Journal of Geosciences, Osaka City University
Vol. 35, Art. 3, p. 33-51
March, 1992

Late Permian *Albaillella* (Radiolaria) from a Bedded Chert Section in the Gujo-hachiman Area of the Mino Belt, Central Japan

—Preliminary Report on Morphometry and Cluster Analysis—

Kiyoko KUWAHARA* and Masanori SAKAMOTO*

(With 4 Figures, 2 Tables and 3 Plates)

Abstract

Eight species of Late Permian *Albaillella* (*A. excelsa, A. flexa* n. sp., *A. lauta* n. sp., *A. levis, A.* sp. aff. *A. levis, A. triangularis, A.* sp. A, and *A.* sp. B) were recognized from radiolarian assemblages in a bedded chert section in the Gujo-hachiman area of the Mino Belt, Central Japan. Quantitative features were measured for a total of 1000 specimens representing eight species of *Albaillella.* Their morphometry indicates morphological distinctions among species. From their stratigraphic distribution and resemblance of shell forms, *A. excelsa, A. flexa, A. lauta, A.* sp. A, and *A.* sp. B are considered to have closely phylogenic relations.

Cluster analysis was attempted to well preserved specimens representing five species of *Albaillella,* in order to ascertain classification by visual inspection. Each clustered group generally corresponds to each species.

Key Words: *Albaillella*, Late Permian, morphometry, cluster analysis.

1. Introduction

Suborder Albaillellaria DEFLANDRE is a characteristic and important taxon for Late Paleozoic radiolarian biostratigraphy. ISHIGA *et al.* (1982) described three species of Late Permian *Albaillella* (*A. triangularis, A. excelsa* and *A. levis*) from bedded cherts which are distributed in the Mino-Tamba Belt, Southwest Japan. These species have short ranges which are limited to Late Permian age. There are many reports on these occurrences in Japan, e.g., from the Tamba Belt (e.g., ISHIGA and IMOTO, 1980; TAKEMURA and NAKASEKO, 1981); from the Mino Belt (e.g., KOJIMA, 1982; WAKITA, 1983); from the Chichibu Belt (e.g., NISHIZONO *et al.*, 1982; MIYAMOTO *et al.*, 1985; SASHIDA and TONISHI, 1985); from the Maizuru Belt (e.g., CARIDROIT and DE WEVER, 1986). The report of occurrences for these Late Permian *Albaillella* has increased in other countries too, as for example, in Philippines (CHENG, 1989), in Yunnan, China (WU and LI, 1989), and in California, America (NOBLE and RENNE, 1990).

* Department of Geosciences, Faculty of Science, Osaka City University, Sugimoto 3-3-138, Sumiyoshi-ku, Osaka 558, Japan.

WAKITA (1983) recovered well preserved Late Permian radiolarians occurring in a chert block (G1709) in the Gujo-hachiman area of the Mino Belt, Central Japan. He recongized *Follicucullus scholasticus* ORMISTON and BABCOCK, *F. ventricosus* ORMISTON and BABCOCK, *Neoalbaillella optima* ISHIGA, KITO and IMOTO, *Albaillella levis* ISHIGA, KITO and IMOTO, and other many Albaillellids from this locality. In the present work, a stratigraphic section of bedded chert from the same locality was examined in order to clarify the morphology of *Albaillella*. Quantitative features were measured in order to distinguish *Albaillella* at species level, and cluster analysis using these quantitative features was attempted for some species.

We wish to express our thanks to Associate Professor A. YAO of Osaka City University for his many helpful suggestions during the course of this work.

2. Material and Method

The sampling site (136°51'07"E; 35°43'55"N), which is the same locality as G1709 in WAKITA (1983) and Loc 62 in WAKITA (1984), is located in the Gujo-hachiman area of the Mino Belt, Central Japan (Fig. 1).

Samples were continuously collected, bed by bed, from 155 horizons in a chert section of the allochthonous block (Fig. 2). This block belongs to the Nabigawa Formation, which is a part of the Paleozoic-Mesozoic sedimentary complex (WAKITA, 1984). The total thickness of the studied section is 9.75 m. The section, which is bounded at the base and at the top by faults, is made up of greenish-gray bedded chert. The chert beds vary from 2 to 10 cm, and shale partings are less than several millimeters thick. The recrystallized part (lowermost 75 cm in the section) was not sampled.

Samples were immersed in a 5% solution of hydrofluoric acid for 24 hours. Residues, including fossils, were obtained by using 35 to 200 mesh sieves. Radiolarians were picked up under a binocular microscope and mounted on glass slides using a mounting medium, "ENTELLAN neu". Specimens were measured under the microscope with an ocular micrometer at mainly ×200 magnification. Both a mechanical stage and a turning stage were attached to the microscope.

Seven quantitative features (Fig. 3) were measured in a total of 1000 specimens representing eight species. The number of specimens of each species varied from several specimens to several hundred specimens.

3. Radiolarian Assemblage

The Late Permian radiolarian assemblages from the Gujo-hachiman area are composed of Albaillellarians, stauraxon polycystines and spherical polycystines. Albaillellarian abundance in the total samples was less than several percent. Four genera belonging to Albaillellaria were obtained, namely, *Albaillella* DEFLANDRE, *Neoalbaillella* TAKEMURA and NAKASEKO, *Follicucullus* ORMISTON and BABCOCK, and *Pseudoalbaillella* HOLDSWORTH and JONES. Judging from occurrences of each species of Albaillellaria, the studied

WAKITA (1983) recovered well preserved Late Permian radiolarians occurring in a chert block (G1709) in the Gujo-hachiman area of the Mino Belt, Central Japan. He recongized *Follicucullus scholasticus* ORMISTON and BABCOCK, *F. ventricosus* ORMISTON and BABCOCK, *Neoalbaillella optima* ISHIGA, KITO and IMOTO, *Albaillella levis* ISHIGA, KITO and IMOTO, and other many Albaillellids from this locality. In the present work, a stratigraphic section of bedded chert from the same locality was examined in order to clarify the morphology of *Albaillella*. Quantitative features were measured in order to distinguish *Albaillella* at species level, and cluster analysis using these quantitative features was attempted for some species.

We wish to express our thanks to Associate Professor A. YAO of Osaka City University for his many helpful suggestions during the course of this work.

2. Material and Method

The sampling site (136°51'07"E; 35°43'55"N), which is the same locality as G1709 in WAKITA (1983) and Loc 62 in WAKITA (1984), is located in the Gujo-hachiman area of the Mino Belt, Central Japan (Fig. 1).

Samples were continuously collected, bed by bed, from 155 horizons in a chert section of the allochthonous block (Fig. 2). This block belongs to the Nabigawa Formation, which is a part of the Paleozoic-Mesozoic sedimentary complex (WAKITA, 1984). The total thickness of the studied section is 9.75 m. The section, which is bounded at the base and at the top by faults, is made up of greenish-gray bedded chert. The chert beds vary from 2 to 10 cm, and shale partings are less than several millimeters thick. The recrystallized part (lowermost 75 cm in the section) was not sampled.

Samples were immersed in a 5% solution of hydrofluoric acid for 24 hours. Residues, including fossils, were obtained by using 35 to 200 mesh sieves. Radiolarians were picked up under a binocular microscope and mounted on glass slides using a mounting medium, "ENTELLAN neu". Specimens were measured under the microscope with an ocular micrometer at mainly ×200 magnification. Both a mechanical stage and a turning stage were attached to the microscope.

Seven quantitative features (Fig. 3) were measured in a total of 1000 specimens representing eight species. The number of specimens of each species varied from several specimens to several hundred specimens.

3. Radiolarian Assemblage

The Late Permian radiolarian assemblages from the Gujo-hachiman area are composed of Albaillellarians, stauraxon polycystines and spherical polycystines. Albaillellarian abundance in the total samples was less than several percent. Four genera belonging to Albaillellaria were obtained, namely, *Albaillella* DEFLANDRE, *Neoalbaillella* TAKEMURA and NAKASEKO, *Follicucullus* ORMISTON and BABCOCK, and *Pseudoalbaillella* HOLDSWORTH and JONES. Judging from occurrences of each species of Albaillellaria, the studied

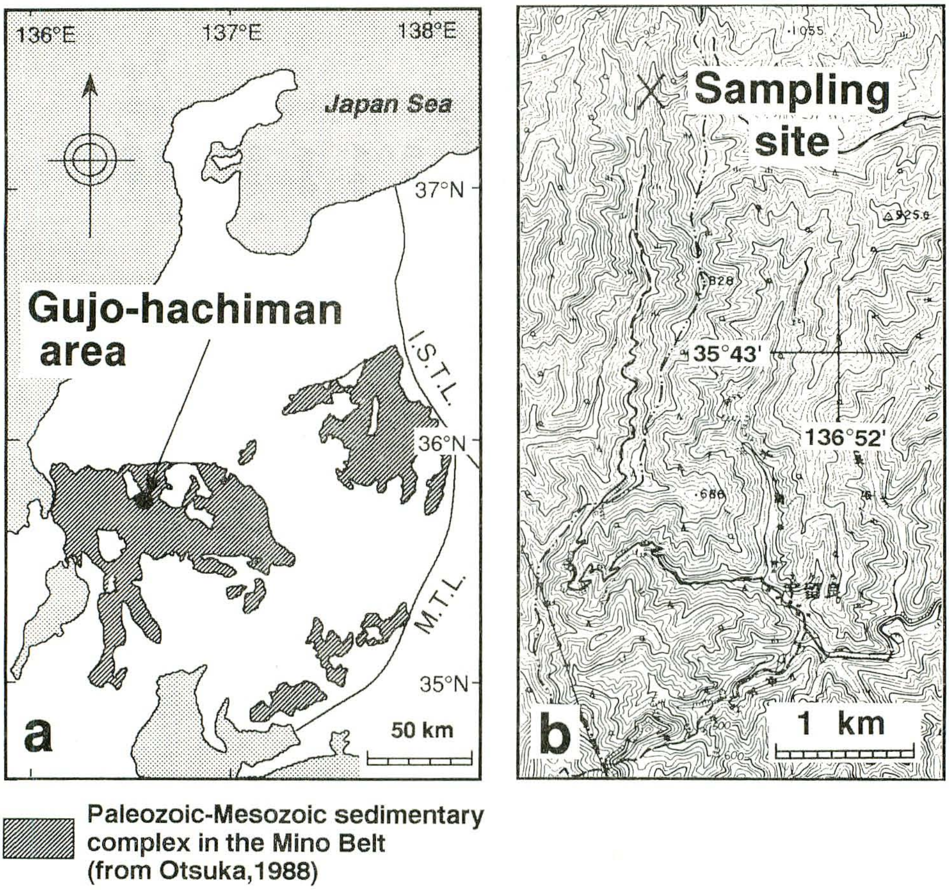


Fig. 1 a: Index map of the Gujo-hachiman area. Abbreviations: M.T.L., Median Tectonic Line; I.S.T.L., Itoigawa-Shizuoka Tectonic Line.
b: Geographical map showing the sampling site. The sampling site is the same locality as G1709 in WAKITA (1983), and Loc. 62 in WAKITA (1984) (a part of 1:50,000 map of "Hachiman" published by the Geographical Survey Institute of Japan).

chert section corresponds to the Upper Permian *Neoalbaillella optima* and *N. ornithoformis* Assemblage-zones of ISHIGA (1986).

Eight species of *Albaillella* were recognized. Among then, two species are described as new species in chapter 4. The stratigraphic distribution of *Albaillella* is shown in Fig. 2.

Rarely encountered specimens of *A. asymmetrica* ISHIGA and IMOTO, and *A. sinuata* ISHIGA and WATASE occurred in a few horizons in this section. These two species have been regarded as Early to Middle Permian radiolaria. There are two possibilities to explain these occurrences from the Upper Permian section. One possibility is that the fossils were reworked from lower horizons; the other is that they have rather longer ranges than

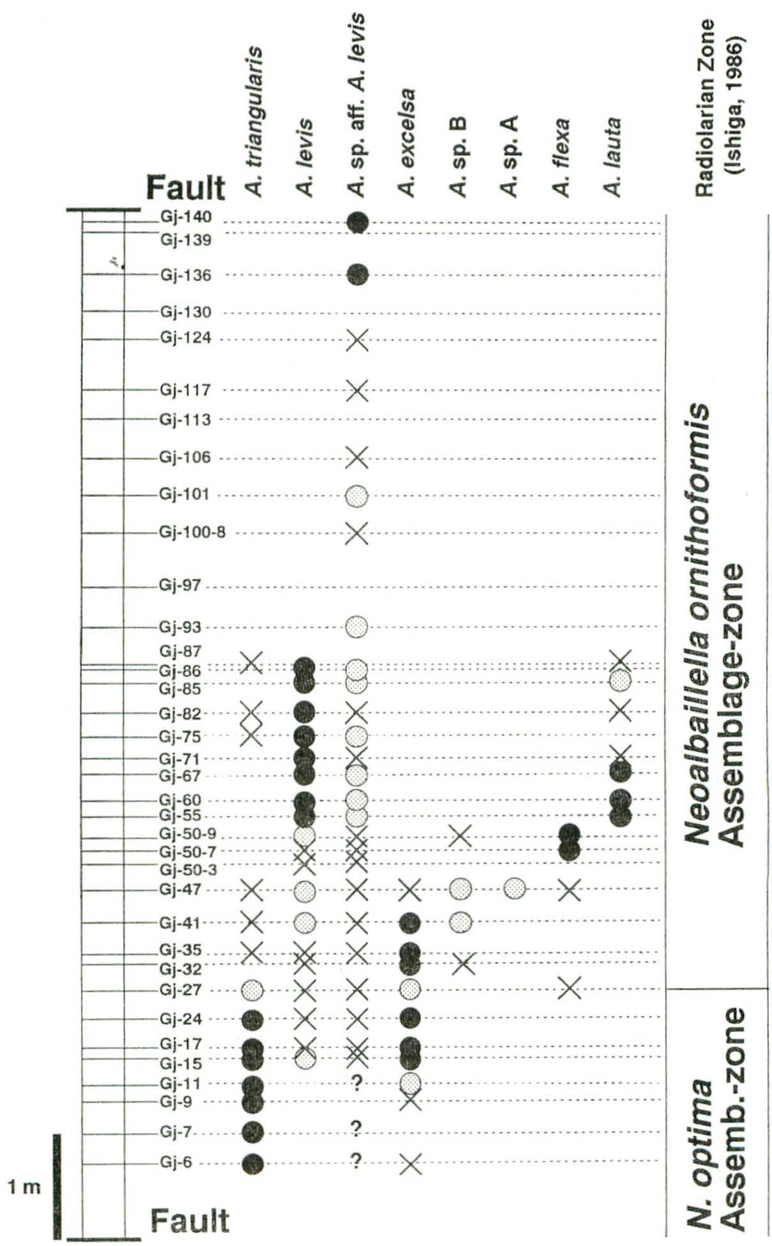


Fig. 2 Stratigraphic distribution of *Albaillella* from a Late Periman bedded chert section in the Gujo-hachiman area of the Mino Belt. Frequency of occurrence is qualitatively shown: black circle, abundant; gray circle, common; cross, rare. Gj-number shows sampling number.

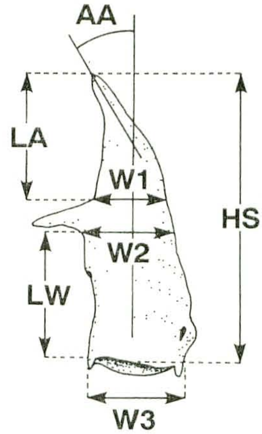


Fig. 3 Sketch of *Albaillella excelsa*, showing measured features in *Albaillella*. Abbrebiations: **HS**, height of shell excluding H-frame; **LA**, length of apical part from shell apex to the proximal part of wing; **LW**, length from proximal part of wing to aperture; **W1**, width of shell on the proximal part of wing; **W2**, width of shell under proximal part of wing; **W3**, width of shell near aperture; **AA**, bending angle of apical part.

previously known. As the present data are little, it is hard to solve this problem. These two species are ignored in this study.

Late Permian *Albaillella* shows closely related shell forms at the species level. They all have one strong ventral wing and a curved apical part. They are distinguishable by their shell height, the position of the wing, the presence of transverse bands (surface construction), the curvature of the apical part, and the proportion of height to width, generally. There are a few specimens that have forms intermediate between species.

Measured features, mean values, number of specimens and standard deviations are shown in Table 1. These mean values and standard deviations show both intraspecific variations and interspecific distinctions.

A. excelsa, A. flexa, and *A. lauta* have relatively high shell height, and show successive stratigraphic distribution. *A. flexa* is distinguished from *A. lauta* by having a strongly bent apical part. Some specimens occured in Gj-50-9 (upper horizon of stratigraphic range of *A. flexa*) show a less curved apical part, thus being similar to *A. lauta* (Pl. 1, Fig. 7). Two peculiar morphotypes, tentatively named *A.* sp. A and *A.* sp. B, have moderate shell height, and occur in the same horizon (Gj-47) as that of the last occurrence of *A. excelsa*. Their morphological features and stratigraphic distributions suggest that they are phylogenic relations. *A. flexa* evolved from *A. excelsa*, and *A. flexa* gave rise to *A. lauta*. *A.* sp. A and *A.* sp. B seem to be evolutionally transitional forms.

4. Systematic Paleontology

Authorship of two new taxa described in the systematic section of this paper is as-

Table 1 List of measurements for each species. Each column shows: total number of measured specimens (N.S.); mean value (mean); number of specimens (N); and standard deviations (S.D.). See Fig. 3 for abbreviations of features.

	N.S.	HS			LA			LW			W1			W2			W3			AA		
		mean	N	S.D.	mean	N	S.D.	mean	N	S.D.	mean	N	S.D.	mean	N	S.D.	mean	N	S.D.	mean	N	S.D.
		μm			μm			μm			μm			μm			μm			degree		
A. excelsa	522	227.6	283	20.1	92.2	340	9.6	105.6	379	18.2	53.9	449	5.9	65.1	435	5.9	73.1	355	7.0	14.0	108	7.7
A. flexa	151	193.8	88	17.8	99.7	100	9.7	63.8	126	12.3	57.0	141	5.9	65.4	137	5.3	70.7	103	7.1	46.5	30	13.4
A. lauta	40	205.6	24	17.9	110.6	26	11.7	69.5	33	14.4	61.6	33	3.8	66.4	34	3.7	70.4	15	4.6	26.6	33	8.1
A. levis	98	156.6	70	10.6	98.3	71	8.8	32.8	92	6.6	67.4	88	4.2	71.8	87	4.8	68.5	74	4.4	34.8	82	7.1
A. sp. aff. *A. levis*	54	146.5	32	10.5	92.7	33	7.7	34.7	49	6.5	75.4	47	6.5	81.7	44	6.8	73.2	42	6.4	25.5	47	8.1
A. triangularis	117	147.7	53	15.5	91.2	63	8.7	30.4	87	8.9	75.3	104	6.3	80.9	102	5.7	73.0	75	5.6	28.5	90	8.7
A. sp. A	7	176.4	4	15.2	81.9	4	5.6	61.8	6	13.5	47.2	5	14.8	53.9	4	2.4	62.6	7	6.8	20.2	6	8.0
A. sp. B	11	181.8	8	14.7	87.7	9	7.2	73.4	11	14.3	54.2	11	3.6	63.7	11	5.7	72.8	10	8.5	25.5	11	6.5

cribed to KUWAHARA. Type and figured specimens are registered in the Department of Geosciences, Osaka City University, under numbers OCU PR 0001 to OCU PR 0033.

Subclass Radiolaria MÜLLER, 1858

Order Polycystina EHRENBERG, 1838, emend. RIEDEL, 1967
Suborder Albaillellaria DEFLANDRE, 1953, emend. HOLDSWORTH, 1969

Family Albaillellidae DEFLANDRE, 1952
Genus *Albaillella* DEFLANDRE, 1952
Type species : Albaillella paradoxa DEFLANDRE, 1952

Albaillella excelsa ISHIGA, KITO and IMOTO

(Pl. 1, Fig. 8; Pl. 3, Figs. 1–3)

Measurements (based on 522 specimens from Gj–11, Gj–17, Gj–24, Gj–27, Gj–32, Gj–35 and Gj–41): See Table 1.

Remarks: This species is distinguished from the other Late Permian *Albaillella* by its large shell height and the proportion of the protruding ventral wing. Shell height (HS) is more than 3 times (mean 3.5 times) that of width (W2). Position of the small aperture under the ventral wing is different from other Late Permian *Albaillella*. A few specimens show remarkable transverse bands (Pl. 3, Fig. 2).

Albaillella flexa KUWAHARA, n. sp.

(Pl. 1, Figs. 1–3; Pl. 2, Figs. 1–7)

Description: Imperforate, slightly flattended conical shell having a ventral wing. Shell height (HS) is less than 3 times width (W2). Upper part of shell is curved strongly to the ventral side. Curved angle (AA) is more than 30 degrees, and the mean value is 45 degrees. Curvature maximized in the middle of shell apex and base of wing. Weak transverse bands on the surface of the shell. Large hollow wing protrudes from nearly lower one third of the shell. A small aperture under ventral wing. Two small apertures on distal dorsal side near main aperture. Two internal rods are observed in transmitted light. Dorsal internal rod stronger than ventral one. Dorsal internal rod and outer shell are connected indirectly. H-frame is incompletely preserved. Small blade like spines on H-freme.

Measurements (based on 151 specimens from Gj–50–7 and Gj–50–9): See Table 1.

Remarks: This species is distinguished from the other Late Permian *Albaillella* by having diagnostic bending at the apical part. Shell curvature is variable.

Etymology: Named from Latin *flexus, –a, –um*, meaning bend.

Type specimens: Holotype, OCU PR 0001 (Pl. 1, Fig. 1); Palatype, OCU PR 0003 (Pl. 1, Fig. 3). Holotype and paratype from Gj–50–9.

Range and Occurrences: Late Permian. This species occurs abundantly in Gj–50–7 and Gj–50–9 of the Gujo-hachiman bedded chert section in the Mino Belt (see Fig.

2). It occurs in the Upper Permian, lower part of the *Neoalbaillella ornithoformis* Assemblage-zone of ISHIGA (1986).

Albaillella lauta KUWAHARA, n. sp.

(Pl. 1, Figs. 4–6; Pl. 2, Figs. 8–12)

Description: Imperforate, flattened conical shell having a ventral wing. Shell height (HS) is about 3 times width (W2). Upper part of shell curved to ventral side gradually. Shell surface smooth. Two or three dimple-like depressions on dorsal surface. Large, hollow ventral wing originating from lower two-fifths of the shell. A small aperture under ventral wing. Two small apertures on distal dorsal side near main aperture. Internal structure is not clear; only two internal rods are preserved in some specimens. Internal rod of dorsal side and outer shell are connected indirectly. H-frame is not completely preserved. Small blade like spines on H-frame.

Measurements (based on 40 specimens from Gj–55 and Gj–60): See Table 1.

Remarks: This species resembles *Albaillella levis*, but differs by having large shell height and protruding portion of wing protruded.

Etymology: Named from Latin *lautus, -a, -um*, meaning neat, elegant.

Type specimen: Holotype OCU PR 0004 (Pl. 1, Fig. 4); Paratype OCU PR 0005 (Pl. 1, Fig. 5). Holotype and paratype from Gj–60.

Range and occurrences: Late Permian. This species occurs from Gj–55 to Gj–87 of the bedded chert section in the Gujo-hachiman area of the Mino belt (see Fig. 2). It occurs in the Upper Permian, *Neoalbaillella ornithoformis* Assemblage-zone of ISHIGA (1986).

Albaillella levis ISHIGA, KITO and IMOTO

(Pl. 3, Figs. 8–9, 12)

Measurements (based on 98 specimens from Gj–47, Gj–50–9, Gj–55, Gj–60, Gj–67 and Gj–75): See Table 1.

Remarks: This species resembles *A.* sp. aff. *A. levis* but differs by having slender shell width (W2) and higher shell height (HS).

Albaillella sp. aff. *A. levis* ISHIGA, KITO and IMOTO

(Pl. 3, Figs. 10–11)

Measurements (based on 54 specimens from the Gj–47, Gj–50–9, Gj–67, Gj–75, Gj–136 and Gj–140): See Table 1.

Remarks: This species closely resembles *Albaillella levis*, but differs in the shape of curve and proportion of height and width. Shell shape of this species resembles *A. triangularis*, except for structure of shell surface.

Occurrences: This species occurs abundantly in Gj–136 and Gj–140 (see Fig. 2). First occurrence was not clear.

Albaillella triangularis Ishiga, Kito and Imoto

(Pl. 3, Figs. 5–6)

Measurements (based on 117 specimens from the Gj–7, Gj–9, Gj–11 and Gj–27): See Table 1.

Remarks: This species resembles *A. levis* and *A.* sp. aff. *A. levis*, but differs by having diagnostic transverse bands.

Albaillella sp. A

(Pl. 1, Fig. 9)

Measurements (based on 7 specimens from Gj–47): See Table 1.

Remarks: Small *Albaillella* with transverse bands. Ventral wing protrudes from middle part of the shell. Shell width is narrow. This species resembles *Albaillella triangularis* in its remarkable transverse bands, but differs in shell proportion.

Occurrence: This species commonly occurs from Gj–47 (see Fig. 2).

Albaillella sp. B

(Pl. 1, Fig. 10; Pl. 3, Figs. 4, 7)

Measurements (based on 11 specimens from Gj–47): See Table 1.

Remarks: Small *Albaillella* without transverse bands. This species is closely related to *Albaillella excelsa*, but differs in having short shell height. Intermediate forms of *A. excelsa* and *A.* sp. B exist.

Occurrences: This species commonly occurs from Gj–47 (see Fig. 2). First occurrence was not clear.

5. Cluster Analysis

5.1. Method

Cluster analysis is the method of numerical classification by similarity (or dissimilarity) between specimens. Clusters are represented in a dendrogram which is made by connecting specimens or groups of specimens on the basis of the similarity. The application of cluster analysis in micropaleontology has developed considerably in recent years. For example, Wei (1987) reported the differentiation of chronospecies in the foraminiferal lineage by multivariate morphometrics, and used cluster analysis in an attempt to reveal possible groupings in a sequence of analyses.

In this study, cluster analysis was applied to Late Permian *Albaillella* which have similar shell forms, in order to ascertain their classification by visual inspection. *A. triangularis*, *A. levis*, and *A.* sp. aff. *A. levis* were excluded from the analysis because they are easy to distinguish from other *Albaillella* by their relatively small shell height. Cluster analysis was, therefore, applied to five species (*Albaillella excelsa, A. flexa, A. lauta*, *A.* sp. A and *A.* sp. B). Well preserved specimens numbering 51 from 12 horizons were selected (Table 2). These specimens had already been identified by visual

Table 2 Data of specimens relating to cluster analysis. See Fig. 3 for abbreviations of features.

	species	level	LW	AA	HS/W2	HS	W2	Pl. No.
			μm	degree		μm	μm	
1	*A. excelsa*	Gj-11	152.3	5	4.417	269.0	60.9	
2	*A.* sp.	Gj-11	63.5	13	2.857	203.0	71.1	
3	*A. excelsa*	Gj-17	139.6	3	4.130	241.1	58.4	
4	*A. excelsa*	Gj-17	101.5	30	4.045	225.9	55.8	
5	*A. excelsa*	Gj-24	121.8	9	3.800	241.1	63.5	
6	*A. excelsa*	Gj-27	126.9	20	4.000	253.8	63.5	
7	*A. excelsa*	Gj-27	137.1	38	4.304	251.3	58.4	
8	*A. excelsa*	Gj-27	126.9	25	3.667	251.3	68.5	
9	*A. excelsa*	Gj-27	126.9	11	3.833	233.5	60.9	
10	*A. excelsa*	Gj-32	126.9	7	4.300	218.3	50.8	
11	*A. excelsa*	Gj-32	142.1	12	4.074	279.2	68.5	
12	*A. excelsa*	Gj-32	121.8	32	3.926	269.0	68.5	
13	*A. excelsa*	Gj-35	126.9	11	3.481	238.6	68.5	
14	*A. excelsa*	Gj-35	104.1	7	3.417	208.1	60.9	
15	*A. excelsa*	Gj-35	134.5	16	3.846	253.8	66.0	
16	*A. excelsa*	Gj-35	119.3	14	3.103	228.4	73.6	
17	*A. excelsa*	Gj-35	101.5	7	3.185	218.3	68.5	
18	*A. excelsa*	Gj-35	109.1	11	3.680	233.5	63.5	
19	*A. excelsa*	Gj-35	121.8	16	3.462	228.4	66.0	
20	*A. excelsa*	Gj-35	121.8	7	4.273	238.6	55.8	
21	*A. excelsa*	Gj-41	116.7	16	3.840	243.6	63.5	
22	*A. excelsa*	Gj-41	109.1	5	3.481	238.6	68.5	
23	*A. excelsa*	Gj-41	119.3	25	3.917	238.6	60.9	
24	*A. excelsa*	Gj-41	96.4	14	3.462	228.4	66.0	
25	*A. excelsa*	Gj-41	109.1	35	3.769	248.7	66.0	
26	*A. excelsa*	Gj-41	109.1	20	3.286	233.5	71.1	
27	*A.* sp. A	Gj-47	71.1	10	3.091	172.6	55.8	Pl.1, Fig.9
28	*A.* sp. A	Gj-47	45.7	27	3.100	157.4	50.8	
29	*A.* sp. B	Gj-47	45.7	25	2.500	165.0	66.0	
30	*A.* sp. B	Gj-47	78.7	28	3.217	187.8	58.4	
31	*A.* sp. B	Gj-47	60.9	28	2.593	177.7	68.5	Pl.1, Fig.10
32	*A.* sp. B	Gj-47	50.8	20	2.480	157.4	63.5	
33	*A.* sp. B	Gj-47	83.8	32	2.840	180.2	63.5	
34	*A.* sp. B	Gj-47	76.1	15	2.923	192.9	66.0	
35	*A. flexa*	Gj-50-7	76.1	59	2.963	203.0	68.5	
36	*A. flexa*	Gj-50-7	48.2	27	2.880	182.7.	63.5	Pl.1, Fig.2
37	*A. flexa*	Gj-50-9	60.9	44	3.364	187.8	55.8	
38	*A.* sp.	Gj-50-9	96.4	35	3.143	223.3	71.1	
39	*A. flexa*	Gj-50-9	60.9	50	2.963	203.0	68.5	Pl.1, Fig.3
40	*A. flexa*	Gj-50-9	45.7	43	2.769	182.7	66.0	
41	*A. flexa*	Gj-50-9	50.8	45	3.217	187.8	58.4	
42	*A.* sp.	Gj-50-9	88.8	32	2.968	233.5	78.7	Pl.1, Fig.7
43	*A. flexa*	Gj-50-9	60.9	47	3.000	198.0	66.0	
44	*A. lauta*	Gj-55	68.5	22	2.923	192.9	66.0	
45	*A. lauta*	Gj-55	58.4	37	3.231	213.2	66.0	
46	*A. lauta*	Gj-55	76.1	30	3.231	213.2	66.0	
47	*A. lauta*	Gj-60	101.5	21	3.370	231.0	68.5	
48	*A. lauta*	Gj-60	81.2	38	3.333	228.4	68.5	Pl.1, Fig.4
49	*A. lauta*	Gj-60	96.4	25	3.036	215.7	71.1	
50	*A. lauta*	Gj-60	88.8	33	3.600	228.4	63.5	
51	*A. lauta*	Gj-60	96.4	26	3.036	215.7	71.1	

inspection.

Cluster analysis was attempted to two measured values and one derived ratio, which represent characters of species. The values used were:

(1) LW: length from proximal part of wing to aperture.

(2) AA: bending angle of apical part.

(3) HS/W2: ratio as an indicator of shell proportion.

The dissimilarities between specimens were calculated on the standardized squared Euclidean distance, and the clustering method applied was the group-average method. Cluster analysis was carried out using the statistical program of TANAKA *et al.* (1984).

5.2 Results

Figure 4 shows the result of analysis. A large Cluster A designates *A. excelsa.*

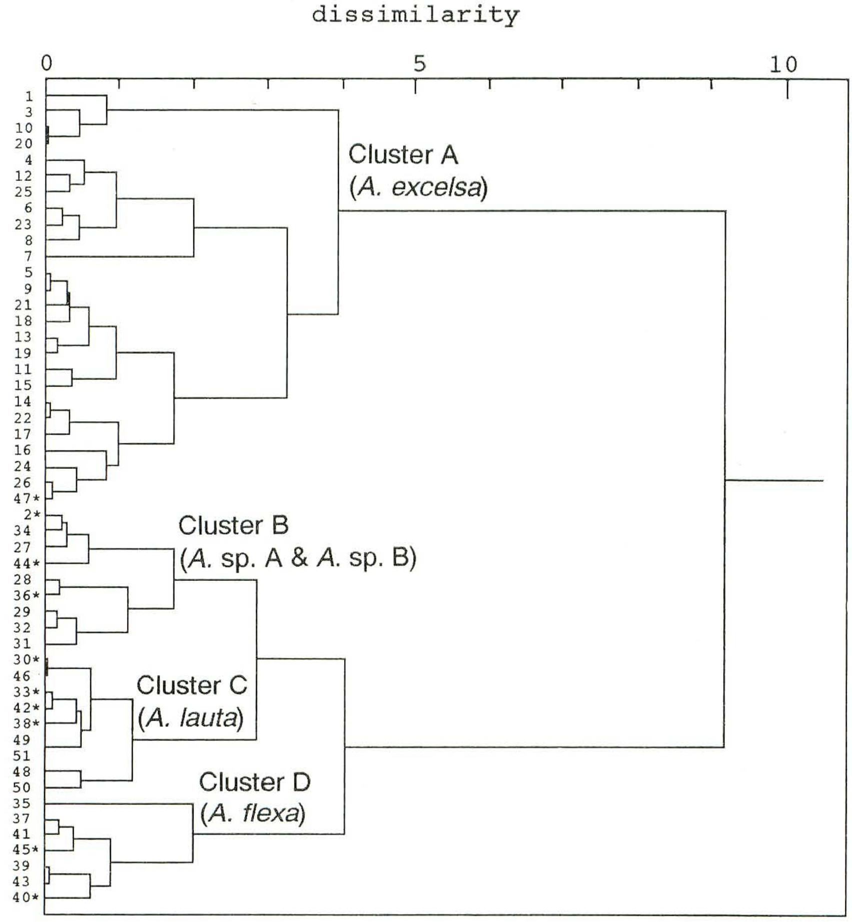


Fig. 4 Dendrogram of cluster analysis showing distinctive clusters. Asterisk shows outlier.

Cluster B is referable to *A.* sp. A and *A.* sp. B. Cluster C reveals *A. lauta*, and Cluster D corresponds to *A. flexa*. The resulting clusters correspond to each species, generally. This result indicates that the method of cluster analysis is applicable to the classification of Late Permian *Albaillella* in general, and that these quantitative features could express species distinctions by visual inspection.

5.3 Discussion

Some outliers exist on the dendrogram in this study, and they may be caused by the following differences between the visual inspection and cluster analysis. The morphometric features used in cluster analysis may be insufficient and/or inadequate to express the shell form. In visual inspection, non-measurable diagnostic features (e.g., the presence of transverse bands) and the difficulty of measuring some parts (e.g., the form of curvature) could be considered as such features. However, the cluster analysis in this study excluded those factors.

For further study, some multivariate analyses will be applied to the classification. Principal-component analysis is another means of classification. Using this method, the scatter-plot of scores of first and second principal components in 51 specimens showed the same grouping as the result of the cluster analysis. Methods of multivariate analysis can be an effective technique to find out discriminating features.

6. Conclusions

(1) Eight *Albaillella*, which included two newly proposed species were distinguished from the bedded chert section in the Gujo-hachiman area of the Mino Belt, Central Japan.

(2) Species distinctions were clarified by means of measurement of quantitative features.

(3) Cluster analysis using well preserved specimens could support classification by visual inspection.

References

CARIDROIT, M. and DE WEVER, P. (1986): Some Late Permian radiolarians from pelitic rocks of the Tatsuno Formation (Hyogo Prefecture), southwest Japan. *Mar. Micropaleontol.*, **11**, 55–90.

CHENG, Y-N. (1989): Upper Paleozoic and Lower Mesozoic radiolarian assemblages from the Busuanga Islands, North Palawan Block, Philippines. *Bull. National Museum Natural Sci.*, no. 1, 129–175.

ISHIGA, H. (1986): Late Carboniferous and Permian radiolarian biostratigraphy of Southwest Japan. *J. Geosci., Osaka City Univ.*, **29**, 89–100.

ISHIGA, H. and IMOTO, N. (1980): Some Permian radiolarians in the Tamba district, Southwest Japan. *"Earth Sci." (Chikyu Kagaku)*, **34**, 333–345.

ISHIGA, H., KITO, T., and IMOTO, N. (1982): Late Permian radiolarian assemblages in the Tamba district and an adjacent area, Southwest Japan. *"Earth Sci." (Chikyu Kagaku)*, **36**, 10–22.

KOJIMA, S. (1982): Some Jurassic, Triassic and Permian radiolarians from the eastern part of Takayama City, central Japan (in Japanese with English abstract). *News of Osaka Micropaleontologists Special Vol.*, no. 5, 81–91.

MIYAMOTO, T., KUWAZURU, J., NOMOTO, T., YAMADA, H., TOMINAGA, R. and HASE, A. (1985): Discovery of Late Permian radiolarians from the Kakisako and Kuma Formations in the Futae district, Izumi-mura, Yatsushiro county, Kumamoto Prefecture, Kyushu (in Japanese). *"Earth Sci."* (*Chiyku Kagaku*), **39**, 78–84.

NISHIZONO, Y., OHISHI, A., SATO, T. and MURATA, M. (1982): Radiolarian Fauna from the Paleozoic and Mesozoic Formations, distributed along the Mid-Stream of Kuma River, Kyushu, Japan (in Japanese with English abstract). *News of Osaka Micropaleontologists Special Vol.*, no. 5, 311–326.

NOBLE, P. and RENNE, P. (1990): Paleoenvironmental and biostratigraphic significance of siliceous microfossils of the Permo-Triassic Redding Section, Eastern Klamath Mountains, California. *Mar. Micropaleontol.*, **15**, 379–391.

SASHIDA, K., and TONISHI, K. (1985): Permian radiolarians from the Kanto Mountains, Central Japan —Some Upper Permian Spumellaria from Itsukaichi, western part of Tokyo Prefecture—. *Sci. Rep., Inst. Geosci., Univ. Tsukuba, Sec. B*, **6**, 1–19.

TAKEMURA, A. and NAKASEKO, K. (1981): A New Permian radiolarian genus from the Tamba Belt, Southwest Japan. *Trans. Proc. Palaeont. Soc. Japan. N.S.*, **124**, 208–214.

TANAKA, Y., TARUMI, T. and WAKIMOTO, K. (1984): *Paso-com toukei kaiseki handbook* II *tahenryo kaisekihen* (Personal Computer Statistic Analysis handbook II, Multivariate Analysis) (in Japanese). Tokyo, Kyoritsu Shuppan, 403pp.

WAKITA, K. (1983): Allochthonous blocks and submarine slide deposits in the Jurassic formation southwest of Gujo-hachiman, Gifu Prefecture, central Japan (in Japanese with English abstract). *Bull. Geol. Surv. Japan*, **34**, 329–342.

WAKITA, K. (1984): *Geology of the Hachiman District* (in Japanese with English abstract). Quadrangle Series, Scale 1: 50,000, Geological Survey of Japan, 89p.

WEI, K-Y. (1987): Multivariate morphometric differentiation of chronospecies in the late Neogene planktonic foraminiferal lineage *Globoconella*. *Mar. Micropaleontol.*, **12**, 183–202.

WU, H-R. and LI, H-S. (1989): Carboniferous and Permian radiolaria in the Menglian area, Western Yunnan, *Acta Micropalaeontologica Sinica*, **6**, 337–343.

Explanation of Plate 1

(All figures ×225)

All figures are transmitted light photomicrographs of Late Permian *Albaillella* (Radiolaria) from a bedded chert section in the Gujo-hachiman area of the Mino Belt, Central Japan.

Figs. 1–3. *Albaillella flexa* KUWAHARA, n. sp.
1. OCU PR 0001, Gj–50–9, holotype
2. OCU PR 0002, Gj–50–7
3. OCU PR 0003, Gj–50–9, paratype

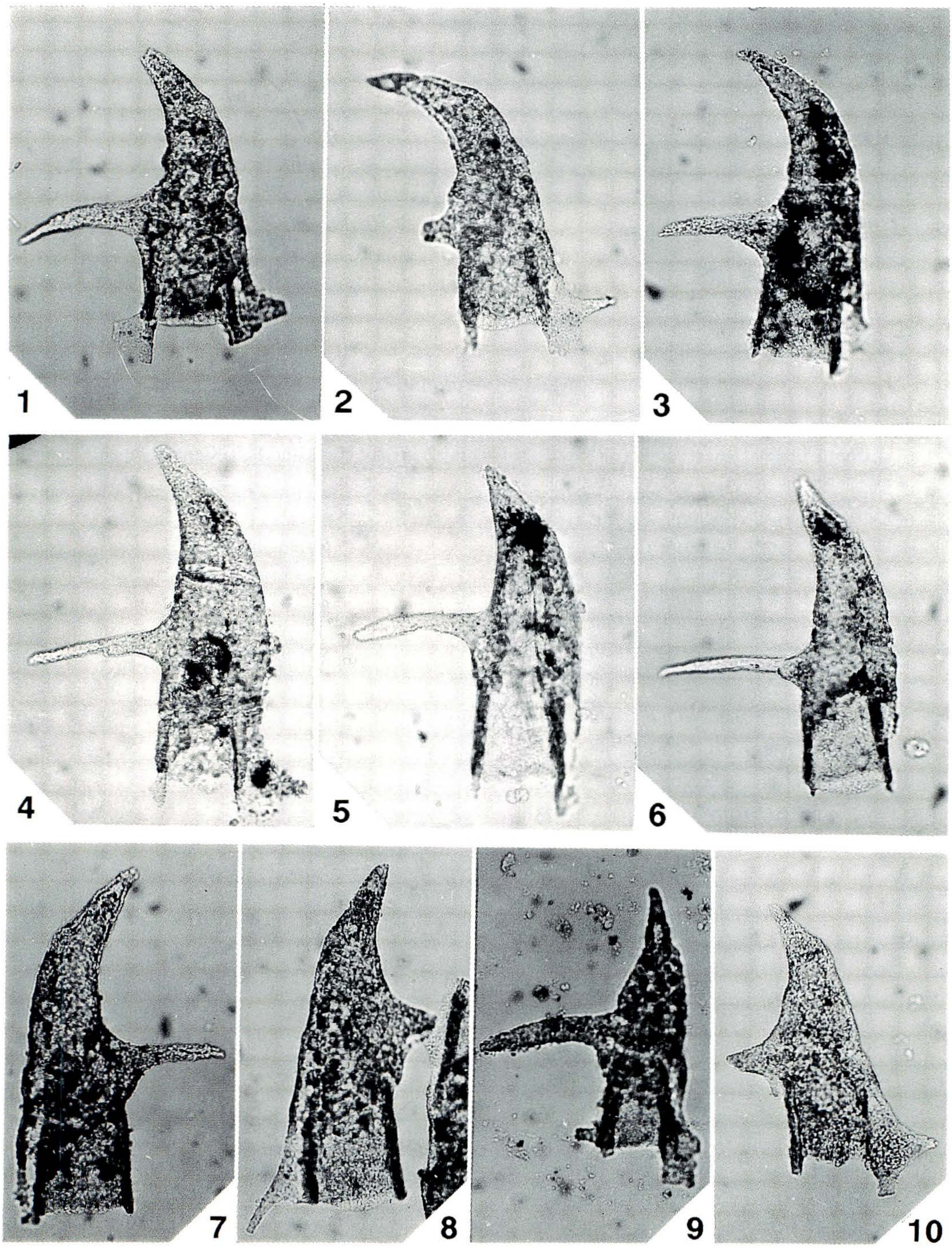
Figs. 4–6. *Albaillella lauta* KUWAHARA, n. sp.
4. OCU PR 0004, Gj–60, holotype
5. OCU PR 0005, Gj–60, paratype
6. OCU PR 0006, Gj–60

Fig. 7. *Albaillella* sp.
OCU PR 0007, Gj–50–9

Fig. 8. *Albaillella excelsa*
OCU PR 0008, Gj–41

Fig. 9. *Albaillella* sp. A
OCU PR 0009, Gj–47

Fig. 10. *Albaillella* sp. B
OCU PR 0010, Gj–47


1
2
3
4
5
6
7
8
9
10

Explanation of Plate 2

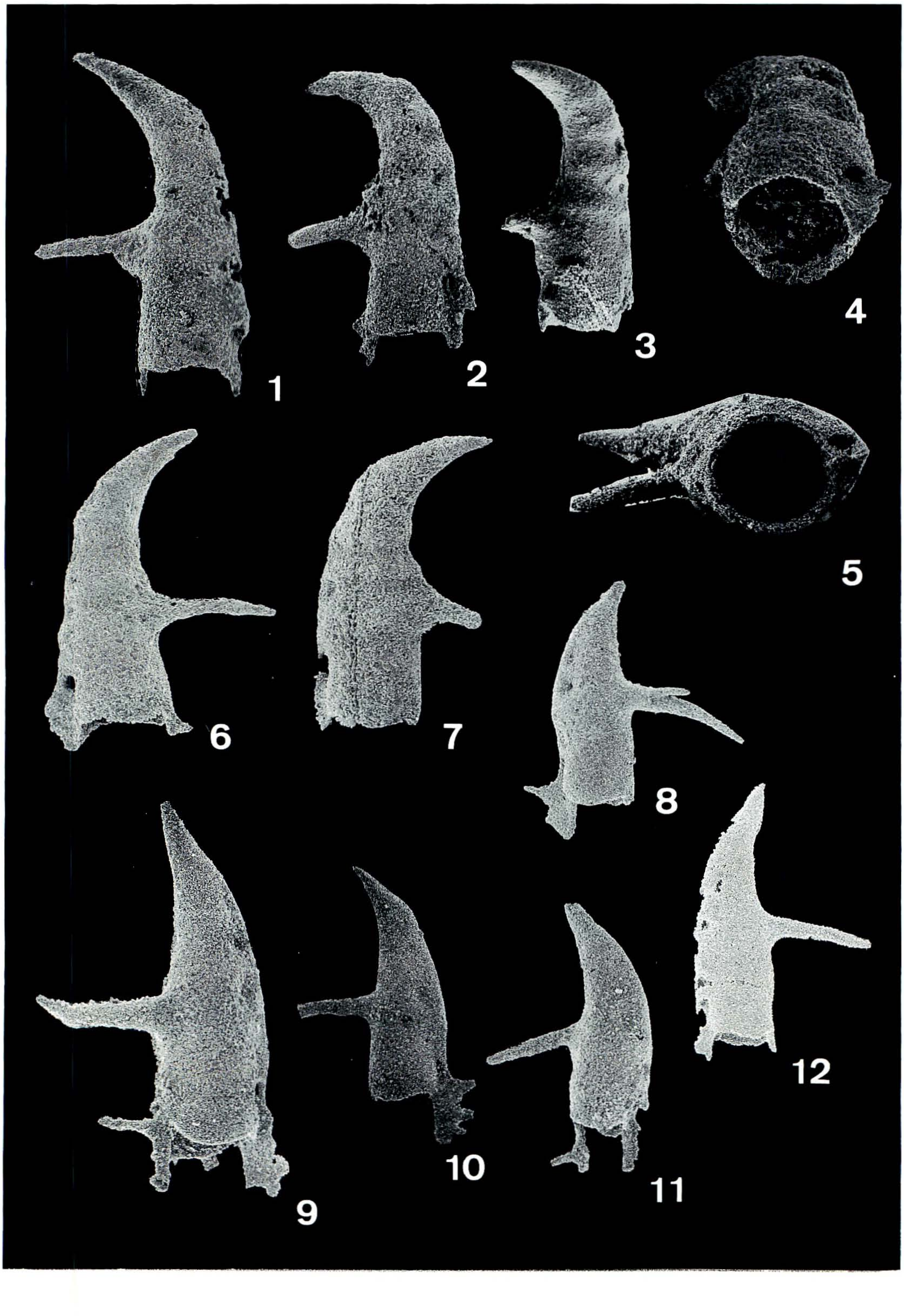
All figures are scanning electron micrographs of Late Permian *Albaillella* (Radiolaria) from a bedded chert section in the Gujo-hachiman area of the Mino Belt, Central Japan.

Figs. 1–7. *Albaillella flexa* Kuwahara, n. sp.

1. OCU PR 0011, Gj–50–7, ×250
2. OCU PR 0012, Gj–47, ×250
3. OCU PR 0013, Gj–24, ×225
4. OCU PR 0014, Gj–50–7, ×375
5. OCU PR 0015, Gj–50–9, ×375
6. OCU PR 0016, Gj–50–7, ×250
7. OCU PR 0017, Gj–50–7, ×250

Figs. 8–12. *Albaillella lauta* Kuwahara, n. sp.

8. OCU PR 0018, Gj–60, ×175
9. OCU PR 0019, Gj–60, ×250
10. OCU PR 0020, Gj–60, ×175
11. OCU PR 0021, Gj–60, ×175
12. OCU PR 0022, Gj–60, ×175


1
2
3
4
5
6
7
8
9
10
11
12

Explanation of Plate 3

All figures are scanning electron micrographs of Late Permian *Albaillella* (Radiolaria) from a bedded chert section in the Gujo-hachiman area of the Mino Belt, Central Japan.

Figs. 1–3. *Albaillella excelsa* ISHIGA, KITO and IMOTO
1. OCU PR 0023, Gj–32, ×250
2. OCU PR 0024, Gj–32, ×250
3. OCU PR 0025, Gj–32, ×175

Fig. 4. *Albaillella* sp. B
OCU PR 0026, Gj–47, ×250

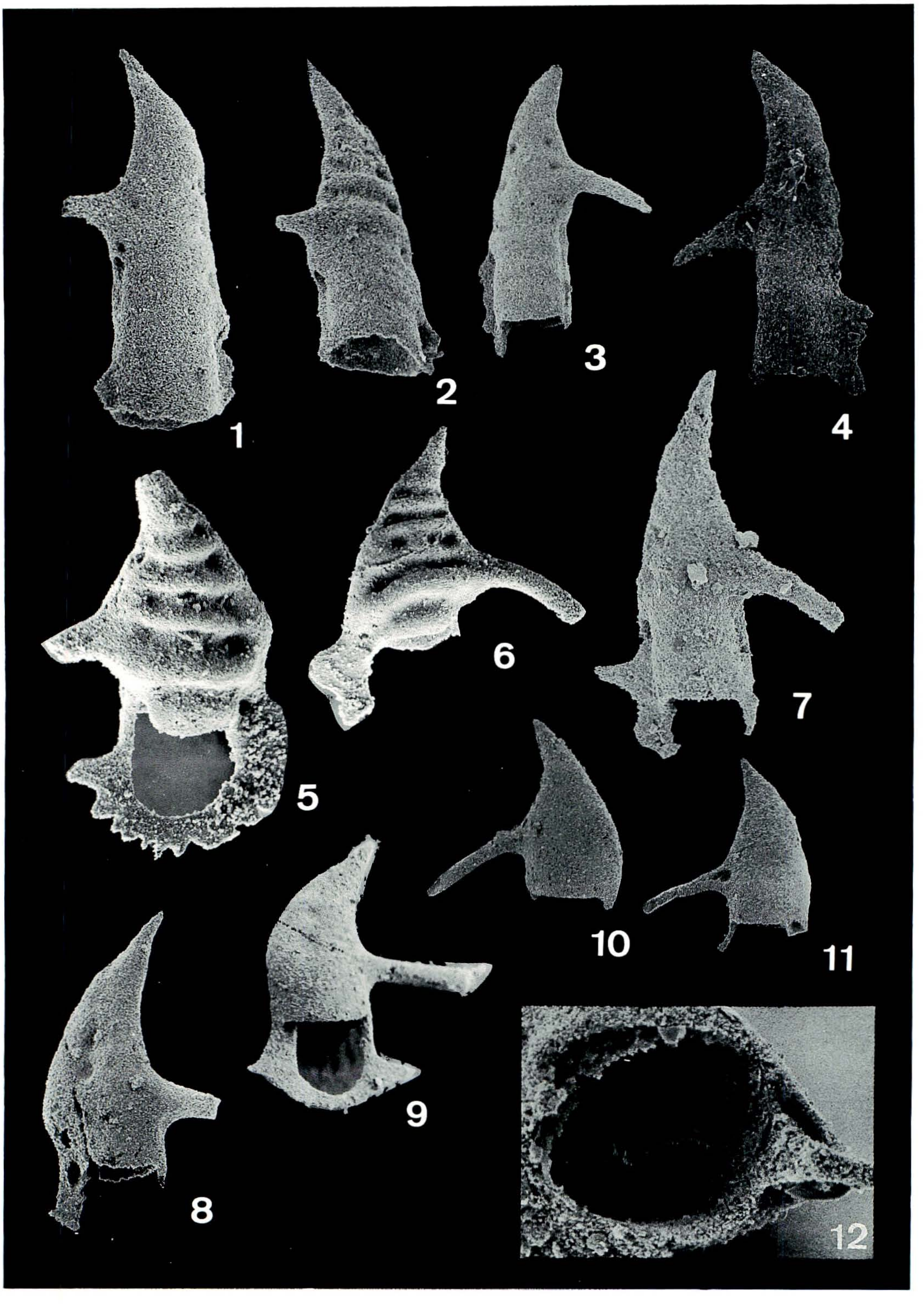
Figs. 5–6. *Albaillella triangularis* ISHIGA, KITO and IMOTO
5. OCU PR 0027, Gj–24, ×300
6. OCU PR 0028, Gj–14, ×225

Fig. 7. *Albaillella* sp. B
OCU PR 0029, Gj–47, ×250

Figs. 8–9. *Albaillella levis* ISHIGA, KITO and IMOTO
8. OCU PR 0030, Gj–50–9, ×250
9. OCU PR 0031, Gj–60, ×225

Figs. 10–11. *Albaillella* sp. aff. *A. levis* ISHIGA, KITO and IMOTO
10. OCU PR 0032, Gj–106, ×175
11. OCU PR 0033, Gj–106, ×175

Fig. 12. *Albaillella levis* ISHIGA, KITO and IMOTO
×750, The same specimen as Fig. 8, showing internal dorsal rod.


1
2
3
4
5
6
7
8
9
10
11
12

NOTES FOR CONTRIBUTORS

Contributions: Contributions for publication should be addressed to the Editorial Committee, Department of Geosciences, Faculty of Science, Osaka City University, Sugimoto 3–3–138, Sumiyoshi-ku, Osaka 558, Japan. Submission implies that the manuscript has not been published previously nor currently submitted for publication elsewhere.

All contributions should be written in English, must be sent in triplicate and typed on one side of A4 size paper, with wide margins and double-lined spacing throughout. Contributions should follow the general style of papers in the recent issue of the Journal. No limitation on the length of the manuscript is generally specified. The authors are required to nominate one or two possible referees, although their services need not necessarity be sought.

The final manuscript should be sent in ready-to- print form by adopting letter forms indicated by red underlining; italic (single line), gothic (wave line), capital (triple line), and small capital (double line).

Articles: Articles must be accompanied by a brief abslract of less than 400 words and 5 key words. Any style of headings are usable, although editors retain the right to suggest an appropriate style to the author. No cross-references of the manuscript should be given by page number, but 'above' and 'below' should be used, preferably with the section specified, e.g. Section 3.2.A. The SI system of units should principally be followed. The authors should mark in the margin of the manuscript where figures and tables may be inserted. References to larger works should, where possible, quote the page references, e.g. Huzita, 1983, p407.

Tables and illustrations: Tables shonld be type-set in such a way these can be directly reproduced. The originals of illustrations including photographs should be attached in the first submission of the manuscript. Duplicates of illustrations should accompany the manuscript copies, and may be prints or, preferably, photocopies reduced to final size. Authors who request for special printing such as folded illustrations, colored pictures etc should take prior consent of the Editorial Committee. Figure captions must be typed with double-line spacing on sheets separate from the running text.

References: The accuracy of references is the responsibility of authors.

References must be double-spaced and spelt in ordinary abbreviations, e.g.

IKEBE, N. and CHIJI, M (1971): Notes on top-datum of *Lepidocyclina* sensulato in reference to planktonic foraminiferal datum. *J. Geosci., Osaka City Univ.*, 14 19–52.

READ, H.H. (1957): *The granite controversy*. London, Thomas Murby, 430 pp.

RAVICH, M.G. (1982): The lower Precambrian of Antarctica. in *Antarctic Geosciences* (ed. C. CRADDOCK), University of Wisconsin Press, 421–427.

References related to publications written in languages other than English should be given by their original title spelled in English alphabet, together with the Engllsh translation of the title and language used in the cited reference in parentheses, as:

HUZITA, K. (1983): *Nihon no sanchi keiseiron* (Genesis of Japanese mountains) (in Japanese). Tokyo, Soju Shoboh, 466 pp.

ICHIKAWA, K., ISHII, K., NAKAGAWA, C., SUYARI, K. and YAMASHITA, N. (1956): Kurosegawa kozotai: Shikoku Chichibu ruitai no kenkyu III (Kurosegawa Tectonic Zone: Study of the Chichibu Belts, III) (in Japanese with English abstract), *J. Geol. Soc. Japan*, **62**, 82–103.

Unpublished work should normally be referred to in the text in parentheses as, for example, 'private commun., 1990', 'in preparation, 1990', or 'in press' etc and preferably be includcd in the reference list as below.

CRADDOCK, C. (private commun., 1977): Antarctica and Gondwanaland. Manuscript presented at the 4th International Symposium on Antarctic Geology and Geophyrics, Madison, August, 1977.

Proofs and offprints: The author is asked to check gally proofs for typographical errors, but is advised not to make any other changes. 200 offprints of each paper will generally be provided free of charge. Additional offprints may be purchased by order at the time of returning the first corrected proofs.