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FIRST APPEARANCE BIOHORIZON OF *TRICOLOCAPSA CONEXA* WITHIN JURASSIC SILICEOUS MUDSTONE SEQUENCES OF THE KAMIASO AREA IN THE MINO TERRANE, CENTRAL JAPAN—A CORRELATION OF RADIOLARIAN ZONES OF THE MIDDLE JURASSIC

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Abstract Vertical distribution of *Tricolocapsa plicarum* YAO and *Tricolocapsa conexa* MATSUOKA in the Kashibara and Hisuikyo sections has been investigated. As a result, it is clarified that *T. conexa* first occurs within both sections. The boundary between *Tricolocapsa plicarum* Zone and the *Tricolocapsa conexa* Zone is situated about 13 m higher than that between the *Unuma echinatus* Assemblage-zone and the *Dictyomitrella*(?) *kamoensis—Pantanellium foveatum* Assemblage-zone by MIZUTANI and KIDO (1983) in the Kashibara section and about 15 m higher than the above in the Hisuikyo section. In the Kashibara section, black mudstone, conformably overlying greenish gray siliceous mudstone, corresponds to the upper part of the *T. conexa* Zone.

Introduction

Our knowledge of Jurassic radiolarians has been rapidly accumulated in this decade. Because several workers in Japan proposed independently Jurassic radiolarian zonation, a number of radiolarian zones exist in the Japanese Jurassic (YAO, 1986). These zones need to be correlated.

We established eight radiolarian zones for the Jurassic of Japan through biostratigraphic study on stratigraphically continuous sections in the Southern Chichibu and Mino Terranes (MATSUOKA & YAO, 1986). In our zonal scheme, two zones are recognized in the Middle Jurassic part, namely the *Tricolocapsa plicarum* Zone and the *Tricolocapsa conexa* Zone in ascending order. The boundary of two zones is defined by the evolutionary first appearance biohorizon of *T. conexa* MATSUOKA where *T. conexa* diverges from its ancestral species, *T. plicarum* YAO (MATSUOKA, 1983 ; MATSUOKA & YAO, 1986).

While in the Mino Terrane, two successive radiolarian zones of Middle Jurassic age, the *Unuma echinatus* Assemblage-zone and the *Dictyomitrella*(?) *kamoensis* — *Pantanellium foveatum* Assemblage-zone, are recognized in the continuous sequences of the Kamiaso area (KIDO *et al.*, 1982 ; MIZUTANI & KIDO, 1983).

In order to correlate our zones to those of the above-mentioned authors , I reinvestigated the radiolarian biostratigraphy in the same stratigraphic sequences of the Kamiaso area (MATSUOKA, 1986). In this paper, the first appearance biohorizon of *T. conexa* is determined within two continuous sequences and the stratigraphic relationship between the zonal boundary of MIZUTANI & KIDO (1983) and that of MATSUOKA (1983) is discussed. In addition, radiolarian content of a black mudstone conformably overlying siliceous mudstone, is reported and its biostratigraphic position is clarified.

Geologic setting

The Kamiaso area (Fig. 1) has geologically been surveyed by many workers (MIZUTANI, 1964 ; ADACHI & MIZUTANI, 1971 ; KANO,

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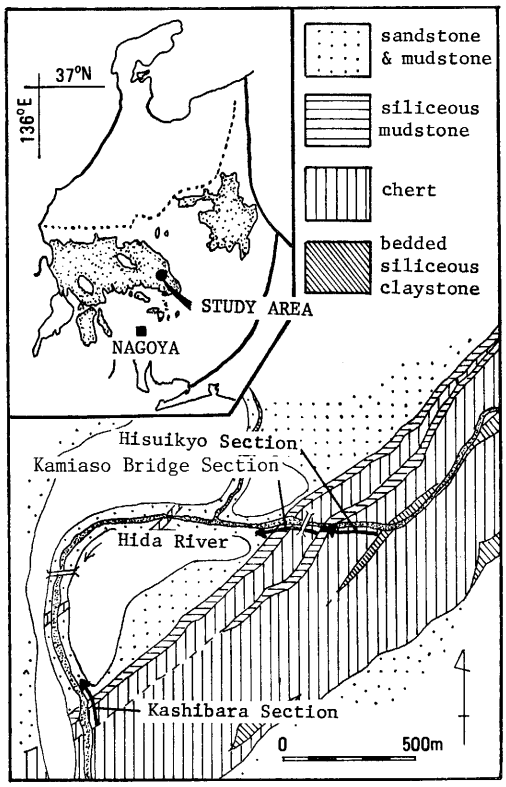


Fig. 1. Geological map of the Kamiaso area. The dotted area in the inset map shows the distribution of the Mesozoic-Paleozoic sedimentary complex of the Mino Terrane, central Japan. Modified from KIDO (1982) and MIZUTANI & KIDO (1983).

1979; KIDO, 1982). Radiolarian studies have been done by NAKASEKO & NISHIMURA (1979), KIDO *et al.* (1982), MIZUTANI & KIDO (1983), MATSUDA & ISOZAKI (1982), ISOZAKI & MATSUDA (1985) and MATSUOKA (1986).

KIDO (1982) and MIZUTANI & KIDO (1983) presented a detailed geological map of the Kamiaso area (Fig. 1). In this area, a stratigraphic sequence consisting of bedded siliceous claystone, chert, siliceous mudstone, black mudstone and coarse clastics units in ascending order is recognized. The sequence (chert-clastics sequence) is an upward coarsening one and is tectonically piled up to form an imbricate structure dipping NW. KIDO *et al.* (1982) reported radiolarians from the siliceous mudstone unit of three measured stratigraphic sections, namely the Kashibara, Hisuikyo and Kamiaso Bridge sections (Fig. 1). Because MIZUTANI & KIDO (1983) separated the siliceous mudstone unit in the first two sections into two successive radiolarian zones, the Kashibara and Hisuikyo sections (Fig. 1) are reexamined in the present study.

Lithostratigraphy of the study sections

KIDO (1982) described the lithology and lithostratigraphy in the study sections. A brief description of them are made below. Tables 1 and 2 give the list of sample lithology, abundance of radiolarians and degree of preservation of radiolarian tests for the Kashibara and Hisuikyo sections, respectively.

1. Kashibara section

The Kashibara section consists of chert, siliceous mudstone and black mudstone units in ascending order. Fig. 2 shows a sketch map of the upper part of the section. The chert unit is composed of vari-colored bedded chert and is in fault contact with the siliceous mudstone unit. The fault zone, ranging 0.5—1.0 m in thickness, is characterized by lens-like chert blocks and a consolidated siliceous mudstone matrix. The siliceous mudstone unit is composed mainly of siliceous mudstone associated subordinately with mudstone and sandstone. The siliceous mudstone is gray, greenish gray and red and is interbedded with thin mudstone layers. The siliceous mudstone unit changes vertically in lithology. Red siliceous mudstone occurs dominantly in the lower part, while red siliceous mudstone is not recognized in the upper part of this unit. The black mudstone unit consists of weakly stratified black mudstone and thin (2—5 cm) sandstone layers. The unit seems to overlie conformably the siliceous mudstone unit. An oblique fault cuts the siliceous mudstone and black mudstone units in this section. Judging from the separation of units by the fault, observable in the boundary between the siliceous mudstone and black mudstone units, the MKS–6b horizon is set above the MKS–9.5a horizon in the columnar section (Fig. 3). In the Kashibara section, more than 40 samples were collected from the siliceous mudstone and black mudstone units for this study.

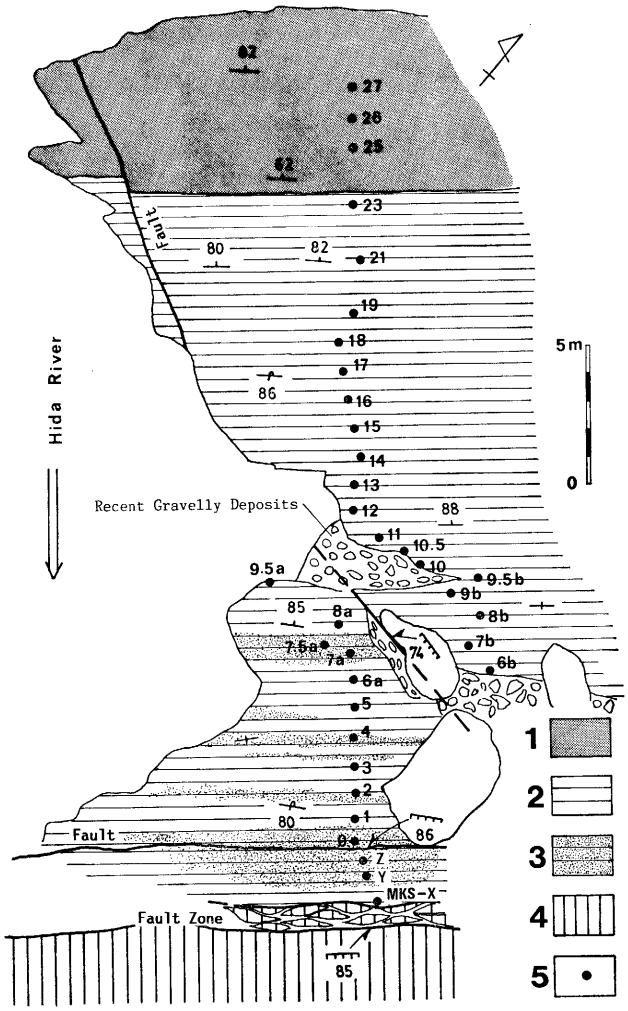


Fig. 2. Sketch map of the Kashibara section. 1. black mudstone unit, 2, 3. siliceous mudstone unit (3. red siliceous mudstone), 4. chert unit, 5. sampling point.

Table 1. List of samples from the Kashibara section, showing lithology, abundance of radiolarian content (A), degree of preservation (P).

Sample	Lithology	A	P
MKS-27	black ms	F	M
26	black ms	F	P
25	black ms	F	P
23	gray sil.ms	C	M
21	gray sil.ms	C	G
19	gray sil.ms	C	M
18	gray sil.ms	C	M
17	gray sil.ms	C	M
16	gray sil.ms	C	M
15	gray sil.ms	C	M
14	gray sil.ms	C	M
13	gray sil.ms	C	M
12	gray sil.ms	C	M
11	gray sil.ms	A	G
10.5	gray sil.ms	C	M
10	gray sil.ms	A	M
9.5b	gray sil.ms	C	M
9b	gray sil.ms	A	G
8b	gray sil.ms	A	G
7b	gray sil.ms	A	M
6b	gray sil.ms	A	G
9.5a	gray sil.ms	C	M
8a	gray sil.ms	A	G
7.5a	red sil.ms	A	M
7a	red sil.ms	A	M
6a	gray sil.ms	A	M
5	gray sil.ms	A	G
4	red sil.ms	A	M
3	gray sil.ms	A	G
2	red sil.ms	C	M
1	gray sil.ms	A	M
0	red sil.ms	A	M
Z	red sil.ms	A	M
Y	red sil.ms	A	M
X	red sil.ms	A	M

Abbreviations are as follows, sil. ; siliceous, A ; abundant, C ; common, F ; few, G ; good, M ; moderate, P ; poor.

Samples which contain few radiolarians and/or ill-preserved tests are ommitted in the list. After the selection, 35 samples are examined and used in this study (Figs. 2, 3, Table 1).

2. Hisuikyo section

Kido (1982) figured a sketch map of the Hisuikyo section and showed sampling points for radiolarian fossils (Fig. 4). This section is composed of chert, hard siliceous mudstone and siliceous mudstone units in ascending order. Because the hard siliceous mudstone unit yields a radiolarian assemblage older than the *Unuma echinatus* Assemblage (Kido, 1982), only strata above the base of the siliceous mudstone unit are treated in this study. The top of the siliceous mudstone unit is in fault contact with the chert unit which is the base of the neighboring chert-clastics sequence. In the Hisuikyo section, 12 samples were collected (Table 2). Sampling points for this study are added on the original sketch map and columnar section by Kido (1982) and Kido *et al.* (1982) (Figs. 4, 5). All samples contain a large number of moderately to well

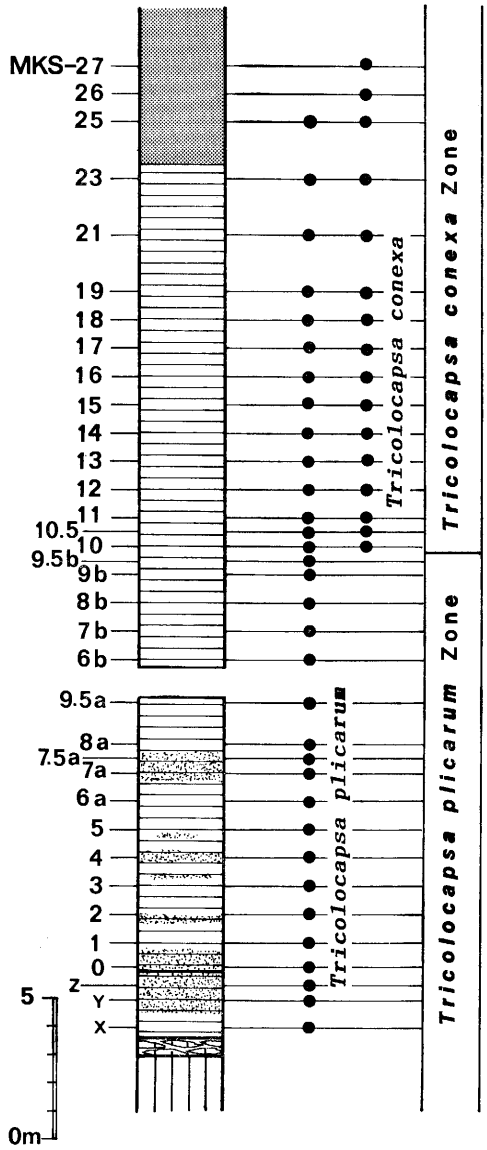


Fig. 3. Vertical distribution of *Tricolocapsa plicarum* and *Tricolocapsa conexa* in the Kashibara section. For lithology of the columnar section see Fig. 2.

preserved radiolarian tests.

First appearance biohorizon of *Tricolocapsa conexa* and a correlation of zones

Vertical distribution of *Tricolocapsa plicarum* YAO (Plate I–1, 2) and *Tricolocapsa conexa* MATSUOKA (Plate I–3, 4, 5) is presented in Figs. 3 and 5 for the Kashibara and Hisuikyo sections, respectively. *T. plicarum* occurs almost in all horizons of both sections. On the other hand, *T. conexa* first occurs at the MKS–10 horizon in the Kashibara section and at the MHS–C horizon in the Hisuikyo section, and occurs in all horizons higher than the horizon of the first occurrence. Therefore the first appearance biohorizon of *T. conexa* exists at a certain horizon between MKS–9.5b and MKS–10 in the Kashibara section (Fig. 3) and between MKS–B and MKS–C in the Hisuikyo section (Fig. 5). According to the zonal definition by MATSUOKA (1983) and MATSUOKA & YAO (1986), the zonal boundary between the *T. plicarum* Zone and the *T. conexa* Zone is placed at the above-mentioned horizons within these two sections (Figs. 3, 5).

Table 2. List of samples from the Hisuikyo section. For abbreviations see Table 1.

Sample	Lithology	A	P
MHS-D	gray sil.ms	C	G
C	gray sil.ms	C	M
B	gray sil.ms	A	M
A	gray sil.ms	C	M
13.8	gray sil.ms	A	G
12	gray sil.ms	A	G
10	gray sil.ms	C	M
08	gray sil.ms	A	G
06	red sil.ms	A	M
04	gray sil.ms	A	G
02	gray sil.ms	A	G
00	gray sil.ms	A	M

KIDO *et al.* (1982) and MIZUTANI & KIDO (1983) distinguished two successive zones on the basis of differences of radiolarian assemblage, namely the *Unuma echinatus* Assemblage and the *Dictyomitrella* (?) *kamoensis* —*Pantanellium foveatum* Assemblage in ascending order, in the Kashibara and Hisuikyo sections (Fig. 6). Their *Unuma echinatus* Assemblage-zone occupies a few meters of the lower part of both sections. The rest of the siliceous mudstone unit is assigned to the *D.* (?) *kamoensis* —*P. foveatum* Assemblage-zone.

The boundary between the *T. plicarum* and *T. conexa* Zones is situated about 13m in the Kashibara section and about 15m in the

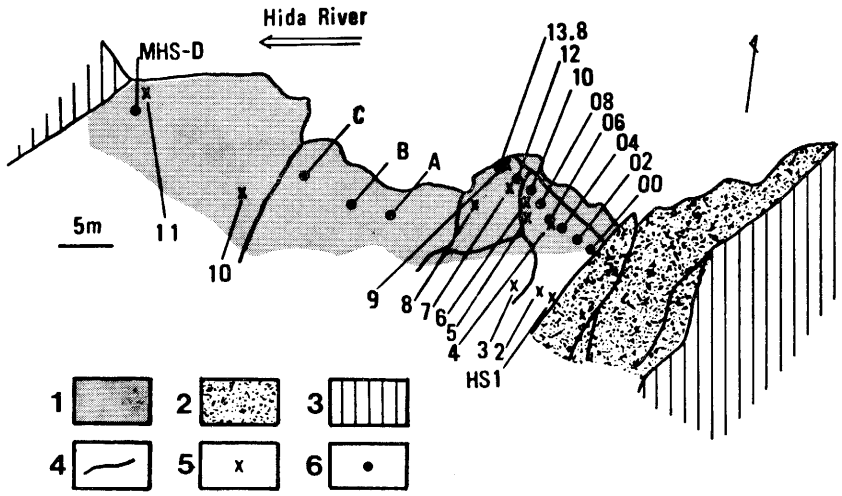


Fig. 4. Sketch map of the Hisuikyo section, showing sampling points of rock specimens. Original sketch map from KIDO (1982). 1. siliceous mudstone unit, 2. hard siliceous mudstone unit, 3. chert unit, 4. fault, 5. sampling point by KIDO (1982), 6. sampling point in this study.

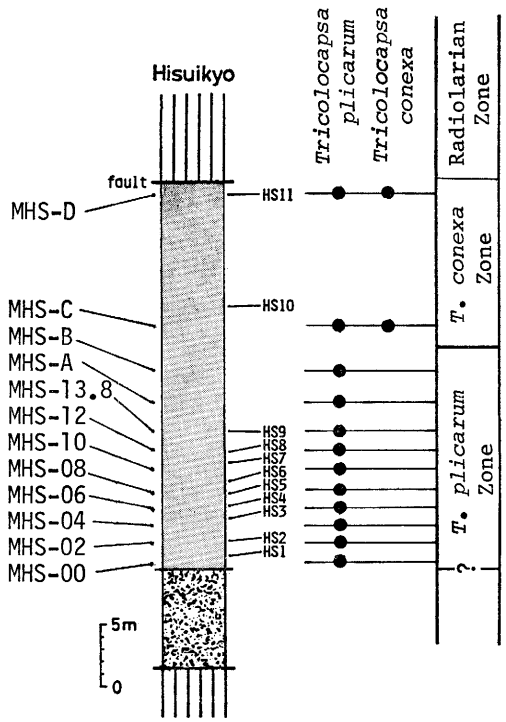


Fig. 5. Vertical distribution of *Tricolocapsa plicarum* and *Tricolocapsa conexa* in the Hisuikyo section. Original columnar section comes from KIDO *et al.* (1982). For lithology of the columnar section see Fig. 4.

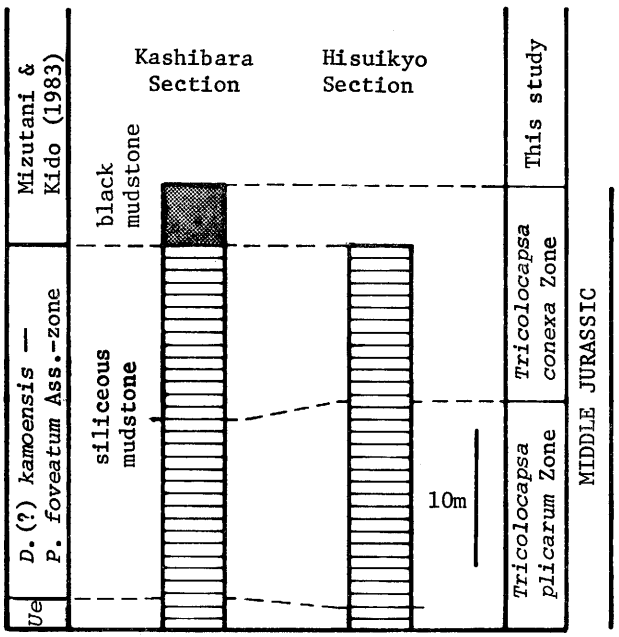
Hisuikyo section higher than that between the *U. echinatus* and *D.*(?) *kamoensis*—*P. foveatum* Assemblage-zones. Consequently, the lower part of the *D.* (?) *kamoensis* — *P. foveatum* Assemblage-zone corresponds to the upper part of the *T. plicarum* Zone.

Radiolarian content in the black mudstone unit

Although Jurassic radiolarians were reported from the chert and siliceous mudstone units in the study area by many workers (KIDO *et al.*, 1982 ; KIDO, 1982 ; MIZUTANI & KIDO, 1983 ; MATSUDA & ISOZAKI, 1982 ; ISOZAKI & MATSUDA, 1985 ; MATSUOKA, 1986), radiolarians from the black mudstone unit, which overlies the siliceous mudstone unit, have not been reported yet.

Three samples (MKS–25, –26, –27) of the black mudstone unit in the Kashibara section yield preserved radiolarians enough to determine their biostratigraphic positions. Radiolarian tests in the black mudstone is generally worse than those in the siliceous mudstone in preservation. Fossil content in the black mudstone is also less than that in the siliceous mudstone.

Among the three samples, MKS–27 yields the best preserved radiolarians. The sample (MKS–27) contains the following species ; *Tricolocapsa conexa* MATSUOKA (Plate I–5), *Stylocapsa tecta* MATSUOKA (Plate I–6, 7), *Stichocapsa robusta* MATSUOKA (Plate I–8), *Guexella nudata* (KOCHER) (Plate I–9), *Archaeodictyomitra* sp. aff. *A. rigida* PESSAGNO (Plate I–10), *Dictyomitrella* (?) sp. cf. *D.* (?) *kamoensis* MIZUTANI & KIDO (Plate I–11),



Ue: Unuma echinatus Assemblage-zone

Fig. 6. Biostratigraphic division of the Kashibara and Hisuikyo sections, showing stratigraphio relationship between the zonal boundary by MIZUTANI & KIDO (1983) and that by this study.

Pseudodictyomitra sp. D in MATSUOKA & YAO (1985) (Plate I–12). Due to poor preservation, the other two samples yield fewer radiolarians identifiable at species level than MKS–27. Their faunal composition, however, is similar to that of MKS–27.

According to MATSUOKA (1983), *G. nudata* first occurs in the middle part of the *T. conexa* Zone and *S. tecta* makes its first occurrence in the upper part of the *T. conexa* Zone. Co-occurrence of the two species is confined to the upper part of the *T. conexa* Zone and the lower part of the next younger *Stylocapsa* (?) *spiralis* Zone. The samples contain no diagnostic species of the *S.* (?) *spiralis* Zone such as *Stylocapsa* (?) *spiralis* MATSUOKA, *Stylocapsa catenarum* M., *Gongylothorax sakawaensis* M. and *Stichocapsa naradaniensis* M. The above-mentioned association indicates that the black mudstone unit is assigned to the upper part of the *T. conexa* Zone.

Concluding remarks

The first appearance biohorizon of *T. conexa* is first reported from three continuous sequences in the Sakawa and Niyodo areas, central Shikoku (MATSUOKA, 1983). This biohorizon is one of the most reliable among the Jurassic radiolarian biohorizons because the evolutionary lineage from the ancestral form (*T. plicarum*) to the descendant one (*T. conexa*) is clarified. Determination of the biohorizon enables us to correlate radiolarian zones defined in different areas as shown in the present study. The first appearance biohorizon of *T. conexa* is recognized in siliceous mudstone sequence in the Unazawa section, Kanto Mountains (FURUKUBO *et al.*, 1985) and in the Shimodomari section, western Shikoku (AITA, 1987).

In order to correlate radiolarian zones more precisely, we need to find reliable biohorizons and to reexamine the type sections of proposed radiolarian zones by using the biohorizons.

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* : in Japanese with English abstract.

＜地　名＞

Hisuikyo……飛水峡　Kamiaso……上麻生　Kashibara ……樫原

（要　旨）

MATSUOKA, A., 1988 : First appearance biohorizon of *Tricolocapsa conexa* within Jurassic siliceous mudstone sequences 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.（松岡　篤，1988：美濃帯上麻生地域の珪質泥岩層中に認められる *Tricolocapsa conexa* の初出現層準—中部ジュラ系放散虫化石帯の対比．地質雑，**94**, 583–590.）

標題地域の樫原セクション，飛水峡セクションにおいて，*Tricolocapsa plicarum* YAO と *Tricolocapsa conexa* MATSUOKA の垂直分布を検討した．その結果，*T. conexa* の初出現層準が上記のセクション中に存在することが明らかになった．*T. plicarum* 帯と *T. conexa* 帯との境界は，MIZUTANI & KIDO(1983)による *Unuma echinatus* 群集帯と *Dictyomitrella*(?) *kamoensis—Pantanellium foveatum* 群集帯との境界の，樫原セクションでは約 13 m 上位に，飛水峡セクションでは約 15 m 上位に位置する．また，樫原セクションの灰緑色珪質泥岩をおおう黒色泥岩は，*T. conexa* 帯上部に相当する．