Middle Jurassic radiolarians from a siliceous mudstone clast within conglomerate of the Tetori Group in the Itoigawa area, Niigata Prefecture, central Japan

Tsuyoshi ITO, Yusuke SAKAI, Yousuke IBARAKI
and Atsushi MATSUOKA

SCIENCE REPORTS OF NIIGATA UNIVERSITY (GEOLOGY)
No. 29 (2014)

Published by
The Department of Geology, Faculty of Science
Niigata University, Niigata, Japan
31 March 2014

Middle Jurassic radiolarians from a siliceous mudstone clast within conglomerate of the Tetori Group in the Itoigawa area, Niigata Prefecture, central Japan

Tsuyoshi ITO*, Yusuke SAKAI**, Yousuke IBARAKI***
and Atsushi MATSUOKA****

Abstract

Well-preserved radiolarians were extracted from a siliceous mudstone pebble within conglomerate of the Mizukamidani Formation of the Tetori Group in the Itoigawa area, Niigata Prefecture, central Japan. These radiolarians correspond to the assemblage of the Middle Jurassic (*Striatojaponocapsa plicarum* Zone (JR4): Bajocian to early Bathonian). Based on general features of an accretionary complex and previous knowledge of the surrounding geological units in East Asia, the Middle Jurassic (JR4) siliceous mudstone was derived from the latest Middle or Late Jurassic accretionary complexes. This result indicates that the latest Middle or Late Jurassic accretionary complexes had been exposed and denudated in the depositional time of the Mizukamidani Formation.

Key words: conglomerate, etched surface, Jurassic radiolaria, Mizukamidani Formation, Tetori Group, accretionary complexes.

Introduction

The Middle Jurassic to Lower Cretaceous Tetori Group is distributed in the Hokuriku District, central Japan (Fig. 1.2). Some radiolarian fossils have occurred from siliceous rock clasts within conglomerates of the Tetori Group (Kojima, 1986; Saida, 1987; Takeuchi et al., 1991; Matsukawa and Takahashi, 1999; Tomita et al., 2007; Ito et al., 2012). Based on these

* State Key Laboratory of Geo-processes and Mineral Resources, China University of Geosciences, Wuhan 430074, China
** Graduate School of Science and Technology, Niigata University, Niigata 950-2181, Japan
*** Fossa Magna Museum, Ichinomiya 1313, Itoigawa 941-0056, Japan
**** Department of Geology, Faculty of Science, Niigata University, Niigata 950-2181, Japan
(Manuscript received 23 October, 2013; accepted 7 November, 2013)

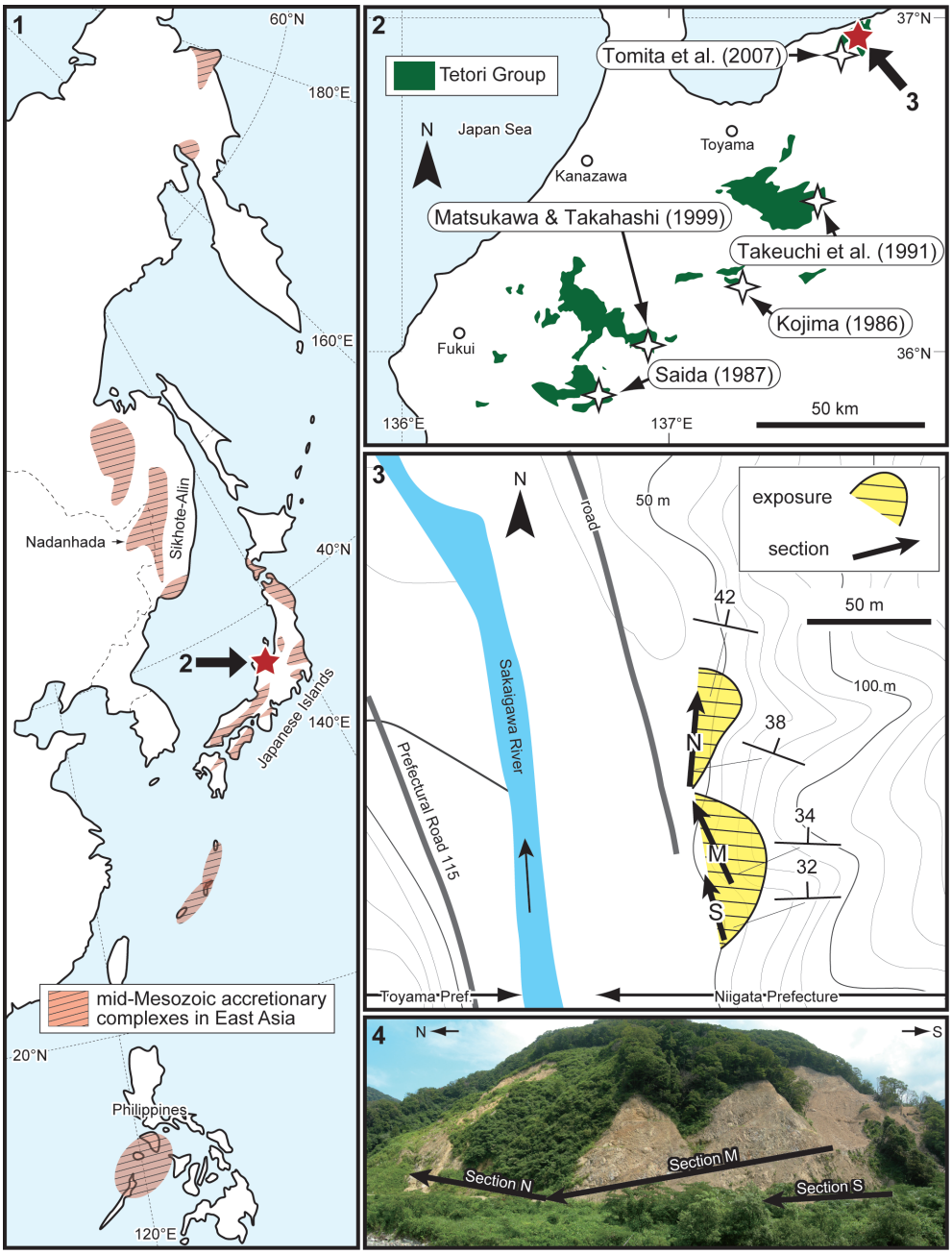

Fig. 1. 1: Distributions of mid-Mesozoic accretionary complexes in East Asia modified from Kojima and Kametaka (2000). 2: Distributions of the Tetori Group (after Maeda, 1961) and radiolarian localities from clasts in previous studies. 3: The studied successions which outcrop along the right bank of the Sakaigawa River. 4: Panoramic view of the study sections from the left bank of the Sakaigawa River.

occurrences, some researchers have discussed the provenances of the Tetori Group. Takeuchi et al. (1991) concluded that the Mino terrane in a broad sense, mid-Mesozoic accretionary complex (AC), was already uplifted and eroded in the late Neocomian (Early Cretaceous) on the basis of the presences of Triassic and Jurassic clasts within conglomerates of the Yakushizawa-migimata Conglomerate Member of the Tetori Group. Matsukawa and Takahashi (1999) found Permian or Triassic chert clasts from the Otaniyama Formation of the Tetori Group in the upper reaches of the Shokawa River. It had been presumed that the Otaniyama Formation corresponds partially to the Upper Jurassic to lowest Cretaceous based on the stratigraphic relationship to the underlying Mitarai Formation, ammonoid-bearing marine deposits. They highlighted the Mino terrane sensu Takeuchi et al. (1991) had been exposed earlier than the age presumed by Takeuchi et al. (1991). However, a Berriasian ammonoid (*Neocosmoceras*) was found from the Mitarai Formation (Sato et al., 2008), indicating that the Otaniyama Formation corresponds to the Lower Cretaceous. In previous studies, valuable radiolarians for detailed age assignments had not occurred from siliceous mudstone clasts of the Tetori Group.

The Itoigawa Mesozoic Research Team has investigated the Mizukamidani Formation of the Tetori Group in the Itoigawa area, Niigata Prefecture, central Japan (Ito et al., 2010, 2012; Sakai et al., 2012, 2013). We obtained Middle Jurassic radiolarian fossils from a siliceous mudstone pebble within conglomerate of the Mizukamidani Formation. In this paper, we report this radiolarian assemblage and speculate the origin of the siliceous mudstone clast.

Geological setting

The Tetori Group is representative sediments from the Middle Jurassic to Early Cretaceous in the Inner Zone of Southwest Japan. The Tetori Group is characterized by marine–terrestrial deposits consisting mainly of clastics and subdivided into the following three subgroups: the Kuzuryu, Itoshiro, and Akaiwa subgroups in ascending order (Maeda, 1961). The Kuzuryu Subgroup consists of marine–brackish strata yielding ammonoids; the Itoshiro Subgroup is composed mainly of brackish–terrestrial strata and characterized by flood plain deposits; the Akaiwa Subgroup consists mainly of brackish–terrestrial strata and is characterized by coarse-grained sandstone formed on braided stream (Isaji, 2010).

The Itoigawa area is located at the west-end of Niigata Prefecture (Fig. 1). The Mesozoic sequences in this area are composed of the Kuruma Group (Lower Jurassic) and the Tetori Group. The Tetori Group in this area consists of the Kurobishiyama Conglomerate, and the Mizukamidani and Shiritakayama formations (e.g., Tomita et al., 2006). The Mizukamidani Formation (Kobayashi et al., 1957) consists mainly of poorly-sorted conglomerates and sandstone. Coaly matters and plant-fossil-fragments occur commonly from the Mizukamidani Formation, while other fossils have barely occurred. Although the Mizukamidani Formation

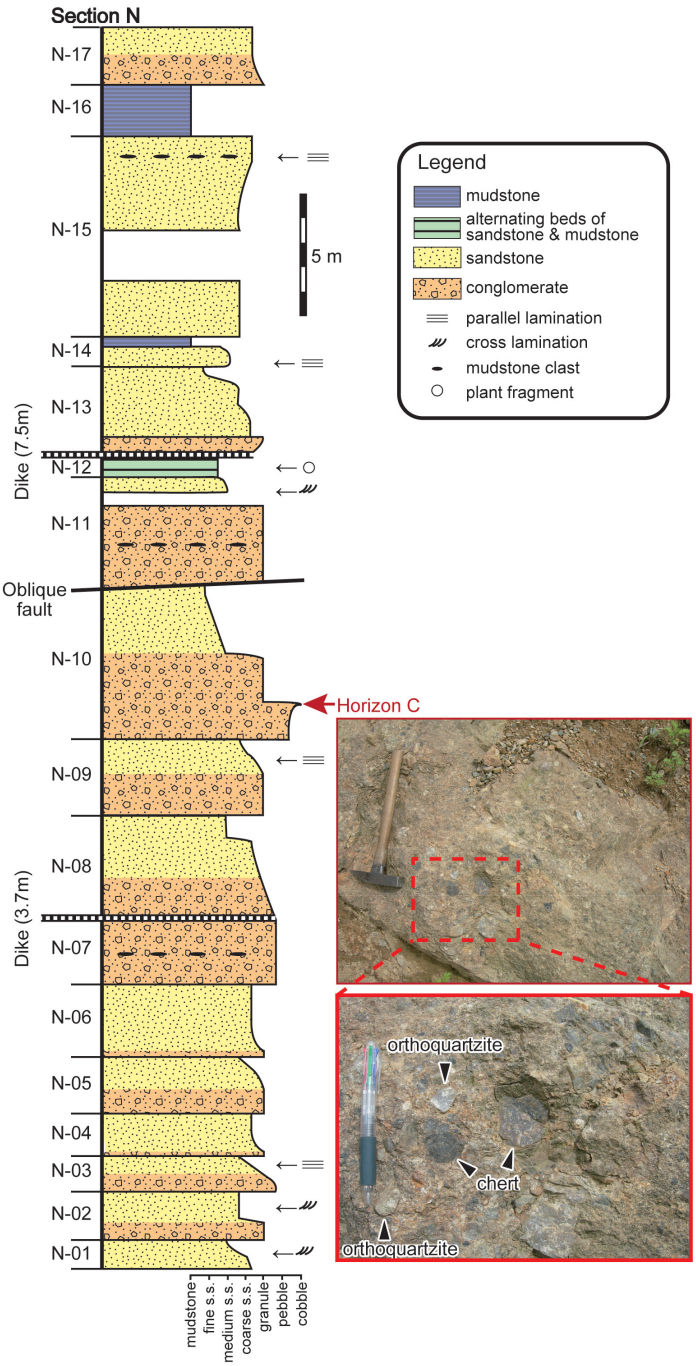

Fig. 2. Stratigraphic column for Section N of the Mizukamidani Formation and the occurrence of conglomerate at Horizon C.

had been formerly considered as the uppermost part of the Kuruma Group (e.g., Kobayashi et al., 1957; Goto, 1983), it has been corresponded to the Akaiwa Subgroup in recent decades (e.g., Takizawa, 1984; Shiraishi 1992; Tomita et al., 2006; Sakai et al., 2012). Based on a zircon U–Pb dating, the youngest zircon grain from the sandstone of the Mizukamidani Formation has the concordant age of 128 Ma (Takeuchi et al., 2013).

The study sections (36°57.556′ N, 137°39.152′ E) outcrop along the right bank of the Sakaigawa River (Figs. 1.3, 1.4). We sectioned three columns, northward-namely S, M, and N (Sakai et al., 2012). These sections are subdivided into 43 subsections. The uppermost part of Section S (S-11 to S-13) and the lowermost part of Section M (M-01 to M-03) are the same horizons. Section M and Section N are successive. These strata approximately strike N80° W and dip 35° N. There are some high-angled oblique faults in the sections. Some bedding faults are recognized in subsection boundaries. The sections are composed mainly of feldspathic-arenite and conglomerates with minor mudstones. The conglomerates are characterized by abundances of chert and orthoquartzite clasts. Fining-upward cycles are repeated in the sections. Coaly matters occur commonly from the sections; plant-fossil-fragments occurred from several horizons; trace fossils are observed. Sakai et al. (2012) reported molluscan fossils from mudstone clasts in the lower S-06 as a first report of mollusks from the Mizukamidani Formation. In this study, we deal with Section N (Fig. 2).

Materials and methods

Ito et al. (2012) collected conglomerate samples from five horizons of Section M and three horizons of Section N. A black siliceous mudstone pebble (IT12050102-1) (Fig. 3.1), dealt in this paper, was collected from Horizon C in Ito et al. (2012). Horizon C is situated in a brown conglomerate layer (3.4 m) in lower N-10 (Fig. 2). Clasts are typically 2 cm in diameter; the largest clasts are approximately 10 cm in diameter. Clasts are sub-rounded to rounded, poorly-sorted, and clast-supported. Chert (black, dark-gray, and gray) and orthoquartzite clasts are dominant; black siliceous mudstone, fine-grained sandstone, and granite clasts are minor; bright-gray very-coarse-grained sandstones are matrices.

The conglomerate sample was cut in hand-size with rock cutter and then soaked in an approximately 5% hydrofluoric acid (HF) solution for one day at room temperature. The HF solution was removed and the etched sample was subsequently refilled with fresh water. The water was removed and the etched sample was dried naturally. Surface of the etched siliceous mudstone without gold coating was photographed with a scanning electron microscope (SEM). A SEM image of the etched surface is shown in Fig. 3.2; SEM images of selected radiolarians are shown in Figs. 3.3–3.12.

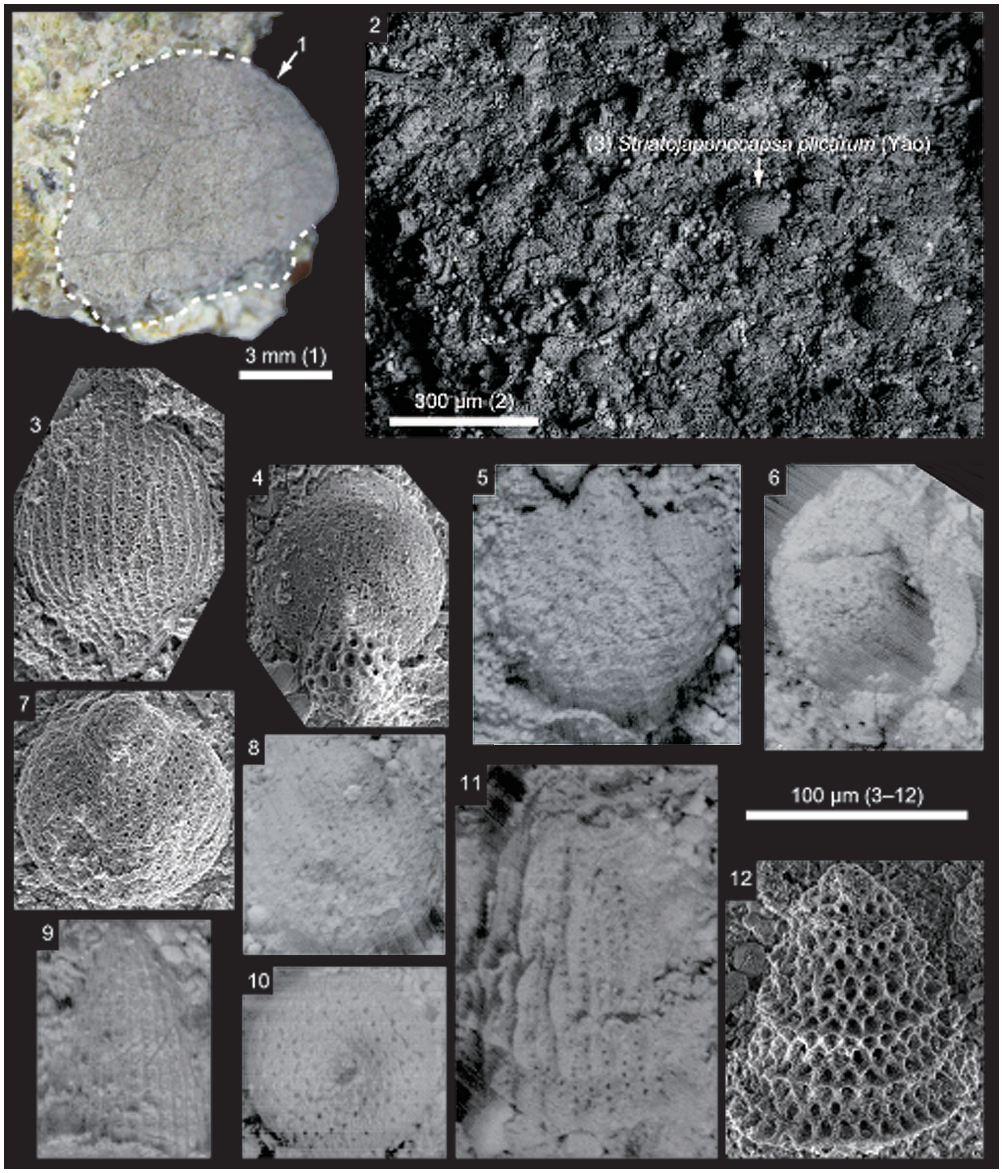

Fig. 3. Photograph of a siliceous mudstone pebble (IT12050102-1) (1), SEM images of enlarged HF-etched surface (2), and radiolarians scattered at the surface (3–12); 3: *Striatojaponocapsa plicarum* (Yao); 4: *Cyrtocapsa mastoidea* Yao; 5–8, 10: closed-end nassellarians; 9: *Archaeodictyomitra* sp.; 11: *Hsuum* sp.; 12: *Parvicingula* sp.

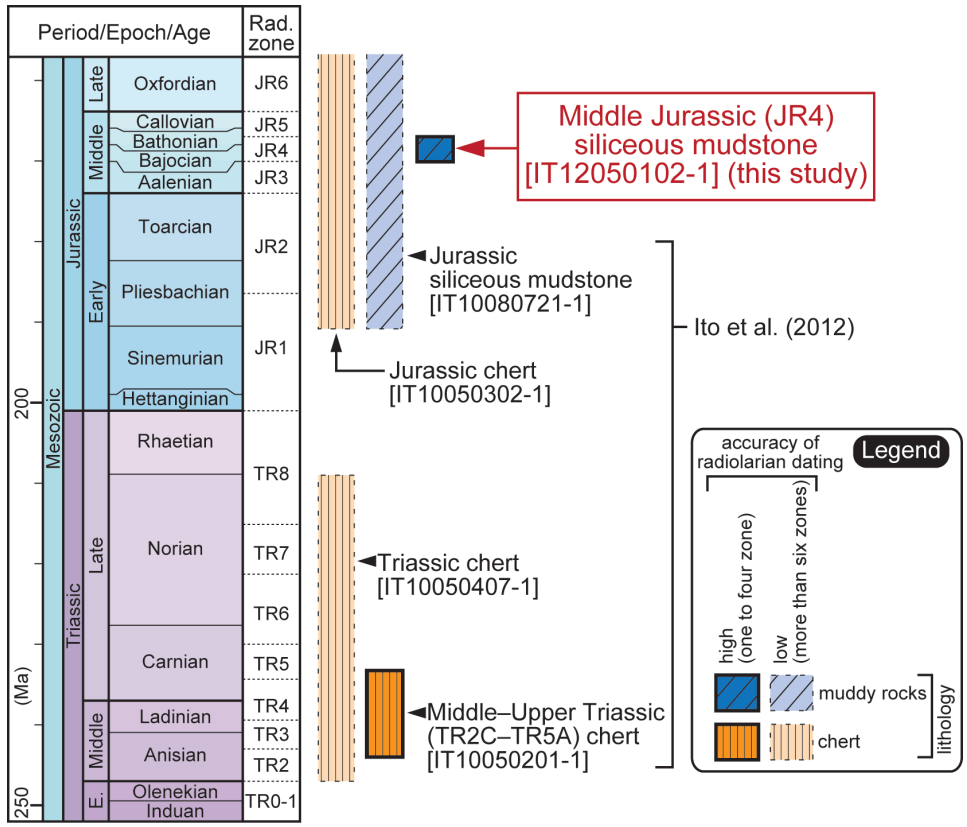

Fig. 4. Relations between the lithology of radiolarian-bearing clasts and their age assignments within conglomerates in the Mizukamidani Formation. Radiolarian zones and their age assignments are after Sugiyama (1997) and Matsuoka (1995).

Radiolarian occurrence

An etched surface of the siliceous mudstone pebble (IT12050102-1) is characterized by dominance of closed-end and multi-segmented nassellarians, and being slightly-matrix-supported (Fig. 3.2). The bioclasts are distributed uniformly in the surface. The preferred orientation of bioclasts is not observed.

The following radiolarians occurred from the siliceous mudstone pebble: *Striatojaponocapsa plicarum* (Yao) (Fig. 3.3), *Cyrtocapsa mastoidea* Yao (Fig. 3.4), closed-end nassellarians (Figs. 3.5–3.8, 3.10), *Archaeodictyomitra* sp. (Fig. 3.9), *Hsuum* sp. (Fig. 3.11), and *Parvicingula* sp. (Fig. 3.12).

Striatojaponocapsa is a key genus of Middle Jurassic and its lineage has been investigated in detail (e.g., Matsuoka, 1983, 1986, 1988; O'Dogherty et al., 2005; Hatakeda et

al., 2007). *Striatojaponocapsa plicarum* is a diagnostic species of the *Striatojaponocapsa plicarum* Zone (JR4) of Matsuoka (1995) and occurs from the *S. plicarum* and *Striatojaponocapsa conexa* zones (JR4 and JR5). *Striatojaponocapsa plicarum* evolved from the *Stichocapsa tegiminis* Yao group (Matsuoka and Yao, 1986; Matsuoka, 1995). The first evolutionary appearance of *S. plicarum* defines the base of the JR4 Zone. The occurrence of *Cyrtocapsa mastoidea* is limited to only the JR4 Zone (Matsuoka, 1983, 1995). Therefore, the siliceous mudstone pebble corresponds to the JR4 Zone (Bajocian to lower Bathonian).

Discussion

This study recognized the Middle Jurassic (JR4) siliceous mudstone clast from the study section, in addition to the Middle to Upper Triassic (TR2C to TR5A zones of Sugiyama, 1997: middle Anisian to middle Carnian) chert, Jurassic chert, Triassic chert, and Jurassic siliceous mudstone clasts of Ito et al. (2012). Based on the previous knowledge of the surrounding geological units in East Asia, these clasts are probably derived from the mid-Mesozoic ACs. Figure 4 shows relations between the lithology of the radiolarian-bearing clasts and their age assignments. The mid-Mesozoic ACs are widely distributed in southwest Japan (Kojima and Kametaka, 2000; Nakae, 2000) and other countries in East Asia (e.g., Russian, China, and the Philippines) (Wakita and Metcalfe, 2005) (Fig. 1.1). Middle Jurassic (JR4) siliceous mudstones have occurred from some geologic bodies of the mid-Mesozoic ACs, such as the Kamiaso Complex of the Mino terrane (Matsuoka, 1988), the Togano Unit of the Southern Chichibu terrane (Matsuoka, 1983), the Otori Formation of the North Kitakami terrane (Suzuki et al., 2007), the Khabarovsk Complex in Russian (Kojima et al., 1991), and the Northern Busuanga Belt in the Philippines (Zamoras and Matsuoka, 2001). Based on the general feature of an AC and the previous occurrences as mentioned above, the Middle Jurassic (JR4) siliceous mudstone clast was derived from the latest Middle or Late Jurassic ACs. In other words, the middle Middle Jurassic and older ACs should not include Middle Jurassic (JR4) siliceous mudstones. Hence the siliceous mudstone clast from this study should not be originated from the middle Middle Jurassic and older ACs but some of the latest Middle or Late Jurassic ACs such as the above geological bodies or corresponding ones.

Although some researchers have reported radiolarian occurrences from clasts within the Tetori Group, there has no occurrence of valuable Mesozoic radiolarians for age assignment from siliceous mudstone clasts. The result of this study, the first report of Middle Jurassic siliceous mudstone clast, indicates that the latest Middle or Late Jurassic accretionary complexes had been exposed and denudated in the depositional time of the Mizukamidani Formation.

Acknowledgements

We express our thanks to Dr. T. Kurihara of Niigata University for his critical review of the manuscript. We wish to thank Mr. N. Handa of Shinshushinmachi Fossil Museum for his valuable comments and information of some papers about the Tetori Group. We are grateful to the Itoigawa Mesozoic Research Team for their cooperation with the making the columnar section in this study. We extend our gratitude to the following persons. Some radiolarian photomicrographs (Figs. 3.2, 3.5, 3.6, 3.8–3.11) were taken with a SEM of Dr. T. Nishiumi of Niigata University; Mr. T. Ogawara of Niigata University kindly helped us to use the SEM. This study is the achievement of a part of the Niigata University–Itoigawa City Initiative since 2010.

References

Goto, M., 1983, Some bivalves from the Lower Jurassic Kuruma Group of central Japan. *Trans. Proc. Palaeont. Soc. Japan*, **130**, 79–85.

Hatakeda, K., Suzuki, N. and Matsuoka, A., 2007, Quantitative morphological analyses and evolutionary history of the Middle Jurassic polycystine radiolarian genus *Striatojaponocapsa* Kozur. *Marine Micropaleont.,* **63**, 39–56.

Isaji, S., 2010, Tetori Group. *In* Palaeontological Society of Japan, ed., *Palaeontological Encyclopedia,* Asakura Publishing, Tokyo, 368 (in Japanese).

Ito, T., Ishida, N., Ibaraki, Y., Umetsu, T., Sakai, Y., Nakada, K., Matsumoto, A., Yoshino, K. and Matsuoka, A., 2010, Lithology of the Mizukamidani Formation in the Itoigawa area of Niigata Prefecture, and radiolarian fossils from conglomerate –Mesozoic in Itoigawa Part 1–. *117th Ann. Meet. Geol. Soc. Japan, Abstr.,* 59 (in Japanese).

Ito, T., Sakai, Y., Ibaraki, Y., Yoshino, K., Ishida, N., Umetsu, T., Nakada, K., Matsumoto, A., Hinohara, T., Matsumoto, K. and Matsuoka, A., 2012, Radiolarian fossils from siliceous rock pebbles within conglomerates in the Mizukamidani Formation of the Tetori Group in the Itoigawa area, Niigata Prefecture, central Japan. *Bull. Itoigawa City Mus.,* no. 3, 13–25 (in Japanese with English abstract).

Kobayashi, T., Konishi, K., Sato, T., Hayami, I. and Tokuyama, A., 1957, On the Lower Jurassic Kuruma Group. *Jour. Geol. Soc. Japan,* **63**, 182–194 (in Japanese with English abstract).

Kojima, S., 1986, Occurrence of Permian radiolarians from chert pebbles in conglomerate at Yokoo, Nyukawa Village, Gifu prefecture, central Japan. *News Osaka Micropaleontol., Spec. Vol.,* no. 7, 175–179 (in Japanese with English abstract).

Kojima, S. and Kametaka, M., 2000, Jurassic accretionary complexes in East Asia. *Mem. Geol. Soc. Japan,* no. 55, 61–72 (in Japanese with English abstract).

Kojima, S., Wakita, K., Okamura, Y., Natal'in, B. A., Zyabrev, A. V., Zhang, Q. L. and Shao, J. A., 1991, Mesozoic radiolarians from the Khabarovsk complex, eastern USSR: their significance in relation to the Mino terrane, central Japan. *Jour. Geol. Soc. Japan,* **97**, 549–552.

Maeda, S., 1961, On the geological history of the Mesozoic Tetori Group in Japan. *Jour.*

College Arts and Sci., Chiba Univ., **3**, 369–426 (in Japanese with English abstract).

Matsukawa, M. and Takahashi, O., 1999, Radiolarian fossils occurred from the Itoshiro Subgroup of the Tetori Group and its geological significance. *106th Ann. Meet. Geol. Soc. Japan, Abstr.,* 165 (in Japanese).

Matsuoka, A., 1983, Middle and Late Jurassic radiolarian biostratigraphy in the Sakawa and adjacent areas, Shikoku, southwest Japan. *Jour. Geosci., Osaka City Univ.,* **26**, 1–49.

Matsuoka, A., 1986, Stratigraphic distribution of two species of *Tricolocapsa* in the Hisuikyo Section of the Kamiaso area, Mino Terrane. *News Osaka Micropaleontol., Spec. Vol.,* no. 7, 59–62 (in Japanese with English abstract).

Matsuoka, A., 1988, First appearance biohorizon of *Tricolocapsa conexa* within Jurassic siliceous mudstone sequence of the Kamiaso area in the Mino terrane, central Japan–a correlation of radiolarian zones of the Middle Jurassic. *Jour. Geol. Soc. Japan,* **94**, 583–590.

Matsuoka, A., 1995, Jurassic and Lower Cretaceous radiolarian zonation in Japan and in the western Pacific. *Island Arc,* **4**, 140–153.

Matsuoka, A. and Yao, A., 1986, A newly proposed radiolarian zonation for the Jurassic of Japan. *Marine Micropaleont.,* **11**, 91–106.

Nakae, S., 2000, Regional correlation of the Jurassic accretionary complex in the Inner Zone of Southwest Japan. *Mem. Geol. Soc. Japan,* no. 55, 73–98 (in Japanese with English abstract).

O'Dogherty, L., Bill, M., Goričan, S., Dumitrica, P. and Masson, H., 2005, Bathonian radiolarians from an ophiolitic mélange of the Alpine Tethys (Gets Nappe, Swiss-French Alps). *Micropaleontology,* **51**, 425–485.

Sakai, Y., Ito, T., Ibaraki, Y., Yoshino, K., Ishida, N., Umetsu, T., Nakada, K., Matsumoto, A., Hinohara, T., Matsumoto, K. and Matsuoka, A., 2012, Lithology and stratigraphy of the Mizukamidani Formation of the Tetori Group in the right bank of the Sakai River in the Itoigawa area, Niigata Prefecture, Japan. *Bull. Itoigawa City Mus.,* no. 3, 1–11 (in Japanese with English abstract).

Sakai, Y., Kitagawa, Y., Uehara, K., Takagi, S., Ibaraki, Y. and Matsuoka, A., 2013, Plant and molluscan fossils from the Mizukamidani Formation of the Tetori Group in the right bank of the Sakaigawa River in the Itoigawa area, Niigata Prefecture, Japan –Mesozoic in Itoigawa Part 2–. *120th Ann. Meet. Geol. Soc. Japan, Abstr.,* 293 (in Japanese).

Saida, T., 1987, Triassic and Jurassic radiolarians in chert clasts of the Tetori Group in Tamodani area of Izumi Village, Fukui Prefecture, central Japan. *Jour. Geol. Soc. Japan,* **93**, 57–59 (in Japanese).

Sato, T., Asami, T., Hachiya, K. and Mizuno, Y., 2008, Discovery of *Neocosmoceras,* a Berriasian (early Cretaceous) ammonite, from Mitarai in the upper reaches of the Shokawa River in Gifu Prefecture, Japan. *Bull. Mizunami Fossil Mus.*, no. 34, 77–80 (in Japanese with English abstract).

Shiraishi, S., 1992, The Hida Marginal Tectonic Belt in the middle reaches of the River Himekawa with special reference to the lower Jurassic Kuruma Group. *Earth Sci.* (*Chikyu Kagaku*), **46**, 1–20 (in Japanese with English abstract).

Sugiyama, K., 1997, Triassic and Lower Jurassic radiolarian biostratigraphy in the siliceous claystone and bedded chert units of the southeastern Mino Terrane, central Japan. *Bull. Mizunami Fossil Mus.*, no. 24, 79–193.

Suzuki, N., Yamakita, S., Takahashi, S. and Ehiro, M., 2007, Middle Jurassic radiolarians from

carbonate manganese nodules in the Otori Formation in the eastern part of the Kuzumaki–Kamaishi Subbelt, the North Kitakami Belt, Northeast Japan. *Jour. Geol. Soc. Japan,* **113**, 274–277 (in Japanese with English abstract).

Takeuchi, M., Kawahara, K. and Tomita, S., 2013, Development of sedimentary basin of the Lower Cretaceous Tetori Group in the northeast Toyama Prefecture, based on clast composition and age distribution of detrital zircon. *120th Ann. Meet. Geol. Soc. Japan, Abstr.*, 81 (in Japanese).

Takeuchi, M., Saito, M. and Takizawa, F., 1991, Radiolarian fossils obtained from conglomerate of the Tetori Group in the upper reaches of the Kurobegawa River, and its geologic significance. *Jour. Geol. Soc. Japan,* **97**, 345–359 (in Japanese with English abstract).

Takizawa, F., 1984, Upper limit of the Kuruma Group of the Hida Gaien belt and overlying strata. *91st Ann. Meet. Geol. Soc. Japan, Abstr.,* 202 (in Japanese).

Tomita, S., Takeuchi, M. and Kametaka, M., 2007, Radiolarian fossils obtained from conglomerate of the Tetori Group in the northeastern part of Toyama Prefecture and its geological significance. *114th Ann. Meet. Geol. Soc. Japan, Abstr.,* 243 (in Japanese).

Tomita, S., Takeuchi, M., Yokota, H. and Tokiwa, T., 2006, Stratigraphy and geological structure of the Tetori Group in the northeastern part of the Hida Gaien Belt. *113th Ann. Meet. Geol. Soc. Japan, Abstr.,* 179 (in Japanese).

Wakita, K. and Metcalfe, I., 2005, Ocean Plate Stratigraphy in East and Southeast Asia. *Jour. Asian Earth Sci.,* **24**, 679–702.

Zamoras, L. R. and Matsuoka, A., 2001, Malampaya Sound Group: a Jurassic-Early Cretaceous accretionary complex in Busuanga Island, North Palawan Block (Philippines). *Jour. Geol. Soc. Japan,* **107**, 316–336.