J. Earth Planet. Sci. Nagoya Univ., Vol. 51, 1 to 10, 2004

Jurassic radiolarian fossils from the Miyakoda Formation in the Lake Hamana area, Shizuoka Prefecture, central Japan

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(Received October 15, 2004 / Accepted December 28, 2004)

ABSTRACT

The Miyakoda Formation of the Chichibu Belt exposed in the Lake Hamana area, Sizuoka Prefecture, Chubu province, consists mainly of mélanges including slabs and blocks of chert and clastic rocks. Along the western coast of Lake Hamana, a mélange including blocks of basalt, bedded chert, sandstone and alternating beds of sandstone and mudstone in a matrix of scaly mudstone is exposed. Radiolarian fossils were extracted from two samples (m-1 and m-2) from the muddy matrix. The radiolarian fossils such as *Archaeodictyomitra* (?) *amabilis* Aita, *Eucyrtidiellum unumaense* (Yao), *Protunuma turbo* Matsuoka, *Stichocapsa japonica* Yao, *Stichocapsa robusta* Matsuoka, *Tricolocapsa* (?) aff. *fusiformis* Yao sensu Matsuoka, *Tricolocapsa plicarum* Yao and *Unuma latusicostatus* (Aita) were extracted from the mudstone of m-1. The radiolarian fossils such as *Amphipyndax tsunoensis* Aita, *Eucyrtidiellum pustulatum* Baumgartner, *Eucyrtidiellum unumaense* (Yao), *Protunuma turbo* Matsuoka and *Sethocapsa zweilli* Jud were extracted from the mudstone of m-2. Judging from the radiolarian fossils, the mudstone of the m-1 and m-2 are middle to late Bathonian in age. This fossil evidence indicates that formation of the mélange occurred after late Middle Jurassic time.
Keywords; Chichibu Belt, Sizuoka Prefecture, Miyakoda Formation, mélange, radiolarian fossil, late Middle Jurassic

INTRODUCTION

The Chichibu Belt, Southwest Japan, is composed mainly of Jurassic to Early Cretaceous accretionary complexes (e.g. Yao, 1984; Matsuoka, 1984; Sashida, 1988). Detailed mapping and radiolarian biostratigraphic study have advanced our understanding of the structure and age of the accretionary complexes. Although the inclusive unit division was proposed in Shikoku and Kanto provinces (Matsuoka et al., 1998), structure and age of this belt in other provinces, such as Kyushu and Chubu provinces, are not revealed precisely. In order to discuss whole geologic structure and tectonic development of this belt, structural analysis and age determination in Chubu province situated between Shikoku and Kanto provinces is important. This paper focuses the radiolarian age of the Miyakoda Formation of the Chichibu Belt exposed in the Lake Hamana area, Sizuoka Prefecture, Chubu province. Particularly the depositional age of muddy matrix of mélange plays an important role to discuss development of the accretionary complex.

GEOLOGICAL OUTLINE OF THE LAKE HAMANA AREA

Study area is in 80 km southeast of Nagoya, central Japan (Fig. 1a). Rocks of the Chichibu Belt in this area were divided into the Iinoya and the Miyakoda Formations from north to south (Saito and Isomi, 1954; Saito, 1955; Isomi and Inoue, 1972; Fig. 1b). The Iinoya Formation is in fault contact with the Mikabu Greenstone at its northern end with southward-dipping fault plane (Isomi and Inoue, 1972). The Mikabu Greenstone is composed of dolerite, gabbro and serpentinite. The Quaternary sediments unconformably overlie the Iinoya and the Miyakoda Formations.

The Iinoya Formation consists of mélanges including large amounts of slabs and blocks of chert, greenstone and limestone in a matrix of scaly mudstone or mafic tuff. The Iinoya Formation structurally overlies the Miyakoda Formation (Isomi and Inoue, 1972). Middle Permian fusulinoideans were reported from limestone slabs of this formation (Isomi and Inoue, 1972). Middle Permian and Middle Jurassic radiolarian fossils were reported from chert and mudstone respectively (Mizugaki, 1985). In the Toyohashi area (3 km west of the study area), Ieda and Sugiyama (1998) reported Middle Triassic radiolarian fossils from chert of the Unit A (Niwa and Otsuka, 2001) which is correlative with the Iinoya Formation. Niwa and Otsuka (2001) reported

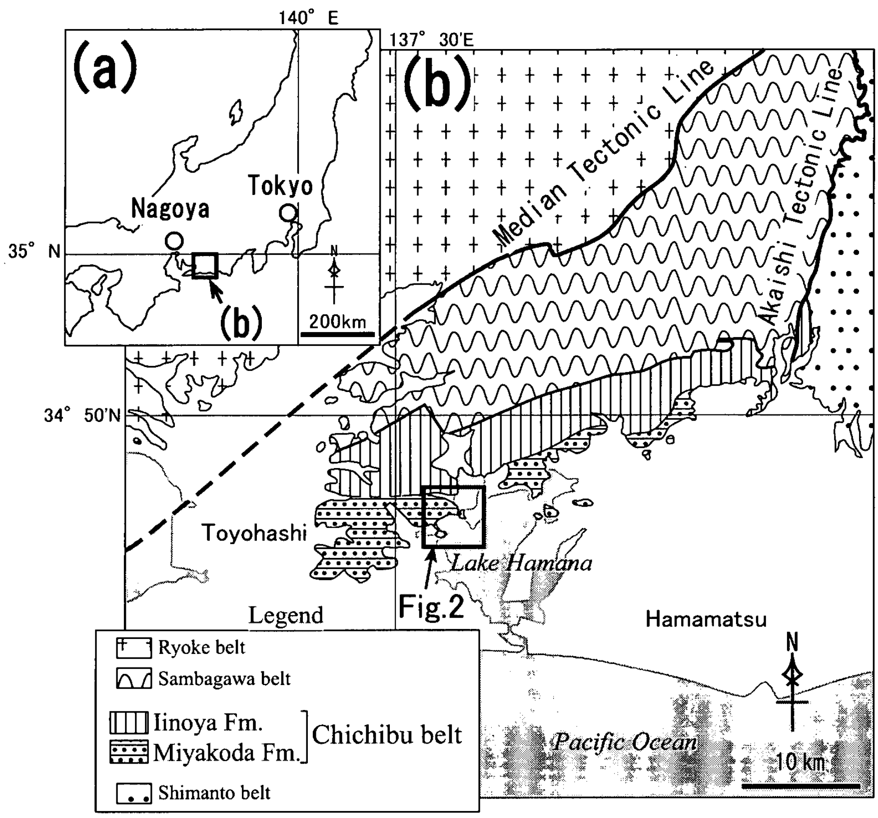


Fig. 1 (a) Index map and (b) tectonic division around Lake Hamana (modified from Isomi and Inoue, 1972 and Yamada et al., 1972).

Middle to Late Jurassic radiolarian fossils from chert and siliceous mudstone of the Unit A.

The Miyakoda Formation consists of mélanges including large amounts of slabs and blocks of chert and clastic rocks such as massive sandstone, mudstone and alternating beds of sandstone and mudstone in a matrix of scaly mudstone. Greenstone is scarcely included in the Miyakoda Formation. The alternating beds of sandstone and mudstone are predominantly deformed into broken or dismembered formation (Raymond, 1984) showing boudinage structures. The alternating beds rarely show sedimentary structures such as graded bedding and lamination. Permian to Triassic, and Early to Middle Jurassic radiolarian fossils were reported from chert and mudstone of the Miyakoda Formation, respectively (Mizugaki, 1985; Ieda, 2001). In the Toyohashi area, Early Permian and Middle Triassic radiolarian fossils were reported from chert of the Unit B (Niwa and Otsuka, 2001) which is correlative with the Miyakoda Formation (Ieda and Sugiyama, 1998; Niwa and Otsuka, 2001). Niwa and Otsuka (2001) reported Middle Jurassic radiolarian fossils from siliceous mudstone, mudstone and felsic tuff of the Unit B.

GEOLOGICAL DESCRIPTION OF RADIOLARIAN LOCALITY

Radiolarian fossils in this paper were from the Miyakoda Formation at the western coast of Lake Hamana, Osaki hamlet, Mikkabi Town (Fig. 2). In this locality, a mélange

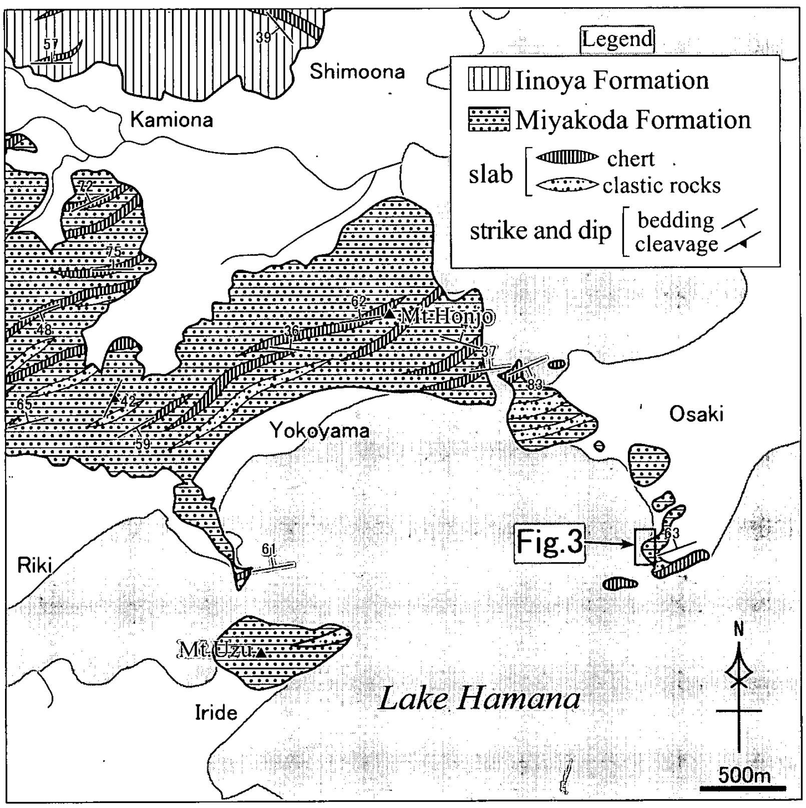


Fig. 2 Simplified geological map of the study area (modified from Isomi and Inoue, 1972).

including blocks of basalt, bedded chert, sandstone and alternating beds of sandstone and mudstone in a matrix of scaly mudstone is well exposed (Fig. 3). The blocks range from 2 cm to several tens cm in diameter.

The basalt blocks are lenticular or irregular in shape (Photo 1a). The basalt is vesicular and amygdaloidal lava showing porphyritic texture. The phenocrysts are of idiomorphic augite ranging from 0.2 mm to 2 mm in diameter (Photo 1b). The groundmass is composed mainly of small laths and needles of plagioclase, interstitial glass and opaque minerals. Plagioclase is generally saussuritized. Most of amygdules ranging from 0.8 mm to 1.5 mm in diameter are filled with zeolite, pumpellyite and chlorite.

The bedded chert blocks are generally lenticular or irregular in shape (Photo 1c). Thickness of a chert layer ranges from 3 cm to 5 cm, and that of an interbedded mudstone layer is less than 1 mm. The chert layers are composed of microcrystalline to cryptocrystalline quartz and sporadically contain poor-preserved radiolarian fossils (Photo 1d). The bedded chert generally trends ENE-WSW and steeply dips northward. Quartz veins ranging in width from 0.05 mm to 0.2 mm cut across the bedded chert.

The alternating beds of sandstone and mudstone generally trending ENE-WSW are deformed into broken formation or dismembered formation (Raymond 1984; Photo 1d). A bed of sandstone ranges in thickness from 3 cm to 10 cm. Graded beddings showing northward facing can be observed. The sandstone is composed mostly of angular to subangular grains of quartz, potassium feldspar and plagioclase with a minor amount of biotite, muscovite, chlorite, zircon, garnet and volcanic rock fragments (Photos 1e–1f). The sandstone is generally poorly-sorted and fine- to medium-grained.

The muddy matrix of the mélange (Photos 1a–1d) is composed mainly of clay minerals and detrital quartz grains. The quartz grains are less than 0.05 mm in diameter (Photos 1g–1h). The muddy matrix contains radiolarian fossils. Scaly cleavages trending ENE-WSW can be seen in the muddy matrix with a spacing of several cm.

RADIOLARIAN ASSEMBLAGES AND THEIR AGES

Thirteen species of radiolarian fossils were extracted from two samples of the muddy matrix (m-1 and m-2 of Fig. 3) as follows;

m-1: *Archaeodictyomitra* (?) *amabilis* Aita, *Eucyrtidiellum unumaense* (Yao), *Protunuma turbo* Matsuoka, *Stichocapsa japonica* Yao, *Stichocapsa robusta* Matsuoka, *Tricolocapsa* (?) aff. *fusiformis* Yao sensu Matsuoka, *Tricolocapsa plicarum* Yao and *Unuma latusicostatus* (Aita) (Photos 2 and Table 1).

m-2: *Amphipyndax tsunoensis* Aita, *Eucyrtidiellum pustulatum* Baumgartner, *Eucyrtidiellum unumaense* (Yao), *Protunuma turbo* Matsuoka, *Sethocapsa zweilli* Jud, *Stichomitra* (?) *takanoensis* Aita and *Williriedellum carpathicum* Dumitrica (Photos 2 and Table 1).

Co-occurrence of *A.* (?) *amabilis*, *E. unumaense*, *P. turbo*, *S. japonica*, *S. robusta*, *T. plicarum* and *U. latusicostatus* shows upper part of the *Tricolocapsa tetragona* Zone to the *Guexella nudata* Zone indicating middle Callovian in age (Aita, 1987). Co-occurrence of *E. unumaense* and *T. plicarum* suggests the *Tricolocapsa plicarum*

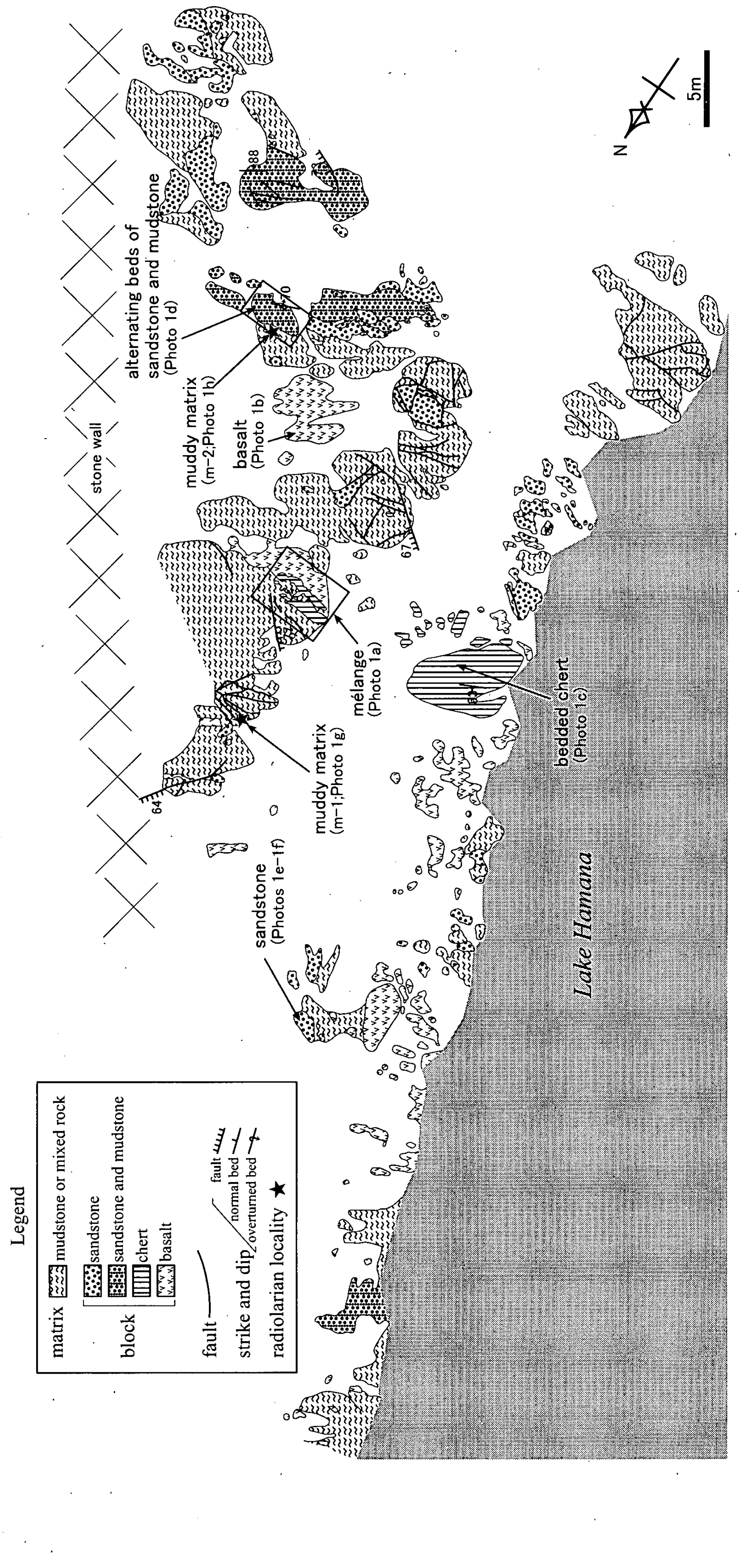
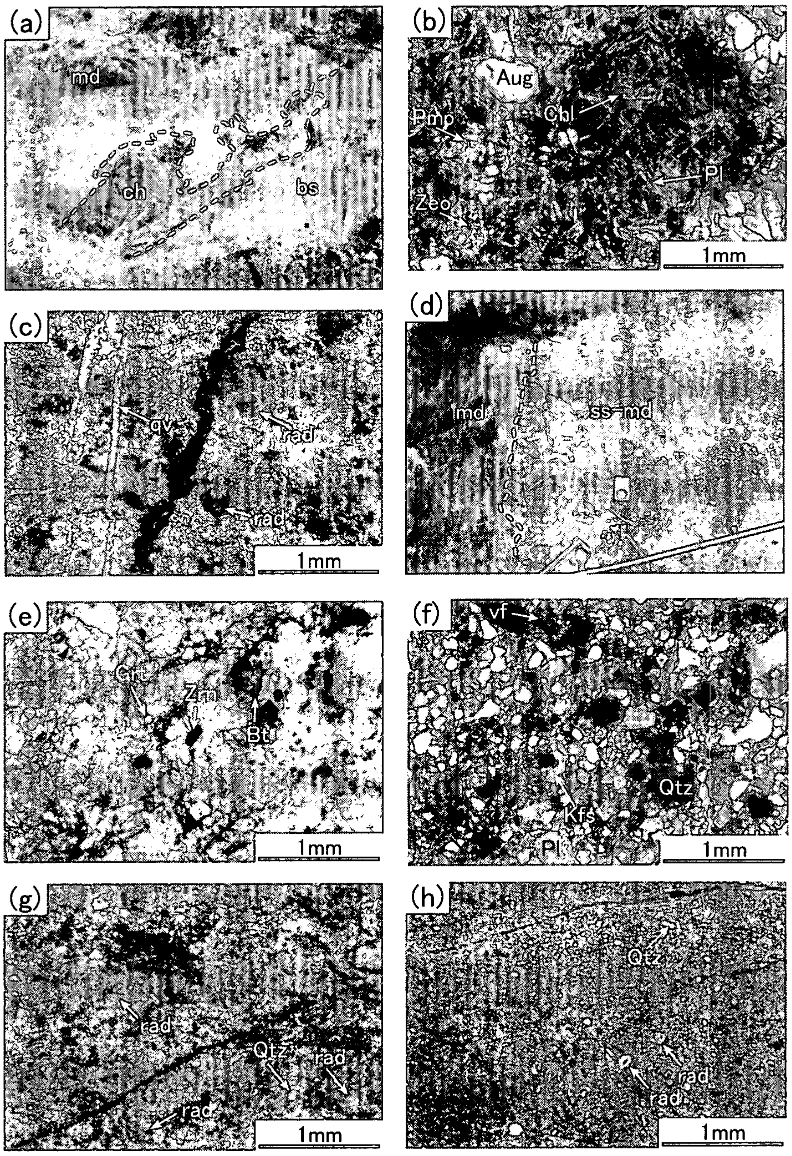
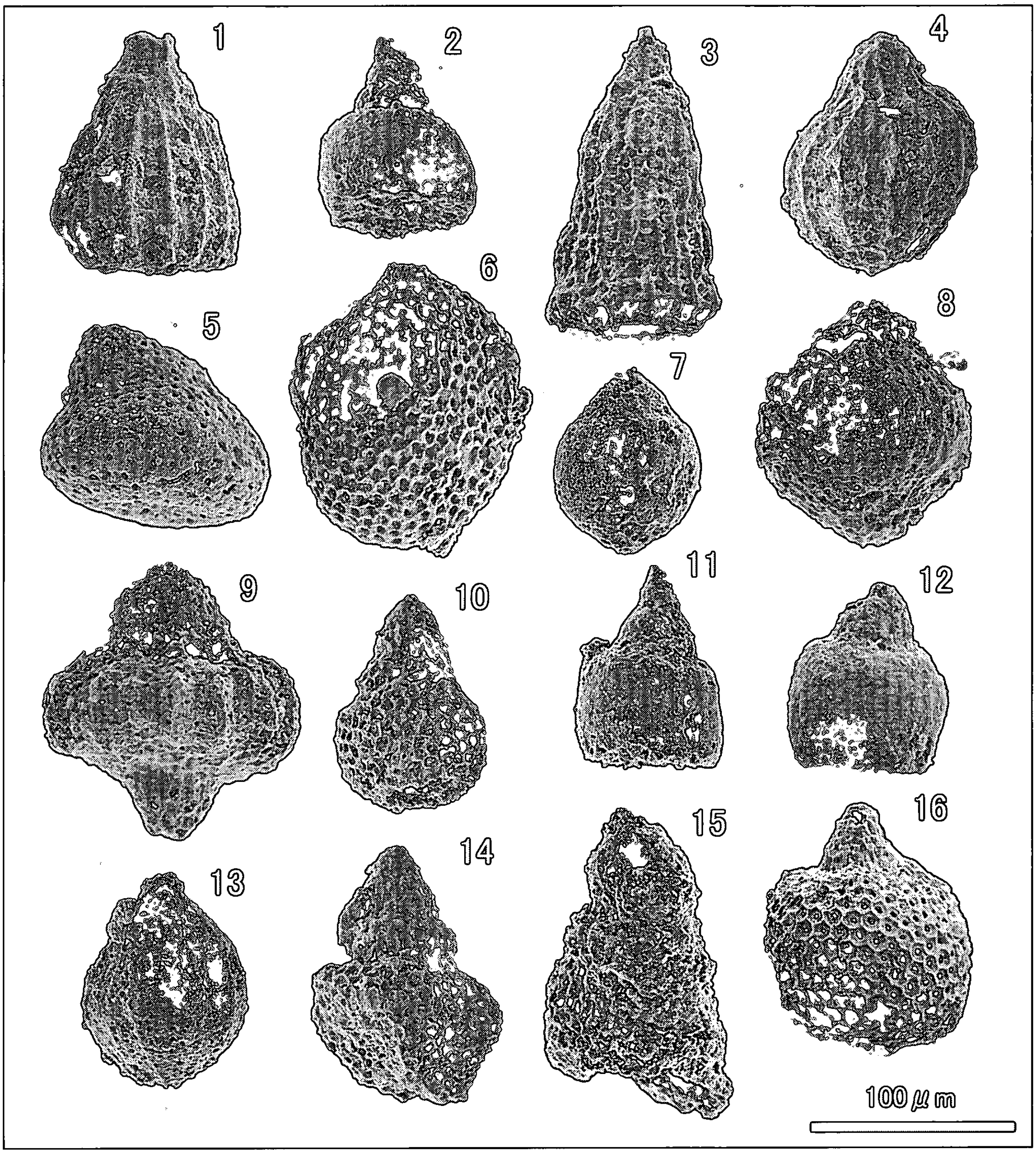


Fig. 3 Route map showing the radiolarian locality (shown in Fig. 2). The mélange includes blocks of basalt, bedded chert, sandstone, and alternating beds of sandstone and mudstone in a matrix of scaly mudstone.



Photos 1 Photographs showing mode of occurrence of the mélange. Sampling points are shown in Fig. 3.
(a) Photograph of mélange including blocks of basalt (bs) and bedded chert (ch) in a matrix of scaly mudstone (md). **(b)** Photomicrograph (crossed polarized light) of a basalt block. Phenocrysts are of idiomorphic augite (Aug). Grounndmass is composed mainly of plagioclase (Pl), interstitial glass and opaque minerals. Amygdules are filled with zeolite (Zeo), pumpellyite (Pmp) and chlorite (Chl). **(c)** Photomicrograph (crossed polarized light) of a chert block. The chert is composed of microcrystalline to cryptocrystalline quartz and contains radiolarian fossils (rad). Quartz veins (qv) cut across the bed of chert. **(d)** Photograph of mélange including blocks of alternating beds of sandstone and mudstone (ss-md) in a matrix of scaly mudstone (md). **(e-f)** Photomicrographs (e: plane polarized light, f: crossed polarized light) of a sandstone block. The sandstone is composed mostly angular to subangular grains of quartz (Qtz), potassium feldspar (Kfs) and plagioclase (Pl) with a small amount of biotite (Bt), muscovite, chlorite, zircon (Zrn), garnet (Grt) and volcanic rock fragments (vf). **(g-h)** Photomicrographs of muddy matrix of the mélange (g: m-1, h: m-2). The mudstones are composed of clay minerals and quartz grains (Qtz). The muddy matrix yields radiolarian fossils (rad). Crossed polarized light.



Photos 2 Radiolarian fossils from m-1 (1–9) and m-2 (10–16). Sampling points are shown in Fig. 3.

1: *Archaeodictyomitra* (?) *amabilis* Aita **2**: *Eucyrtidiellum unumaense* (Yao) **3**: *Hsuum maxwelli* Pessagno **4**: *Protunuma turbo* Matsuoka **5**: *Stichocapsa japonica* Yao **6**: *Stichocapsa robusta* Matsuoka **7**: *Tricolocapsa* (?) aff. *fusiformis* Yao **8**: *Tricolocapsa plicarum* Yao **9**: *Unuma latusicostatus* (Aita) **10**: *Amphipyndax tsunoensis* Aita **11**: *Eucyrtidiellum unumaense* (Yao) **12**: *Eucyrtidiellum pustulatum* Baumgartner **13**: *Protunuma turbo* Matsuoka **14**: *Sethocapsa zweilli* Jud **15**: *Stichomitra* (?) *takanoensis* Aita **16**: *Williriedellum carpathicum* Dumitrica

Table 1 A list of the radiolarians. Sampling points are shown in Fig. 3.

radiolarian species \ sample No.	m-1	m-2
Amphipyndax tsunoensis Aita		●
Archaeodictyomitra (?) *amabilis* Aita	●	
Archaeodictyomitra sp.		●
Eucyrtidiellum pustulatum Baumgartner		●
Eucyrtidiellum unumaense (Yao)	●	●
Hsuum sp.		●
Parasuum sp.	●	
Parvicingula sp.	●	●
Protunuma turbo Matsuoka	●	●
Sethocapsa zweilli Jud		●
Stichocapsa japonica Yao	●	
Stichocapsa robusta Matsuoka	●	
Stichomitra (?) *takanoensis* Aita		●
Tricolocapsa (?) aff. *fusiformis* Yao	●	
Tricolocapsa plicarum Yao	●	
Tricolocapsa sp.	●	●
Unuma latusicostatus (Aita)	●	
Williriedellum carpathicum Dumitrica		●

Zone to the *Tricolocapsa conexa* Zone indicating Bajocian to late Callovian in age (Matsuoka, 1995). In addition, co-occurrence of *T. plicarum*, *T.* (?) aff. *fusiformis* Yao and *P. turbo* suggests the lower to middle part of the *Tricolocapsa conexa* Zone indicating middle to late Bathonian in age (Matsuoka, 1983). Thus, the age of the mudstone of m-1 is restricted to middle to late Bathonian in age (Fig. 4).

Co-occurrence of *A. tsunoensis*, *E. unumaense* and *P. turbo* shows upper part of the *Amphipyndax tsunoensis* Zone indicating late Callovian in age (Aita, 1987). Occurrence of *E. unumaense* suggests the *Tricolocapsa plicarum* Zone to the *Tricolocapsa conexa* Zone indicating Bajocian to late Callovian in age (Matsuoka, 1995). *E. pustulatum* suggests the *Tricolocapsa conexa* Zone to the upper part of the *Stylocapsa* (?) *spiralis* Zone indicating middle Bathonian to middle Oxfordian in age (Matsuoka and Yao, 1986; Nagai and Mizutani, 1990). In addition, the occurrence of *P. turbo* suggests the lower to middle part of the *Tricolocapsa conexa* Zone indicating middle to late Bathonian in age (Matsuoka, 1983). Thus, the age of the mudstone of m-2 is restricted to middle to late Bathonian in age (Fig. 4).

SUMMARY

A mélange of the Miyakoda Formation including blocks of basalt, bedded chert, sandstone and alternating beds of sandstone and mudstone in a matrix of scaly mudstone is well exposed at the western coast of Lake Hamana, Chubu province. Radiolarian fossils from the muddy matrix indicate middle to late Bathonian in age. This fossil evidence indicates that formation of the mélange occurred after late Middle Jurassic time.

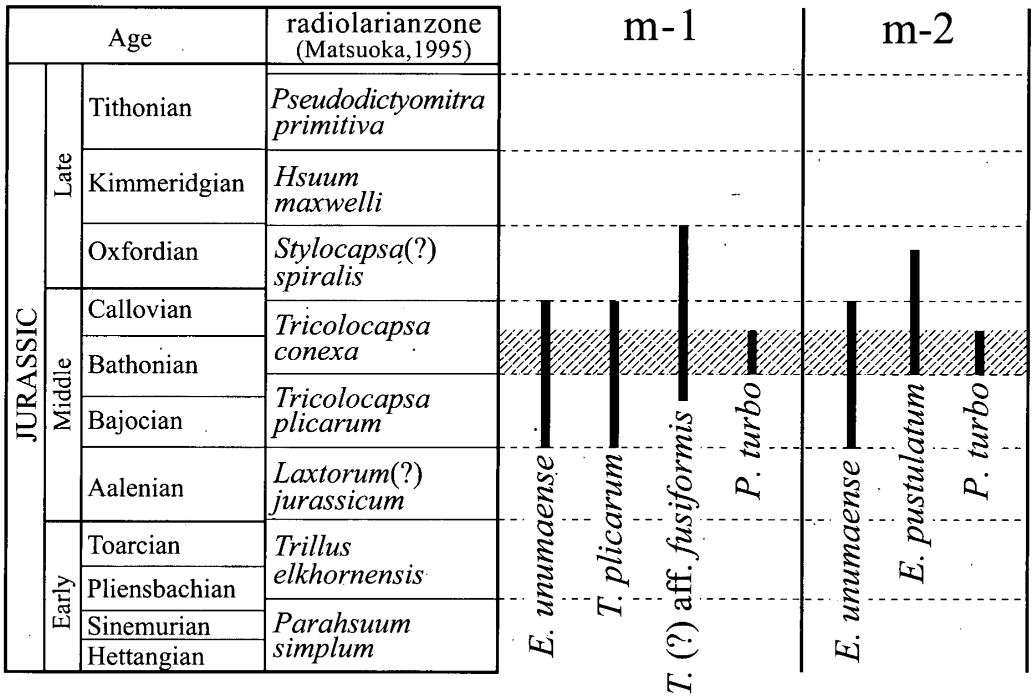


Fig. 4 Ages of each sample. Radiolarian zones are from Matsuoka (1995). Ranges of *E. unumaense*, *H. maxwelli* and *T. plicarum* are after Matsuoka (1995), of *T.* aff. *fusiformis* and *P. turbo* are after Matsuoka (1983), of *E. pustulatum* is after (Nagai and Mizutani, 1990).

ACKNOWLEDGEMENTS

We would like to thank Prof. M. Adachi, Associate Prof. M. Takeuchi and Associate Prof. H. Yoshida for their critical advice. We are grateful to Dr. K. Kashiwagi for his helpful advice during the course of this work. We wish to thank Dr. N. Hori of Geological Survey of Japan for critical reading of the manuscript.

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