6–10) and late Middle Jurassic (*Guexella nudata* Assemblage : 11–20) radiolarians.

		Fossil No. (Sample No.)	
1	*Triassocampe* sp.	F 10708–12(R 38218)	×144
2	*Triassocampe* sp.	F 10708–14(R 38218)	×182. 4
3	*Pachus* sp.	F 10637–24(R 38147)	×182. 4
4	*Palaeosaturnalis* sp.	F 10616–25(R 38126)	×120
5	*Archaeospongoprunum* (?) *hellenicum* DE WEVER	F 10637–34(R 38147)	×120
6	*Parahsuum* cf. *simplum* YAO	F 12113–57(R 38389)	×182. 4
7	*Parahsuum* sp.	F 10618–15(R 38128)	×182. 4
8	*Katroma* sp.	F 12113–26 a(R 38389)	×120
9	*Bagotum* (?) sp.	F 12113–34(38389)	×182. 4
10	*Trillus* sp.	F 12113–22(R 38389)	×182. 4
11	*Archaeodictyomitra* sp.	F 10791–31(R 38298)	×182. 4
12	*Hsuum brevicostatum* (OZVOLDOVA)	F 10726–12 a(R 38236)	×144
13	*Guexella nudata* (KOCHER)	F 10620–14 d(R 38130)	×182. 4
14	*Dicolocapsa conoformis* MATSUOKA	F 10617–45(R 38127)	×240
15	*Eucyrtidiellum unumaensis* (YAO)	F 10717–21 e(R 38227)	×182. 4
16	*Stylocapsa oblongula* KOCHER	F 10726–23 c(R 38236)	×182. 4
17	*Stylocapsa tecta* MATSUOKA	F 10726–22(R 38236)	×182. 4
18	*Tricolocapsa plicarum* YAO	F 10726–26 c(R 38236)	×182. 4
19	*Tricolocapsa plicarum* YAO	F 10726–26 b(R 38236)	×182. 4
20	*Protunuma* (?) *ochinensis* MATSUOKA	F 10790–18(R 38297)	×182. 4

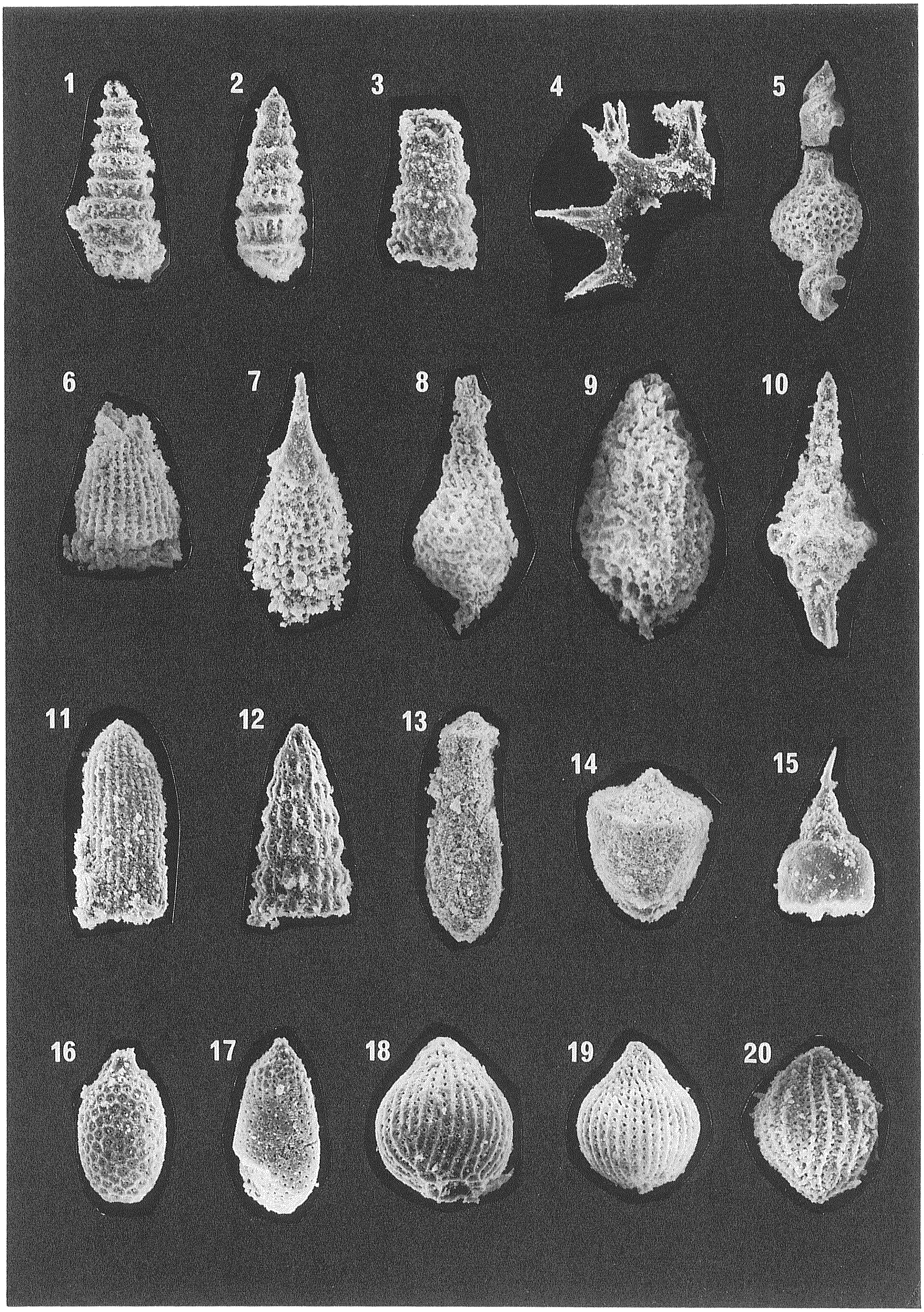
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Plate IV Radiolarians of the *Gongylothorax sakawaensis—Stichocapsa naradaniensis* Assemblage (early Late Jurassic).

		Fossil No. (Sample No.)
1	*Archaeodictyomitra apiara* (RÜST)	F 10635-73 a (R 38145) ×240
2	*Archeaodictyomitra* sp.	F 10632-15 f (R 38142) ×144
3	*Archaeodictyomitra* sp.	F 10631-52 a (R 38141) ×144
4	*Hsuum maxwelli* PESSAGNO	F 10635-21 c (R 38145) ×144
5	*Hsuum maxwelli* PESSAGNO	F 10632-33 b (R 38142) ×120
6	*Hsuum brevicostatum* BAUMGARTNER	F 10597-65 (R 38107) ×144
7	*Parahsuum* sp.	F 10631-12 b (R 38141) ×120
8	*Parahsuum* sp.	F 10631-72 b (R 38141) ×144
9	*Parahsuum* sp.	F 10631-44 a (R 38141) ×144
10	*Parvicingula dhimenaensis* BAUMGARTNER	F 10597-32 (R 38107) ×182. 4
11	*Parvicingula mashitaensis* MIZUTANI	F 10631-53 (R 38141) ×144
12	*Pseudodictyomitra* (?) sp. D MATSUOKA & YAO	F 10632-74 (R 38142) ×240
13	*Dictyomitrella* (?) *kamoensis* MIZUTANI & KIDO	F 10635-23 d (R 38145) ×182. 4
14	*Gongylothorax sakawaensis* MATSUOKA	F 10647-23 (R 38157) ×182. 4
15	*Canoptum* sp.	F 10631-77 a (R 38141) ×120
16	*Cinguloturris carpatica* DUMITRICA	F 10631-67 d (R 38141) ×182. 4
17	*Cyrtocapsa* sp. A MATSUOKA	F 10635-35 e (R 38145) ×240
18	*Stichocapsa* cf. *naradaniensis* MATSUOKA	F 10765-24 e (R 38275) ×182. 4
19	*Stylocapsa* (?) *spilaris* MATSUOKA	F 10635-41 a (R 38145) ×182. 4
20	*Stylocapsa catenarum* MATSUOKA	F 10635-85 e (R 38145) ×240
21	*Zhamoidellum* sp.	F 10635-83 b (R 38145) ×182. 4
22	*Williriedellum* sp. A Group MATSUOKA	F 10635-28 a (38145) ×240
23	*Mirifusus fragilis* BAUMGARTNER	F 10631-55 a (R 38141) ×120
24	*Pseudoeucyrtis* sp.	F 12116-32 (R 38392) ×120
25	*Eucyrtidiellum unumaense* (YAO)	F 10635-54 e (R 38145) ×240
26	*Eucyrtidiellum pustulatum* BAUMGARTNER	F 10635-54 b (R 38145) ×240
27	*Eucyrtidiellum pustulatum* BAUMGARTNER	F 10635-43 a (R 38145) ×240
28	*Eucyrtidiellum ptyctum* (RIEDEL & SANFILIPPO)	F 10632-16 a (R 38142) ×240
29	*Eucyrtidiellum nodosum* WAKITA	F 10631-25 a (R 38141) ×240

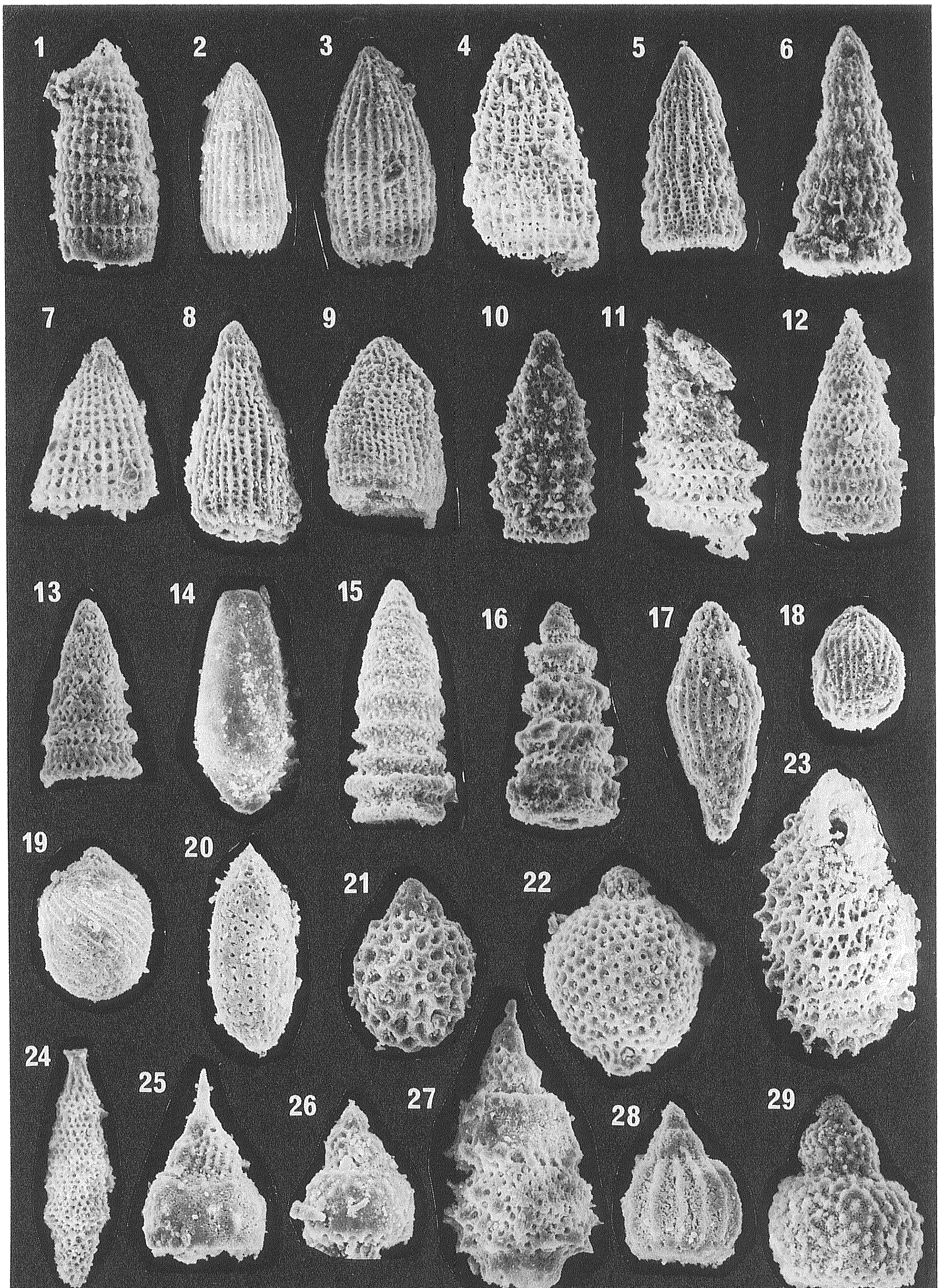
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Plate V Radiolarians of the *Tricolocapsa yaoi* Assemblage (middle Late Jurassic) and the *Peudodictyomitra primitiva—Pseudodictyomitra* sp. A Assemblage (latest Jurassic).

		Fossil No. (Sample No.)
1	*Thanarla* cf. *conica* (ALIEV)	F 10625-17(R 38135) ×182.4
2	*Archaeodictyomitra minoensis* (MIZUTANI)	F 10604-31 b(R 38114) ×144
3	*Pseudodictyomitra primitiva* MATSUOKA & YAO	F 10694-51(R 38204) ×182.4
4	*Pseudodictyomitra* (?) sp. D MATSUOKA & YAO	F 10604-15 a(R 38114) ×240
5	*Pseudodictyomitra okamurai* MIZUTANI	F 10700-35 b(R 38210) ×144
6	*Parvicingula mashitaensis* MIZUTANI	F 10698-13 d(R 38208) ×120
7	*Parvicingula dhimenaensis* BAUMGARTNER	F 10694-18(R 38204) ×144
8	*Cinguroturris carpatica* DUMITRICA	F 10695-53(R 38205) ×144
9	*Xitus gifuensis* MIZUTANI	F 10707-14 a(R 38217) ×144
10	*Solentryma* (?) sp.	F 10625-61 b(R 38135) ×144
11	*Hsuum maxwelli* PESSAGNO	F 10694-33(R 38204) ×182.4
12	*Dictyomitrella* (?) sp. aff. *D* (?) *kamoensis* MIZUTANI & KIDO	F 10604-73 d(R 38114) ×240
13	*Protunuma japonicus* MATSUOKA & YAO	F 10703-31(R 38213) ×182.4
14	*Ristla altissima* (RUST)	F 10694-45(R 38204) ×72
15	*Mirifusus baileyi* PESSAGNO	F 10703-24(R 38213) ×72
16	*Eucyrtidiellum nodosum* WAKITA	F 10695-44 c(R 38205) ×182.4
17	*Eucyrtidiellum ptyctum* (RIEDEL & SANFILIPPO)	F 10625-46 b(R 38135) ×240
18	*Tricolocapsa* cf. *yaoi* MATSUOKA & YAO	F 10697-45(R 38207) ×182.4
19	*Tricolocapsa* sp.	F 10625-25 a(R 38135) ×240
20	*Amphibrachium* sp.	F 10698-42(R 38208) ×72
21	*Pseudoeucyrtis* sp.	F 10693-37(R 38203) ×120
22	*Podobursa* sp.	F 10698-25 c(R 38208) ×120
23	*Triactoma blakei* (PESSAGNO)	F 10702-11(R 38212) ×72
24	*Acaeniotyle* sp.	F 10694-15(R 38204) ×72
25	*Williriedellum* cf. *crystallinum* DUMITRICA	F 10604-84 e(R 38114) ×182.4

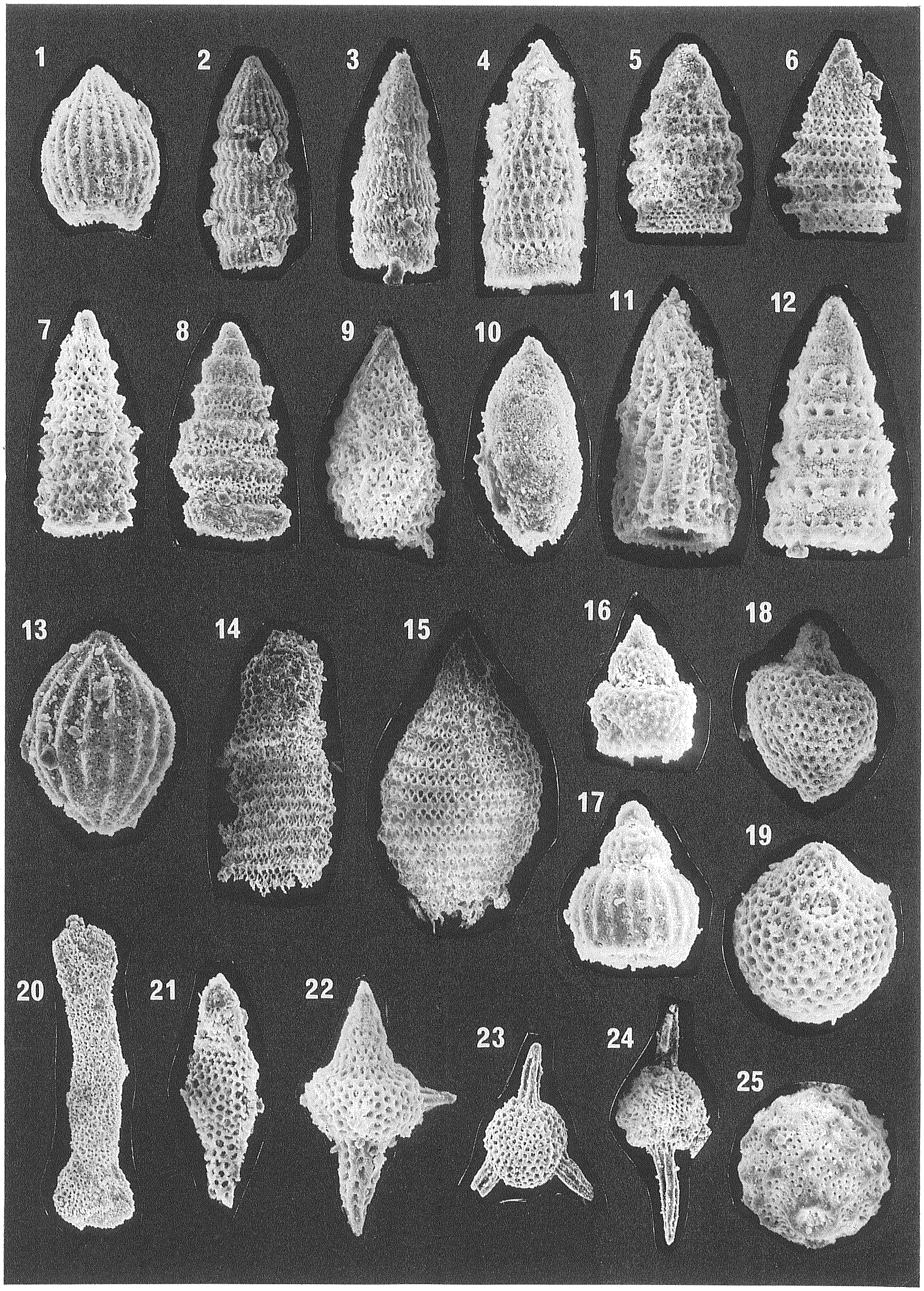
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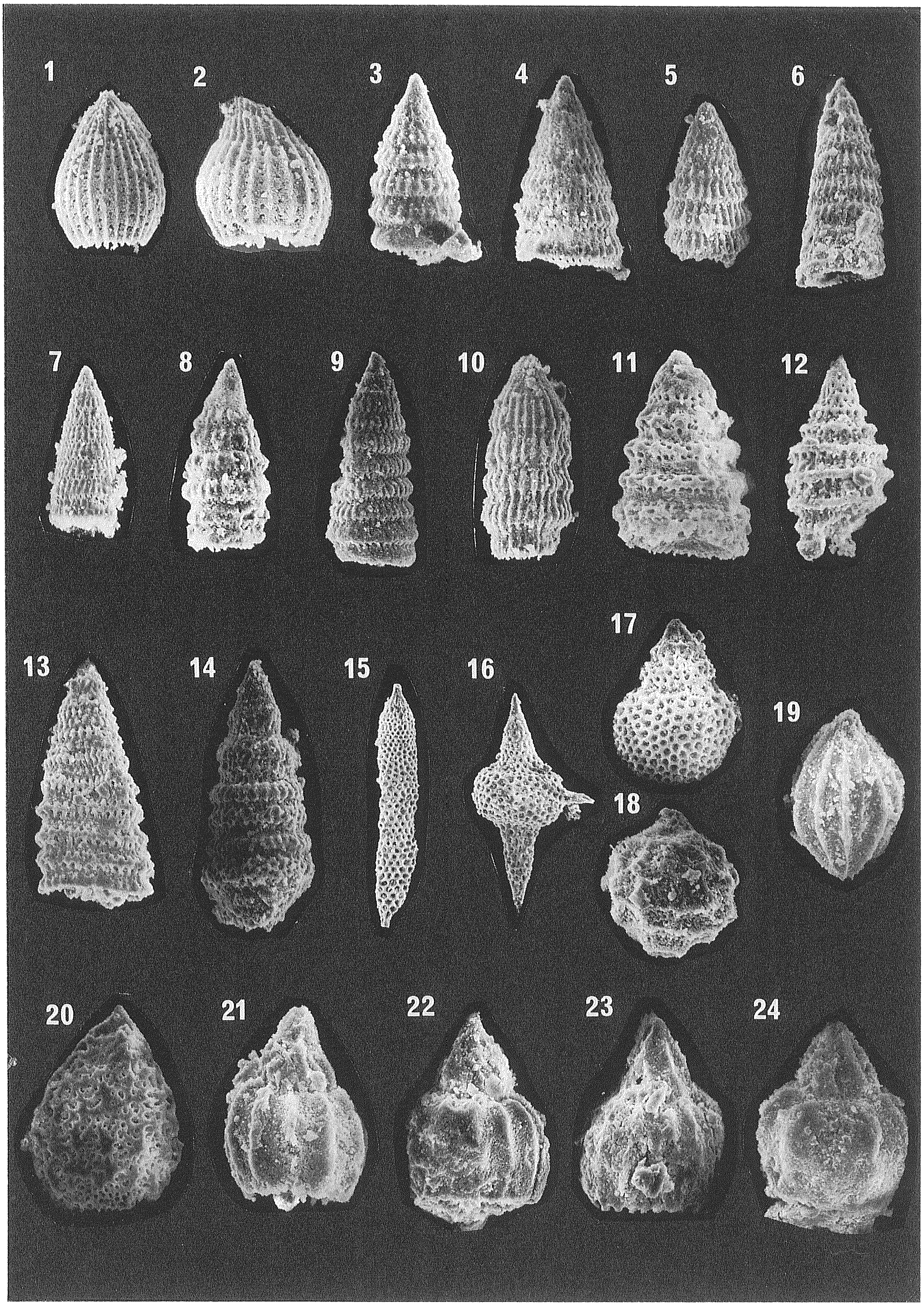
Plate VI Radiolarians of the *Pseudodictyomitra* cf. *carpatica* Assemblage (earliest Cretaceous).

		Fossil No. (Sample No.)
1	*Thanarla conica* (ALIEV)	F 10786-114(R 38293) ×182.4
2	*Thanarla* cf. *pulchula* (SQUINABOL)	F 10701-54(R 38211) ×182.4
3	*Pseudodictyomitra leptoconica* (FOREMAN)	F 10778-22(R 38081) ×182.4
4	*Pseudodictyomitra* sp. aff. *P. primitiva* MATSUOKA & YAO	F 10786-12(R 38293) ×182.4
5	*Pseudodictyomitra* sp. aff. *P. primitiva* MATSUOKA & YAO	F 10799-22 b(R 38087) ×182.4
6	*Pseudodictyomitra primitiva* MATSUOKA & YAO	F 10640-17(R 38150) ×182.4
7	*Pseudodictyomitra primitiva* MATSUOKA & YAO	F 10794-22 k(R 38080) ×144
8	*Pseudodictyomitra* cf. *carpatica* (LOZYNYAK)	F 10701-26 b(R 38211) ×144
9	*Pseudodictyomitra* sp.	F 10701-44 b(R 38211) ×144
10	*Archaeodictyomitra minoensis* (MIZUTANI)	F 10793-12 a(R 38082) ×144
11	*Pseudodictyomitra okamurai* MIZUTANI	F 10701-25(R 38211) ×182.4
12	*Parvicingula mashitaensis* MIZUTANI	F 10794-22 d(R 38080) ×144
13	*Parvicingula* sp.	F 10640-16(R 38150) ×144
14	*Cinguloturris* sp. aff. *C. carpatica* DUMITRICA	F 10793-12 h(R 38082) ×144
15	*Pseudoeucyrtis* sp.	F 10701-32 a(R 38211) ×72
16	*Podobursa* sp.	F 10701-42 b(R 38211) ×72
17	*Sethocapsa* sp. aff. *S. uterculus* (PARONA)	F 10778-13(R 38081) ×182.4
18	*Williriedellum* cf. *crystallinum* DUMITRICA	F 10795-11 h(R 38081) ×182.4
19	*Protunuma japonicus* MATSUOKA & YAO	F 10795-21 B(R 38081) ×182.4
20	*Xitus gifuensis* MIZUTANI	F 10639-17(R 38149) ×182.4
21	*Eucyrtidiellum pyramis* AITA	F 10701-44 c(R 38211) ×240
22	*Eucyrtidiellum pyramis* AITA	F 10775-24(R 38082) ×240
23	*Eucyrtidiellum pyramis* AITA	F 10775-23(R 38082) ×240
24	*Eucyrtidiellum* sp. aff. *E. pyramis* AITA	F 10794-32 g(R 38080) ×240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