Journal of Geosciences, Osaka City University
Vol. 44, Art. 5, p. 97-119, March, 2001

Upper Permian biostratigraphic correlation between conodont and radiolarian zones in the Tamba-Mino Terrane, Southwest Japan

YAO Jianxin*, YAO Akira** and KUWAHARA Kiyoko**

*Institute of Geology, Chinese Academy of Geological Sciences, Baiwanzhuang Road, Beijing 100037, P. R. China
**Department of Geosciences, Faculty of Science, Osaka City University, Osaka 558-8585, Japan

Abstract

Some important Permian conodonts were found in the bedded cherts of the Gujo-hachiman and the Ryozen sections in the Tamba-Mino Terrane, Southwest Japan. On the basis of the biohorizons of characteristic conodont and radiolarian species, six conodont interval zones are recognized in the Upper Permian, where four radiolarian assemblage zones are settled. The conodont interval zones include the *Clarkina liangshanensis* Interval Zone, the *Clarkina orientalis* Interval Zone, the *Clarkina subcarinata* Interval Zone, the *Clarkina parasubcarinata* Interval Zone, the *Clarkina postwangi* Interval Zone and the *Clarkina meishanensis zhangi* Interval Zone, in ascending order. The radiolarian assemblage zones are the *Follicucullus scholasticus-Follicucullus ventricosus* Assemblage Zone, the *Follicucullus charveti-Albaillella yamakitai* Assemblage zone, the *Neoalbaillella ornithoformis* Assemblage Zone and the *Neoalbaillella optima* Assemblage Zone, in ascending order. Both conodont and radiolarian biostratigraphic data have been correlated with each other, and the Upper Permian biostratigraphic zonations have been examined in relation to those in South China. Changes of conodont and radiolarian faunas are discussed. A new species of *Clarkina* is described from the Upper Permian cherts.

Key words : Upper Permian, conodont, radiolaria, biostratigraphic correlation, Tamba-Mino Terrane

Introduction

In pelagic sediments such as the Upper Paleozoic-Middle Mesozoic bedded chert in the Tamba-Mino Terrane of Southwest Japan, radiolarian fossils are one of the important taxa for stratigraphic correlation. The Permian radiolarian biostratigraphy has been investigated in bedded chert sections (e.g. Ishiga et al., 1982b; Ishiga, 1986, 1990; Yao and Kuwahara, 1997; Kuwahara, 1997a; Kuwahara et al., 1998; Kuwahara, 1999a). Radiolarian research also has been done in the Permian cherts of South China, and the Permian and Triassic radiolarian zones have been tentatively correlated with those of Southwest Japan (Yao et al., 1993; Kuwahara et al., 1997; Kuwahara, 1999b; Yao and Kuwahara, 1999a-c).

In South China and Pakistan, Permian and Triassic conodont zones are regarded as one of the important standards for stratigraphic correlation and have been investigated in detail (Sweet, 1970, 1973; Sweet and Bergstrom, 1986; Wang and Wang 1981; Clark and Wang, 1988; Ding, 1992; Kozur, 1995; Mei et al., 1998; Mei and Shi, 1999, etc.). Some research on the Upper Permian and Triassic conodont biostratigraphy has been done in the bedded cherts of pelagic sediments in Japan (Igo, 1979a, 1981; Ishiga et al., 1982a; Igo and Koike, 1983; Kitao, 1993, 1996; Yamakita, 1993; Yamakita et al., 1999). Because the conodonts are not abundant in cherts, detailed conodont zones have not yet been recognized (Igo, 1996). Therefore, the correlation between conodont and radiolarian zones is equivocal.

On the basis of Yao and Kuwahara's research on

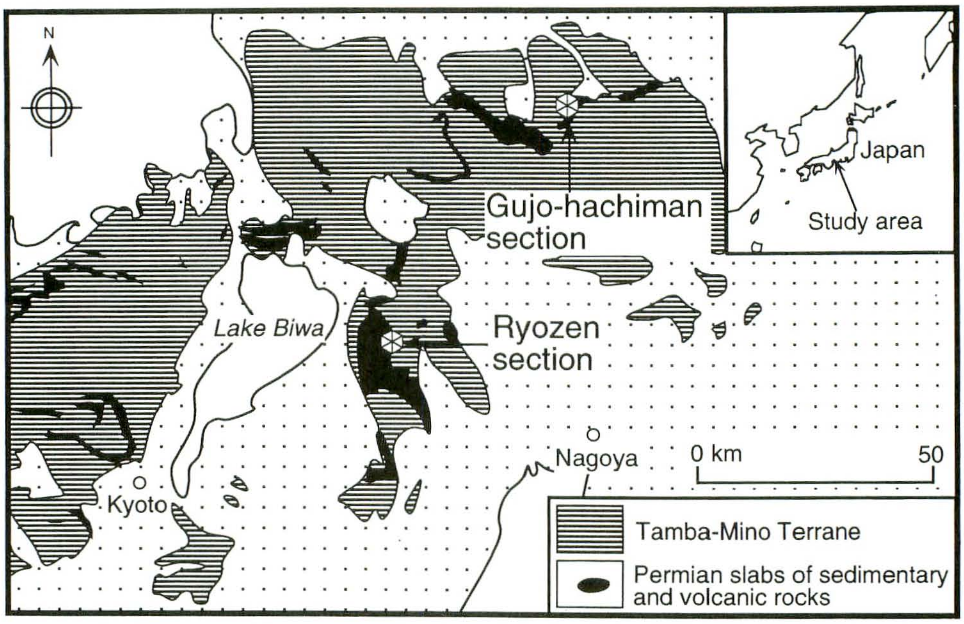


Fig. 1 Index map of the study sections (after Kuwahara, 1999).

the Upper Permian radiolarian biostratigraphy, we made further research on the conodont biostratigraphy and the correlation between radiolarian and conodont zones in the Gujo-hachiman and Ryozen sections of the Tamba-Mino Terrane (Fig. 1). In this paper, we report some important conodont zones and discuss the correlation between the radiolarian and conodont zones.

Outline of geology and materials

1. Gujo-hachiman area

The Jurassic accretionary complex in the Tamba-Mino Terrane is subdivided into several geological units. One of them, the Funafuseyama unit (Wakita, 1988) is composed of stacked slices of Middle Jurassic melanges and disrupted turbidites, and is frequently associated with blocks of Permian greenstone, limestone and chert (Wakita, 1984). The Gujo-hachiman section belongs to the Funafuseyama unit. The section consists of greenish gray bedded chert with a small amount of black siliceous claystone. The apparent thickness of the chert section is about 25 m in the N - S direction. In its lower part there are several intercalations of dolostone layers. In the middle part, hematite nodules or layers occur. The black siliceous claystone layers conformably overlie the uppermost part of the bedded chert. The bedded chert blocks are divided into six stratigraphic subsections GA, GB, GC, GD, GE, and GF by minor faults (Kuwahara, 1997b; Kuwahara et al., 1998).

The geographic site of the sampling locality (Fig. 1) is situated at 35° 43′ 55″ N and 136° 51′ 07″ E, and is the same as the sampling point of G 1709 (Wakita, 1983) and the Gujo-hachiman section (Kuwahara, 1997b). The study materials were collected from the bedded chert blocks and black siliceous claystone layers (Fig. 2). In the GC subsection, 52 rock samples were collected bed by bed, among which were 19 samples (sample numbers: Gc-1～Gc-19) from siliceous claystone layers about 1.2 m thick, and 33 samples (sample numbers: Gc-20～Gc-52) from bedded cherts about 2.5 m thick. Seventy rock samples were collected from the bedded cherts in GA, GD, GE, and GF subsections. The thickness of each subsection and the sample numbers are as follows: the GA subsection: 9.7 m thick (Gc-53～Gc-86), the GD subsection: about 4.5 m thick (Gc-87～Gc-106), the GE subsection: 2.5 m thick (Gc-107～Gc-116), the GF subsection: 2.6 m thick (Gc-117～Gc-122).

2. Ryozen area

The study area is adjacent to the east of the Tamba district and the section is located in the central part of the area included in the geologic map "Hikone-tobu", which is covered by a thick pile of calcareous and non-calcareous sedimentary strata, according to Miyamura et al. (1976). One of the calcareous strata is the Ryozensan Formation, which is mainly composed of limestone and greenstone. The study section has been regarded as a part of the Ryozensan Formation (Kuwahara, 1997b).

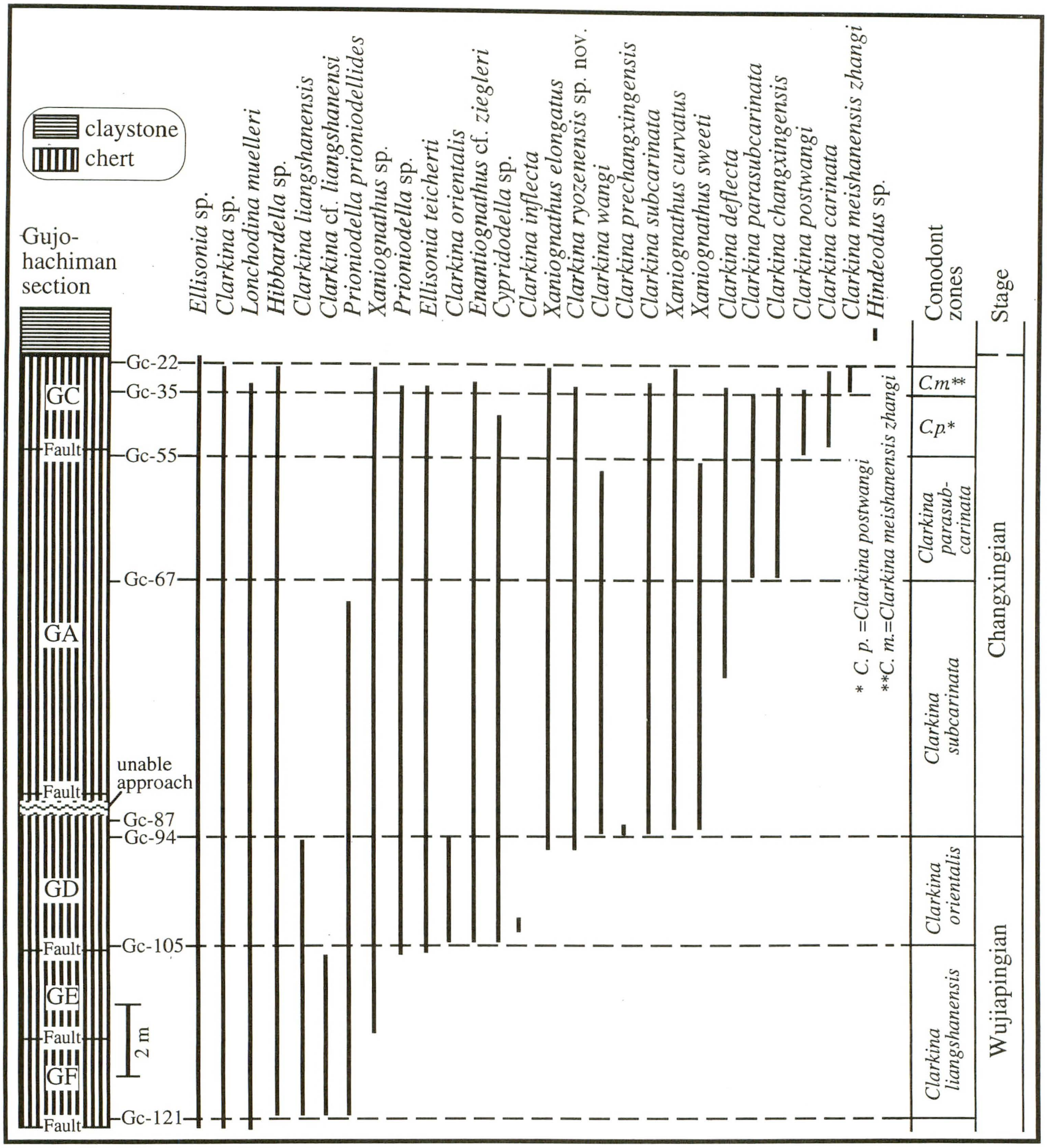


Fig. 2 Range of conodonts in the Gujo-hachiman section.

The geographic site of the sampling locality (Fig. 1) is situated at 35° 14′ 51″ N, 136° 23′ 08″ E, and is located about 1.8 km northeast of Nabejiri-yama Mountain, Taga-cho, Inukami-gun, Shiga Prefecture. Forty-five rock samples (sample numbers: Rc-1～Rc-45) were collected bed by bed from the chert about 4 m thick (Fig. 3). Four rock samples (sample numbers: Rc-46～Rc-49) were collected from the siliceous claystone, which may be in fault contact with the chert.

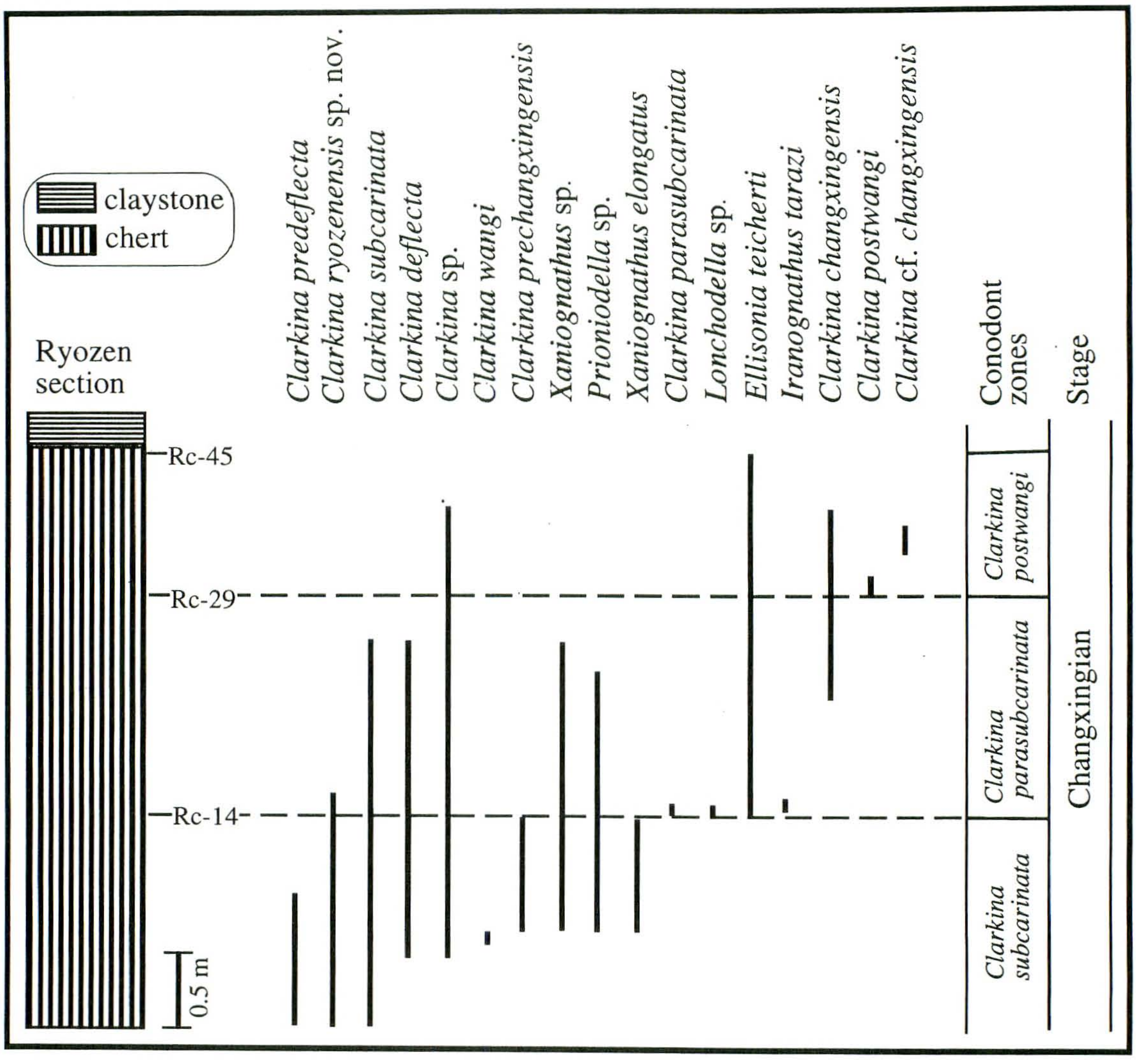


Fig. 3 Range of conodonts in the Ryozen section.

Occurrence of conodonts

In the Gujo-hachiman section, conodont fossils were obtained from 67 rock samples of chert and one rock sample of siliceous claystone (Table 1). In the Ryozen section, conodont fossils occurred in 17 rock samples of chert (Table 2). The conodonts contain pectiniform elements and ramiform elements in which the apparatus species of conodonts *Xainiognathus elongatus*, *X. curvatus* and *Lonchodina muelleri* can be recognized. Conodonts species characteristic of two sections are illustrated in Plates 1-5.

Systematic Paleontology

The Holotype is deposited in the Institute of Geology, Chinese Academy of Geological Sciences (registration numbers IGPC009). The Paratype is deposited in the Osaka City University (registration number: OCUPC0001).

Genus *Clarkina* Kozur, 1989

Type species: *Gondolella leveni* Kozur, Mostler and Rahimi-Yazd, 1976

Clarkina ryozenensis Yao Jianxin, sp. nov.
(Plate 2, Figs. 5-8; Plate 3, Fig. 11)

Diagnosis: A *Clarkina* with an elongate platform, denticles strongly discrete and basically equal in size. Cusp prominent, reclined and terminally located.

Description: A species of *Clarkina* characterized by a Pa element with a relatively long and narrow platform, widest at the parts of the posterior and middle platform. Carina is surrounded by the plat-

Table 1 Occurrence of conodonts in the Gujo-hachiman section.

Subsection	GC																															
Sample	Gc-1	Gc-2	Gc-3	Gc-4	Gc-5	Gc-6	Gc-7	Gc-8	Gc-9	Gc-10	Gc-11	Gc-12	Gc-13	Gc-14	Gc-15	Gc-16	Gc-17	Gc-18	Gc-19	Gc-20	Gc-21	Gc-22	Gc-23	Gc-24	Gc-25	Gc-26	Gc-27	Gc-28	Gc-29	Gc-30	Gc-31	Gc-32
Clarkina sp.																							X	X				X		X		X
Clarkina liangshanensis																																
Clarkina cf. *liangshanensis*																																
Clarkina orientalis																																
Clarkina inflecta																																
Clarkina ryozenensis sp. nov.																																X
Clarkina wangi																																
Clarkina prechangxingensis																																
Clarkina subcarinata																																X
Clarkina deflecta																																
Clarkin parasubcarinata																																
Clarkina changxingensis																																X
Clarkina postwangi																																X
Clarkina meishanensis zhangi																						X										X
Clarkina carinata																										X						
Ellisonia sp.																					X		X								X	X
Lonchodina muelleri																																X
Hibbardella sp.																									X	X						
Prioniodella prioniodellides																																
Prioniodella sp.																																
Ellisonia teicherti																																X
Xaniognathus sp.																							X									
Enantiognathus cf. *ziegleri*																													X			
Cypridodella sp.																																
Xaniognathus elongatus																							X	X	X				X			
Xaniognathus curvatus																								X								
Xaniognathus sweeti																																
Hindeodus sp.									X																							

Subsection	GA																												
Sample	Gc-33	Gc-34	Gc-35	Gc-36	Gc-37	Gc-38	Gc-39	Gc-40	Gc-41	Gc-42	Gc-43	Gc-44	Gc-45	Gc-46	Gc-47	Gc-48	Gc-49	Gc-50	Gc-51	Gc-52	Gc-53	Gc-54	Gc-55	Gc-56	Gc-57	Gc-58	Gc-59	Gc-60	Gc-61
Clarkina sp.							X	X	X	X		X	X			X			X	X				X	X				X
Clarkina liangshanensis																													
Clarkina cf. *liangshanensis*																													
Clarkina orientalis																													
Clarkina inflecta																													
Clarkina ryozenensis sp. nov.	X		X					X																					
Clarkina wangi																											X		
Clarkina prechangxingensis																													
Clarkina subcarinata	X	X						X		X			X	X						X						X	X		X
Clarkina deflecta	X		X										X																
Clarkin parasubcarinata			X	X									X																
Clarkina changxingensis	X															X				X									
Clarkina postwangi				X																X		X	X						
Clarkina meishanensis zhangi			X																										
Clarkina carinata																				X									
Ellisonia sp.								X		X				X								X							
Lonchodina muelleri								X		X																			
Hibbardella sp.										X	X																		
Prioniodella prioniodellides																													
Prioniodella sp.	X				X			X							X														
Ellisonia teicherti																													
Xaniognathus sp.								X					X	X			X			X						X			
Enantiognathus cf. *ziegleri*																		X								X			
Cypridodella sp.											X																		
Xaniognathus elongatus										X				X									X	X	X				
Xaniognathus curvatus								X		X													X			X			
Xaniognathus sweeti																								X					
Hindeodus sp.																													

Subsection	GA																								
Sample	Gc-62	Gc-63	Gc-64	Gc-65	Gc-66	Gc-67	Gc-68	Gc-69	Gc-70	Gc-71	Gc-72	Gc-73	Gc-74	Gc-75	Gc-76	Gc-77	Gc-78	Gc-79	Gc-80	Gc-81	Gc-82	Gc-83	Gc-84	Gc-85	Gc-86
Clarkina sp.				X	X																				
Clarkina liangshanensis																									
Clarkina cf. *liangshanensis*																									
Clarkina orientalis																									
Clarkina inflecta																									
Clarkina ryozenensis sp. nov.	X					X																			
Clarkina wangi														X			X								
Clarkina prechangxingensis																									
Clarkina subcarinata	X					X																			
Clarkina deflecta																	X								
Clarkin parasubcarinata	X					X																			
Clarkina changxingensis						X																			
Clarkina postwangi																									
Clarkina meishanensis zhangi																									
Clarkina carinata																									
Ellisonia sp.																									
Lonchodina muelleri	X			X		X													X						
Hibbardella sp.						X					X														
Prioniodella prioniodellides											X														
Prioniodella sp.																									
Ellisonia teicherti																									
Xaniognathus sp.											X							X							
Enantiognathus cf. *ziegleri*																									
Cypridodella sp.																					X				
Xaniognathus elongatus																			X						
Xaniognathus curvatus																			X						
Xaniognathus sweeti																									
Hindeodus sp.																									

Subsection	GD																			
Sample	Gc-87	Gc-88	Gc-89	Gc-90	Gc-91	Gc-92	Gc-93	Gc-94	Gc-95	Gc-96	Gc-97	Gc-98	Gc-99	Gc-100	Gc-101	Gc-102	Gc-103	Gc-104	Gc-105	Gc-106
Clarkina sp.						X				X										
Clarkina liangshanensis							X			X										
Clarkina cf. *liangshanensis*																				
Clarkina orientalis								X				X			X			X	X	
Clarkina inflecta															X					
Clarkina ryozenensis sp. nov.								X			X									
Clarkina wangi								X												
Clarkina prechangxingensis								X												
Clarkina subcarinata							X	X												
Clarkina deflecta																				
Clarkin parasubcarinata																				
Clarkina changxingensis																				
Clarkina postwangi																				
Clarkina meishanensis zhangi																				
Clarkina carinata																				
Ellisonia sp.										X										
Lonchodina muelleri				X							X								X	
Hibbardella sp.											X			X						
Prioniodella prioniodellides																				
Prioniodella sp.																				
Ellisonia teicherti																				
Xaniognathus sp.											X			X						X
Enantiognathus cf. *ziegleri*																			X	
Cypridodella sp.										X	X									
Xaniognathus elongatus				X				X		X	X									
Xaniognathus curvatus										X	X									
Xaniognathus sweeti											X									
Hindeodus sp.																				

Subsection	GE									
Sample	Gc-107	Gc-108	Gc-109	Gc-110	Gc-111	Gc-112	Gc-113	Gc-114	Gc-115	Gc-116
Clarkina sp.			X	X						X
Clarkina liangshanensis	X									
Clarkina cf. *liangshanensis*			X							
Clarkina orientalis										
Clarkina inflecta										
Clarkina ryozenensis sp. nov.										
Clarkina wangi										
Clarkina prechangxingensis										
Clarkina subcarinata										
Clarkina deflecta										
Clarkin parasubcarinata										
Clarkina changxingensis										
Clarkina postwangi										
Clarkina meishanensis zhangi										
Clarkina carinata										
Ellisonia sp.										
Lonchodina muelleri										
Hibbardella sp.										
Prioniodella prioniodellides										
Prioniodella sp.		X								
Ellisonia teicherti		X								
Xaniognathus sp.										X
Enantiognathus cf. *ziegleri*										
Cypridodella sp.										
Xaniognathus elongatus										
Xaniognathus curvatus										
Xaniognathus sweeti										
Hindeodus sp.										

Subsection	GF					
Sample	Gc-117	Gc-118	Gc-119	Gc-120	Gc-121	Gc-122
Clarkina sp.					X	X
Clarkina liangshanensis					X	
Clarkina cf. *liangshanensis*					X	
Clarkina orientalis						
Clarkina inflecta						
Clarkina ryozenensis sp. nov.						
Clarkina wangi						
Clarkina prechangxingensis						
Clarkina subcarinata						
Clarkina deflecta						
Clarkin parasubcarinata						
Clarkina changxingensis						
Clarkina postwangi						
Clarkina meishanensis zhangi						
Clarkina carinata						
Ellisonia sp.					X	X
Lonchodina muelleri						X
Hibbardella sp.					X	
Prioniodella prioniodellides					X	
Prioniodella sp.						
Ellisonia teicherti						
Xaniognathus sp.						
Enantiognathus cf. *ziegleri*						
Cypridodella sp.						
Xaniognathus elongatus						
Xaniognathus curvatus						
Xaniognathus sweeti						
Hindeodus sp.						

form, consisting of strongly discrete denticles, which are basically equal in size. Cusp prominent, reclined and terminally located, extends beyond the posterior platform margin.

Remarks: This new species can be distinguished from *Clarkina meishanensis zhangi* by equal and strongly discrete denticles.

Etymology: This species is named from the Ryozen section.

Type material: Holotype (IGPC009) from Rc-14 (Pl. 3, Fig. 11); Paratype (OCUPC0001) form Gc-97 (Pl. 2, Fig. 6).

Photographed material: Five specimens.

Age: Late Permian.

Occurrence: This species occurs in Rc-14 of the Ryozen section, and in Gc-32, Gc-33, Gc-35, Gc-

Table 2 Occurrence of conodonts in the Ryozen section.

Sample	Rc-45	Rc-44	Rc-43	Rc-42	Rc-41	Rc-40	Rc-39	Rc-38	Rc-37	Rc-36	Rc-35	Rc-34	Rc-33	Rc-32	Rc-31	Rc-30	Rc-29	Rc-28	Rc-27	Rc-26	Rc-25	Rc-24	Rc-23	Rc-22	Rc-21	Rc-20	Rc-19	Rc-18	Rc-17	Rc-16	Rc-15	Rc-14	Rc-13	Rc-12	Rc-11	Rc-10	Rc-9	Rc-8	Rc-7	Rc-6	Rc-5	Rc-4	Rc-3	Rc-2	Rc-1
Clarkina predeflecta																																						■						■	
Clarkina ryozenensis sp. nov.																															■	■							■					■	
Clarkina subcarinata																						■		■							■							■	■	■				■	
Clarkina deflecta																						■																■			■				
Clarkina sp.							■					■			■				■					■															■		■				
Clarkina wangi																																								■					
Clarkina prechangxingensis																																■							■						
Xaniognathus sp.																						■	■	■								■							■						
Prioniodella sp.																								■								■							■						
Xaniognathus elongatus																																■							■						
Lonchodella sp.																																■													
Clarkina parasubcarinata																																■													
Ellisonia teicherti	■																							■								■													
Iranognathus tarazi																															■														
Clarkina changxingensis							■															■		■																					
Clarkina postwangi																	■																												
Clarkina cf. *liangshanensis*							■		■																																				

40, Gc-62, Gc-67, Gc-94, Gc-97 of the Gujo-hachiman section.

Conodont biostratigraphy

The Upper Permian conodont zones, the *Clarkina changxingensis-C. subcarinata* Zone and the *Hindeodus typicalis-Iranognathus* sp. Zone were recognized in the carbonate sections of Japan (Igo, 1996). Many species of *Clarkina*, such as *Clarkina changxingensis*, *C. subcarinata*, *C. denticulata*, *C. orientalis* and other conodonts were reported in the Tamba-Mino Terrane (Ishiga et al., 1982a; Kitao, 1993, 1996; Yamakita et al., 1999). But the Upper Permian conodont zones have not yet been subdivided in detail. On the basis of research on the compositions and ranges of the conodont faunas in the chert of the Gujo-hachiman and Ryozen areas, six Upper Permian conodont interval zones were recognized. They include the *Clarkina liangshanensis* Interval Zone, the *C. orientalis* Interval Zone, the *C. subcarinata* Interval Zone, the *C. parasubcarinata* Interval Zone, the *C. postwangi* Interval Zone, and the *C. meishanensis zhangi* Interval Zone, in ascending order (Figs. 2 and 3).

1. *Clarkina liangshanensis* Interval Zone

Composition: *Clarkina liangshanensis* is the diagnostic species of this zone, and its existence marks the base of the zone. The upper limit of the zone is drawn at the first occurrence biohorizon of *Clarkina orientalis*. Common species in this zone are *Clarkina* sp., *C.* cf. *liangshanensis*, *Prioniodella prioniodellides*, *Lonchodina muelleri*, *Ellisonia teicherti*, *Hibbardella* sp., *Prioniodella* sp., *Xaniognathus* sp., and *Ellisonia* sp.

Age: earliest Late Permian (early Wujiapingian)

Occurrence: Chert of the GE and GF subsections in Gujo-hachiman (Gc-107～Gc-110, Gc-116, Gc-121, and Gc-122).

Remarks: This zone is possibly equivalent with the *Clarkina transcaucasica* Zone of South China, in which *C. liangshanensis* is abundant besides *C. transcaucasica*. In the GE and GF subsections of the Gujo-hachiman area, *C. transcaucasica* has not been found.

2. *Clarkina orientalis* Interval Zone

Composition: The lower limit of the zone is marked by the first occurrence biohorizon of *Clarkina orientalis*, which is also the diagnostic species of this zone. The upper limit of the zone is marked by the first appearance biohorizon of *Clarkina subcarinata*. Common species in this zone are *Clarkina liangshanensis*, *C. inflecta*, *C. ryozenensis* sp. nov., *C.* sp., *Lonchodina muelleri*, *Enatiognathus* cf. *ziegleri*, *Xaniognathus elongatus*, *X. curvatus*, *X. sweeti*, *Ellisonia* sp., *Hibbardella* sp., *Cypridodella* sp., and *Xaniognathu* sp.

Age: early Late Permian (late Wujiapingian)

Occurrence: Bedded chert of the lower part of the GD subsection in Gujo-hachiman (Gc-96～Gc-98, Gc-100, Gc-101, Gc-104, and Gc-105).

Remarks: The *Clarkina inflecta* Zone was recognized in the top of the Wujiapingian in South China (Mei et al., 1994; Mei et al., 1998). But *C. inflecta* is not yet regarded as the diagnostic species of this zone in the Gujo-hachiman area, because it is rare in numbers. The *C. orientalis* Interval Zone may include the *C. orientalis* and *C. inflecta* Zones of South China. Similar cases are also found in Abadeh and Julfa areas, Iran.

3. *Clarkina subcarinata* Interval Zone

Composition: The lower limit of the zone is marked by the first occurrence biohorizon of *Clarkina subcarinata*, which is also the diagnostic species of this zone. The top of the zone is marked by the first occurrence biohorizon of *Clarkina parasubcarinata*. The common species in this zone are *Clarkina liangshanensis*, *C. wangi*, *C. ryozenensis* sp. nov., *C. prechangxingensis*, *C. deflecta*, *C.* sp., *Lonchodina muelleri*, *Xaniognathus elongatus*, *X. curvatus*, *Prioniodella prioniodellides*, *Hibbardella* sp. and *Xaniognathus* sp.

Age: early-middle Late Permian (earliest Changxingian)

Occurrence: Bedded chert of the upper part of the GD subsection and the lower part of the GA subsection of Gujo-hachiman (Gc-72, Gc-75, Gc-78～Gc-80, Gc-82, Gc-90, Gc-92～Gc-94), and the lower part of the Ryozen section (Rc-2, Rc-5～Rc-8).

Remarks: As mentioned above, the base of this zone is well defined in the GD subsection of Gujo-hachiman, but it is unclear in the Ryozen section, because the diagnostic species of the *Clarkina orientalis* Interval Zone was not found in the Ryozen section.

4. *Clarkina parasubcarinata* Interval Zone

Composition: The diagnostic species of this zone is *Clarkina parasubcarinata*, its first occurrence biohorizon marks the lower limit of this zone. The top of the zone is marked by the first occurrence biohorizon of *Clarkina postwangi*. The common species in this zone are *Clarkina deflecta*, *C. changxingensis*, *C. ryozenensis* sp. nov., *C. wangi*, *C. subcarinata*, *C.* sp., *Lonchodina muelleri*, *Enantiognathus* cf. *ziegleri*, *Xaniognathus elongatus*, *X. curvatus*, *X. sweeti*, *Iranognathus tarazi*, *Ellisonia teicherti*, *Hibbardella* sp., *Prioniodella* sp., and *Xaniognathus* sp.

Age: middle Late Permian (early-middle Changxingian)

Occurrence: Bedded chert of the upper part of the GA subsection of Gujo-hachiman (Gc-56～Gc-59, Gc-61, Gc-62, Gc-65～Gc-67) and the middle part of the Ryozen section (Rc-14, Rc-15, Rc-22～Rc-24, Rc-27).

Remarks: This zone is correlative with the *Clarkina changxingensis* Assemblage Zone of South China, where *Clarkina changxingensis* and *C. parasubcarinata* are concurrent in the *Clarkina changxingensis* Assemblage Zone.

5. *Clarkina postwangi* Interval Zone

Composition: The lower limit of this zone is marked by the first occurrence biohorizon of *Clarkina postwangi*, which is also diagnostic species of the zone. The top of the zone is marked by the first occurrence biohorizon of *Clarkina meishanensis zhangi*. The common species in this zone are *Clarkina subcarinata*, *C. ryozenensis* sp. nov., *C. deflect*, *C. parasubcarinata*, *C. changxingensis*, *C. carinata*, *C.* sp., *Lonchodina muelleri*, *Ellisonia teicherti*, *Enatiognathus* cf. *ziegleri*, *Xaniognathus elongatus*, *X. curvatus*, *Ellisonia* sp., *Hibbardella* sp., *Prioniodella* sp., *Xaniognathus* sp., and *Cypridodella* sp.

Age: middle-late Late Permian (middle Changxingian)

Occurrence: Bedded chert of the upper part of the GA subsection of Gujo-hachiman (Gc-36, Gc-37, Gc- 39～Gc-52, Gc-54, Gc-55) and the upper part of the Ryozen section (Rc-29, Rc-31, Rc-34, Rc-37, Rc- 39, Rc-45).

6. *Clarkina meishanensis zhangi* Interval Zone

Composition: The diagnostic species of this zone is *Clarkina meishanensis zhangi*, its first appearance biohorizon marks the lower limit of the zone. The top of the zone is at the position in which *C. meishanensis* disappears. The common species of the zone are *Clarkina subcarinata*, *C. ryozenensis* sp. nov., *C. deflecta*, *C. parasubcarinata*, *C. changxingensis*, *C. postwangi*, *C. carinata*, *C.* sp., *Lonchodina muelleri*, *Ellisonia teicherti*, *Enantiognathus* cf. *ziegleri*, *Xaniognathus elongatus*, *X. curvatus*, *Ellisonia* sp., *Hibbardella* sp. *Prioniodella* sp., and *Xaniognathus* sp.

Age: late Late Permian (late Changxingian).

Occurrence: Bedded chert of the upper part of the GC subsection of Gujo-hachiman (Gc-21, GC-26, and Gc-28～Gc-35).

Remarks: This zone may correspond to the *Clarkina changxingensis yini*-*C. meishanensis zhangi*

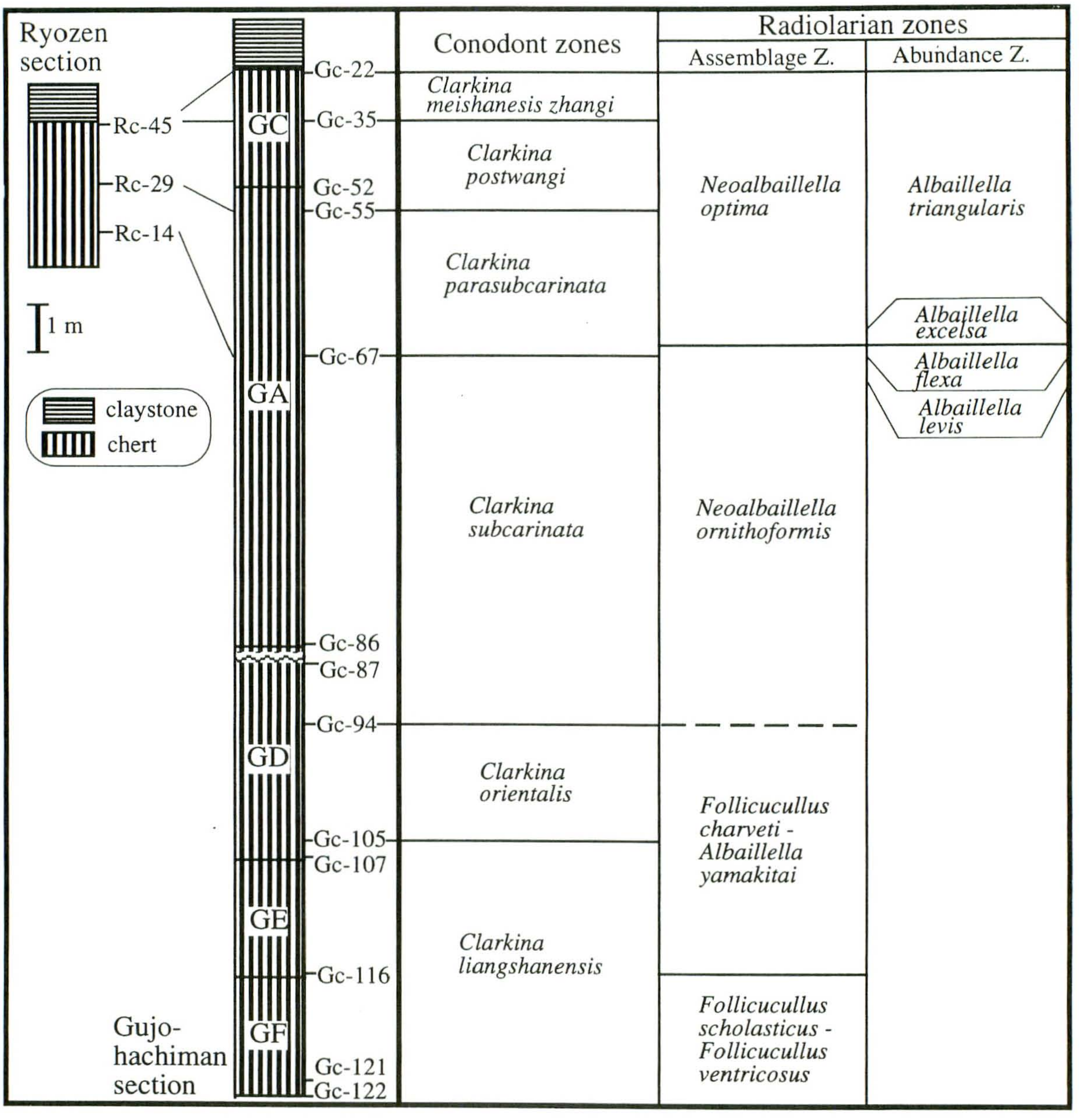


Fig. 4 Correlation of the conodont and radiolarian zones between the Gujo-hachiman and Ryozen sections.

Assemblage Zone of South China where the diagnostic species of the assemblage zone are concurrent in the top of the Changxing Formation (Mei et al., 1998). *Clarkina changxingensis yini* was not found in the top of the bedded chert of the GC subsection in Gujo-hachiman, and therefore, only *C. meishanensis zhangi* is regarded as the diagnostic species in Gujo-hachiman. The upper part of the GC subsection of Gujo-hachiman consists of siliceous claystone. In the lower part of the siliceous claystone, there is no conodont fossil to be found, only conodont *Hindeodus* sp. appears in the upper part of the siliceous claystone. The top of the zone is, therefore, marked by the disappearance biohorizon of *Clarkina meishanensis*.

The correlation of conodont zones between the Gujo-hachiman and Ryozen sections is shown in Fig. 4. According to the correlation, the Ryozen section may only correspond to the GA subsection and the lower part of the GC subsection; the corresponding horizons of the GD, GE and GF subsections and upper part of the GC subsection are absent from the Ryozen section. The absence of the *Clarkina meishanensis zhangi* Zone shows that the boundary between the bedded chert and siliceous claystone is assumed to be a paraconformity in the Ryozen section.

Radiolarian biostratigraphy

Four Upper Permian radiolarian assemblage zones were settled in the Tamba-Mino Terrane. These include the *Fullicucullus scholasticus-Follicucullus ventricosus* Assemblage Zone, the *Follicucullus charveti-Albaillella yamakitai* Assemblage Zone, the *Neoalbaillella ornithoformis* Assemblage Zone, and the *Neoalbaillella optima* Assemblage Zone, in ascending order (Kuwahara et al., 1998; Kuwahara, 1999). Based on the radiolarian data in this study, together with the previous data, radiolarian zones are recognized as follows. In the Gujo-hachiman, the GF subsection is correlated with the *Follicucullus scholasticus-Follicucullus ventricosus* Assemblage Zone (Fig. 4). The GE subsection and the lower part of the GD subsection (at least up to Gc-95) are the *Follicucullus charveti-Albaillella yamakitai* Assemblage Zone. *Albaillella cavitata* occurs from samples Gc-97 and Gc-95, and *Albaillella yamakitai* is detected from Gc-95. The critical boundary between the *Follicucullus charveti-Albaillella yamakitai* Assemblage Zone and the *Neoalbaillella ornithoformis* Assemblage Zone is unknown, because no *Neoalbaillella* species are detected from the GD subsection. The upper part of the GD subsection and the lower part of the GA subsection are the *Neoalbaillella ornithoformis* Assemblage Zone. The first occurrence of *Albaillella triangularis* is Gc-66. The *Neoalbaillella optima* Assemblage Zone is from Gc-66 to Gc-19 probably, because the lower part of the claystone bed was also correlated to the *Neoalbaillella optima* Assemblage Zone (Kuwahara et al., 1991). In the Ryozen section, the boundary of the *Neoalbaillella ornithoformis* Assemblage Zone and the *Neoalbaillella optima* Assemblage Zone is settled between Rc-17 and Rc-18 (Fig. 4). Upper Permian radiolarian abundance zones are useful for correlation, and these zones are also illustrated in Figs. 4 and 5.

Correlation between conodont and radiolarian biostratigraphies

As mentioned in the introduction section, the Permian radiolarian biostratigraphy of the pelagic

	South China	Southwest Japan		
	Conodont Zones	Conodont Zones	Radiolarian Zones	
Changxingian	*Clarkina meishanensis meishanensis*	*Clarkina meishanensis zhangi*	*Neoalbaillella optima*	*Albaillella triangularis*
	Clarkina changxingensis yini-Clarkina meishanensis zhangi			
	Clarkina postwangi	*Clarkina postwangi*		
	Clarkina changxingensis	*Clarkina parasubcarinata*		*Albaillella excelsa*
	Clarkina subcarinata-Clarkina wangi	*Clarkina subcarinata*	*Neoalbaillella ornithoformis*	*Albaillella flexa*
				Albaillella levis
Mid.-Up. Wujiapingian	*Clarkina inflecta*	*Clarkina orientalis*	*Follicucullus charveti - Albaillella yamakitai*	
	Clarkina orientalis			
	Clarkina transcaucasica	*Clarkina liangshanensis*	*Follicucullus scholasticus - Follicucullus ventricosus*	

Fig. 5 Correlation os the conodont and radiolarian zones between Southwest Japan and South China. The conodont zones of South China are after Mei et al. (1998), Mei and Shi (1999).

sediments in the Tamba-Mino Terrane and the evolution series of the conodont in the carbonate platform sediments in South China have been investigated in detail. According to research on the radiolarian and conodont fossils detected from the cherts of the Gujo-hachiman and Ryozen sections, we make a correlation between the conodont and radiolarian zones (Fig. 4) and its relation with the conodont zones of South China (Fig. 5). The results are as follows:

1. The radiolarian *Neoalbaillella optima* Assemblage Zone corresponds to the conodont *Clarkina meishanensis zhangi* Interval Zone, *C. postwangi Interval* Zone and the middle-upper part of *C. parasubcarinata* Interval Zone in the Gujo-hachiman section. In addition, in South China, elements of the *N. optima* Assemblage Zone were also found from the upper part of the Dalong Formation of the Shangsi section of Sichuan Province, which corresponds to the horizon of the above-mentioned conodont zones (Yao and Kuwahara, 1999a, b). The *C. meishanensis zhangi* Interval Zone of the Gujo-hachiman section is equal to the *C. changxingensis yini-C. meishanensis zhangi* Assemblage Zone of South China. The *Clarkina changxingensis yini-C. meishanensis zhangi* Assemblage Zone is just under *C. meishanensis meishanensis* Zone which is located in boundary bed 1 consisting of illite-montmorillonite clay and mudstone in the Meishan section, Changxing County, Zhejiang Province, China (Mei et al., 1998). The *C. meishanensis zhangi* Interval Zone is below the siliceous claystone in the Gujo-hachiman section. Although no conodont fossils have yet been found from the lower part of the siliceous claystone of the Gujo-hachiman section, radiolarian *Neoalbaillella optima* and *Albaillella triangularis* have occurred (Kuwahara et al., 1991). The lower part of the siliceous claystone yielding radiolarian *N. optima* and *A. triangularis* may correspond to the boundary bed 1 yielding conodont *C. meishanensis meishanensis* of South China. The top of the radiolarian *N. optima* Assemblage Zone may include the conodont *C. meishanensis meishanensis* Assemblage Zone of South China.

The range of the radiolarian *Albaillella triangularis* Abundance Zone is similar to the *Neoalbaillella optima* Assemblage Zone in the Gujo-hachiman section, and it is also equal to the conodont *Clarkina meishanensis zhangi* Interval Zone, the *C. postwangi* Interval Zone and the middle-upper parts of the *C. parasubcarinata* Interval Zone. The lower limit of the *N. optima* Assemblage Zone of the Gujo-hachiman section is a little higher than that of the Ryozen section, if the radiolarian *Albaillella excelsa* Abundance Zone and the conodont *Clarkina parasubcarinata* Interval Zone are regarded as the standard of correlation.

2. In the Ryozen section, the radiolarian *Albaillella excelsa* Abundance Zone corresponds to a part of the lower-middle parts of the conodont *C. parasubcarinata* Interval Zone, and the radiolarian *A. levis* Abundance Zone is correlative with a part of the upper part of the conodont *Clarkina subcarinata* Interval Zone. In the Gujo-hachiman section, the radiolarian *Albaillella excelsa* and *A. flexa* Abundance Zones may be equal to the lower part of the conodont *C. parasubcarinata* Interval Zone, and the radiolarian *A. levis* Abundance Zone may be correlative with the top of the conodont *Clarkina subcarinata* Interval Zone.

3. The radiolarian *Neoalbaillella ornithoformis* Assemblage Zone corresponds to the conodont *Clarkina subcarinata* Interval Zone and the lower part of the *C. parasubcarinata* Interval Zone in the Gujo-hachiman section.

4. The radiolarian *Follicucullus charveti- Albaillella yamakitai* Assemblage Zone is equal to the conodont *Clarkina orientalis* Interval Zone and the middle-upper parts of the *Clarkina liangshanensis* Interval Zone in the Gujo-hachiman section. According to the range of the radiolarian zones in the Gujo-hachiman section, the radiolarian *F. charveti-A. yamakitai* Assemblage Zone may also include the horizon of the conodont *Clarkina inflecta* Zone of South China, which is at the top part of the Wujianpingian in South China.

5. The radiolarian *Follicucullus scholasticus-F. ventricosus* Assemblage Zone is correlative with the lower part of the conodont *Clarkina liangshanensis* Interval Zone in the Gujo-hachiman section or the position of the *C. transcaucasica* Zone of South China, which is under the conodont *Clarkina orientalis* Zone in South China.

6. According to the correlation, two boundaries of the conodont and radiolarian zones may be similar. One is settled between the radiolarian *Follicucullus charveti-Albaillella yamakitai* and *Neoalbaillella ornithoformis* Assemblage Zones, which is equal to the boundary between the conodont *Clarkina orientalis* and *Clarkina subcarinata* Interval Zones; it is also the boundary between the Changxingian and Wujiapingian. This means that the stage boundary of the Upper Permian base for conodont and radiolaria may be similar, and horizons of the radiolarian *Neoalbail-*

lella optima and *N. ornithoformis* Assemblage Zones correspond to all the Changxingian.

The other boundary is between the radiolarian *Albaillella levis* and *A. flexa* Abundance Zones, which may be correlative with the boundary between the conodont *Clarkina subcarinata* and *C. parasubcarinata* Interval Zones in the Gujo-hachiman section. This boundary is a little different between conodont and radiolarian zones in the Ryozen section, because the radiolarian *Albaillella flexa* Abundance Zone was not found from the Ryozen section.

Change of conodont and radiolarian faunas

According to the conodont occurrence in the Gujo-hachiman section, two conodont thriving stages of deep-water facies can be recognized (Table 1). One was in late Wujiapingian, which is basically from Gc-94 to Gc-97. The other was in late Changxingian, from Gc-21 to Gc-67. The characteristics of the conodont thriving stages are high diversities (15 species and 21 species) and richness of conodonts of deep-water facies, such as *Xaniognathus elongatus*, *X. curvatus*, *Enatiognathus* cf. *ziegleri*, *Cypridodella* sp., *Hibbardella* sp., *Prioniodella* sp., *Clarkina orientalis*, *C. subcarinata*, *C. changxingensis*, *C. postwangi*, *C. parasubcarinata*, and *C. deflecta*. In the thriving stages, it was difficult to find conodonts of extensive adaptability or shallow-water facies, such as elements of genus *Hindeodus*. This was also found in South China (Yao et al., 1994), specially in the Shangsi section of South China, where the thriving stages of the deep shelf facies conodonts occurred in the base of Dalong Formation (late Wujiapingian) and the upper part of the Dalong Formation (Zhan et al., 1989). The research on sedimentary facies also furnished the evidence that the Shangsi area was located in a deep shelf during early and late Changxingian (Jin and Huang, 1989).

The change of radiolarian fauna is similar to the conodont fauna in the Gujo-hachiman section. The change is characterized by albaillellid abundance. From Gc-97 to Gc-98, albaillellid occurs moderately in abundance. From Gc-71 to Gc-20, albaillellid becomes very abundant, comparing other horizons. Some species of Albaillellaria, Entactinaria and Spumellaria were also found from the Middle and Upper Permian in the Changjianggou section, Guangyuan, Sichuan Province, China (Yao and Kuwahara, 1999). Horizons of the abundant change of the albaillellid may correspond with the positions of the conodont thriving stages.

This identity of changes of the conodont and radiolarian faunas reveals that the changes of eustatic movements may be similar between the Tamba-Mino Terrane, Southwest Japan and South China during Late Permian.

Acknowledgement

The authors thank Dr. Kenji Kashiwagi of Osaka City University, who helped sampling in the field work in the Ryozen area. One of the authors (YAO Jianxin) was funded by Grant-in Aid for Japan Society for the Promotion of Science Fellowship for Research in Japan (L99545) from the Ministry of Education, Science and Culture of Japan. He was also supported partly by the National Nature Science Foundation of China (49572088 and 49972014). The senior author (YAO Akira) was supported by the Scientific Research Fund from the Japanese Ministry of Education, Science and Culture (no. 11640466).

References

Clark, D. L. and Wang, C. Y. (1988) Permian neogondolellids from South China: significance for evolution of the *serrata* and *carinata* groups in North America. *Jour. Paleont*, **62 (1)**, 132-138.

Ding, M. H. (1992) Conodont sequences in the Upper Permian and Lower Triassic of South China and the nature of conodont faunal changes at the systemic boundary. *In*: *Permo-Triassic events in the Eastern Tethys* (Sweet, W. C., Yang, Z., Dickins, J. M. and Yin, H. eds.), 109-119; Cambridge University Press.

Igo, Hh. (1979) Biostratigraphy of Permian conodont. *Mem. Vol. Prof. Mosaburo Kanuma*, 5-20. (in Japanese)

Igo, Hh. (1981) Permian conodont biostratigraphy of Japan. *Palaeont. Soc. Japan, Special Papers*, **24**, 1-50.

Igo, Hh. (1996) Silurian to Triassic conodont biostratigraphy in Japan. *Acta Micropalaeontol. Sinica*. **13 (2)**, 143-160.

Igo, Hy. and Koike, T. (1983) Conodont biostratigraphy of cherts in the Japanese Islands. *In: Siliceous Deposits in the Pacific Region* (Iijima, A., Hein, J. R. and Siever, R. eds.), 65-78, Elsevier, Amsterdam.

Ishiga, H. (1986) Late Carboniferous and Permian radiolarian biostratigraphy of Southwest Japan. *Jour. Geosci., Osaka City Univ.*, **29**, 89-100.

Ishiga, H. (1990) Paleozoic radiolarians. *In: Pre-Cretaceous Terranes of Japan* (Ichikawa, K., Mizutani, S., Hara, I., Hada, S. and Yao, A. eds.), Pub. IGCP 224, Osaka, 285-295.

Ishiga, H., Kito, T. and Imoto, N. (1982a) Late Permian radiolarian assemblages in the Tamba district and an ajacent area, Southwest Japan. *Earth Science* (Chikyu Kagaku), **36**, 10-22.

Ishiga, H., Kito, T. and Imoto, N. (1982b) Permian radiolarian biostratigraphy. *News of Osaka Micropaleontol., Spec. Vol.*, no. **5**, 17-26.

Jin, R. G. and Huan, H. Q. (1989) Permian-Triassic environment evolution of northern Sichuan and southern Shanxi. *In: Study on the Permian-Triassic biostratigraphy and event stratigraphy of northern Sichuan and southern Shanxi* (Li Zishun et al. eds.), People's Republic of China, Ministry of Geology and Mineral Resources, Geological Memoirs, ser. 2, no. **9**, 92-130. (in Chinese with English abstract)

Kitao, K. (1993) Upper Permian conodont biostratigraphy in Ryozen section (Mino Terrane). *Abstracts of the 142nd Regular Meeting of the Palaeontological Society of Japan*, 1. (in Japanese)

Kitao, K. (1996) Middle and Upper Permian conodont biostratigraphy in bedded cherts of the Mino Terrane, Central Japan. *Jour. Geosci., Osaka City Univ.*, **39**, 61-81.

Kozur, H. (1989) Significance of events in conodont for the Permian and Triassic Stratigraphic. *Courier Forsch.-Inst. Senckenberg*, **117**, 385-408.

Kozur, H. (1995) Permian conodont zonation and its importance for the Permian stratigraphic standard scale. *Geol. Palaont. Mitt. Innsbruck*, **20**, 165-205.

Kozur, H., Mostler, H. and Rahimi-Yazd, A. (1976) Beitrage zur Mikropalaontologie permotriadischer Schichtfolgen. Teil II: Neue Conodonten aus dem Oberperm und basalen Trias von Nord-und Zentraliran. *Geol.-Palaont. Mitt. Innsbruck*, **5** (**3**), 1-23, Innsbruck.

Kuwahara, K. (1997a) Evolutionary patterns of Late Permian Albaillella (Radiolaria) as seen in bedded chert sections in the Mino Belt, Japan. *Mar. Micropaleont.*, **30**, 65-78.

Kuwahara, K. (1997b) Upper Permian radiolarian biostratigraphy: Abundance zones of Albaillella. *News of Osaka Micropaleontol., Special Vol.*, no. **10**, 55-75. (in Japanese with English abstract)

Kuwahara, K. (1999a) Phylogenetic lineage of Late Permian Albaillella (Albaillellaria, Radiolaria). *Jour. Geosci., Osaka City Univ.*, **42** (**6**), 85-101.

Kuwahara, K. (1999b) Middle-Late radiolarian assemblages from China and Japan. *In: Biotic and Geological Development of the Paleo- Tethys in China* (Yao, A., Ezaki, Y., Hao, W. and Wang, X. eds.), Peking University Press, 43-54.

Kuwahara, K., Nakae, S. and Yao, A. (1991) Late Permian "Toishi-type" siliceous mudstone in the Mino-Tamba belt. *Jour. Geol. Soc. Japan*, **97**, 1005-1008 (in Japanese).

Kuwahara, K., Yao, A. and An, T. (1997) Paleozoic and Mesozoic complexes in the Yunnan area, China (Part 1): Preliminary report of Middle-Late Permian radiolarian assemblages. *Jour. Geosci., Osaka City Univ.*, **40** (**3**), 37-49.

Kuwahara, K., Yao, A. and Yamakita S. (1998) Reexamination of Upper Permian radiolarian biostratigraphy. *Chikyu Kagaku*, **52** (**5**), 391-404.

Mei, S. L., Jin, Y. G. and Wardlaw, B. R. (1994) Succession of Wujiapingian conodonts from northeastern Sichuan Province and its world wide correlation. *Acta Micropalaeont. Sinica*, **11** (**2**), 121-139. (in Chinese with English abstract)

Mei, S. L. and Shi, X. Y. (1999) On evolution and zonation of Permian and Early Triassic conodonts. *In: Biotic and Geological Development of the Paleo-Tethys in China* (Yao, A , Ezaki, Y., Hao, W. and Wang, X. eds.), Peking University Press, 113-122.

Mei, S. L., Zhang, K. X. and Wardlaw, B. R. (1998) A refined zonation of Changxingian and Griesbachian neogondolellid conodonts from the Meishan section, candidate of the global stratotype section and point of the Permian-Triassic boundary. *Palaeogeogragraphy, Palaeoclimatology, Palaeoecology*, **143** (**4**), 213-226.

Miyamura, M., Mimura, K. and Yokoyama,T. (1976) Geology of the Hikonetobu district. Quadrangle Series, scale 1 : 50,000, *Geol. Surv. Japan*, **49**. (in Japanese with English abstract)

Sweet, W. C. (1970) Uppermost Permian and Lower Triassic conodonts of the Salt Range and Trans-

Indus Ranges, West Pakistan. *In: Stratigraphic boundary problems: Permian and Triassic of West Pakistan* (Kummel, B. and Teichert, C. eds.), 207-273.

Sweet, W. C. (1973) Late Permian and Early Triassic conodont faunas. *Canadian Soc. Petrol. Geol. Mem.* **2**, 630-646.

Sweet, W. C. and Bergstrom, S. M. (1986) Conodonts and biostratigraphic correlation. *Ann. Rev. Planet. Sci.*, **14**, 85-112.

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

Wakita, K. (1984) Geology of the Hachiman district, Quadrangle Series, scale 1: 50,000. *Geol. Surv. Japan*, 89p. (in Japanese with English abstract)

Wakita, K. (1988) Origin of chaotically mixed rock bodies in the Early Jurassic to Early Cretaceous sedimentary complex of the Mino terrane, central Japan. *Bull. Geol. Surv. Japan*, **39**, 675-757.

Wang, C. Y. and Wang, Z. H. (1981) Permian conodont biostratigraphy of China. In: Paleontology in China 1979. *Geol. Soc. Amer. Spec. Pap.* **187**, 227-236, 2 pls.

Yamakita, S. (1993) Conodonts from P/T boundary sections of pelagic sediments in Japan. *Abst. 100th Ann. Meet. Geol. Soc. Japan*, 64-65. (in Japanese)

Yamakita, S., Kadoda, N., Kato, T., Tada, R., Ogihara, S., Tajika, E. and Hamada, Y. (1999) Confirmation of the Permian/Triassic boundary in deep-sea sedimentary rocks; earliest Triassic conodonts from black carbonaceous claystone of the Ubara section in the Tamba Belt, Southwest Japan. *Jour. Geol. Soc. Japan*, **105** (**12**), 895-898.

Yao, A. and Kuwahara, K. (1997) Radiolarian faunal change from Late Permian to Middle Triassic times. *News of Osaka Micropaleontol. Spec. Vol.*, **10**, 55-75. (in Japanese with English abstract)

Yao, A. and Kuwahara, K. (1999a) Middle-Late Permian radiolarians from the Guangyuan-Shangsi area, Sichuan Province, China. *Jour. Geosci., Osaka City Univ.*, **42** (**5**), 69-83.

Yao, A. and Kuwahara, K. (1999b) Permian and Triassic radiolarian assemblages from the Yangzi Platform. *In: Biotic and Geological Development of the Paleo-Tethys in China* (Yao, A., Ezaki, Y., Hao, W. and Wang, X. eds.), Peking University Press, 1-16.

Yao, A. and Kuwahara, K. (1999c) Paleozoic and Mesozoic radiolarian from the Changning-Menglian Terrane, Western Yunnan, China. *In: Biotic and Geological Development of the Paleo-Tethys in China* (Yao, A., Ezaki, Y., Hao, W. and Wang, X. eds), Peking University Press, 17-42.

Yao, A., Yu, J. and An, T. (1993) Late Paleozoic radiolarians from the Guizhou and Guangxi areas, China. *Jour. Geosci., Osaka City Univ.*, **36**, 1-13.

Yao, J. X., Li, Z. S., Zhan, L. P. and Hao, W. C. (1994) Late Permian-Early Triassic conodont biofacies and bioprovinces in Suth China and Himalaya. *Acta Geologica Sinica*, **7** (**2**), 209-218.

Zhan, L. P., Li, Z. S., Dai, J. Y. and Xie, L. C. (1989) Biostragraphic units and their correlation. *In: Study on the Permiam-Triassic biostratigraphy and event stratigraphy of northern Sichuan and southern Shanxi* (Li Zishun et al. eds.), People's Republic of China, Ministry of Geology and Mineral Resources, Geological Memoirs, ser. **2** (**9**) 36-47. (in Chinese with English abstract)

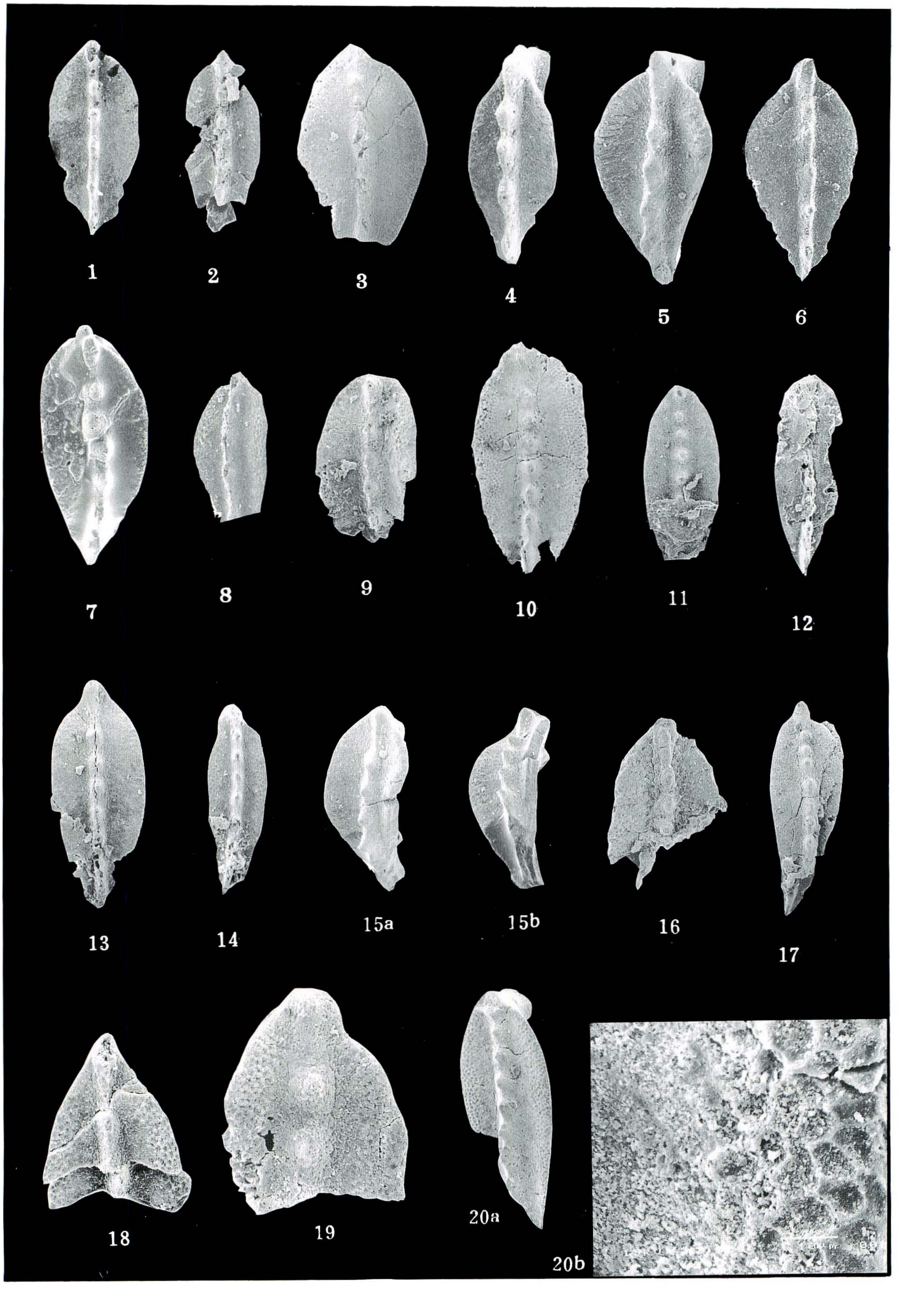
Manuscript received August 30, 2000.
Revised manuscript accepted November 28, 2000.

Explanation of Plate 1

Scanning photomicrographs of Late Permian conodonts from the Gujo-hachiman section in the Tamba-Mino Terrane.

Figs. 1-8	*Clarkina subcarinata* (Sweet, 1973) 1-2. upper views, x200, from Gc-67 and Gc-32 3. upper view, x150, from Gc-33 4-5. upper views, x350, from Gc-67 and Gc-61 6-7. upper views, x200, from Gc-42 and Gc-93 8. upper view, x150, from Gc-46
Figs. 9-12	*Clarkina changxingensis* (Wang and Wang, 1981) 9. upper view, x200, from Gc-32 10. upper view, x150, from Gc-5 11-12. upper views, x100, from Gc-67 and Gc-5
Figs. 13-14	*Clarkina carinata* (Clark, 1959) 13-14. upper views, x200, from Gc-26 and Gc-52
Figs. 15-17	*Clarkina meishanensis zhangi* Mei, 1998 15a. upper view, x200, from Gc-22 15b. oblique upper view, x200, from Gc-22 16. upper view, x200, from Gc-32 17. upper view, x150, from Gc-35
Figs. 18-20	*Clarkina postwangi* (Tian, 1993) 18-19. upper views, x200, from Gc-55 and Gc-54 20a, 20b. upper views, x200, x2000, from Gc-52

Plate 1



Explanation of Plate 2

Scanning photomicrographs of Late Permian conodont from the Gujo-hachiman section, in the Tamba-Mino Terrane

Figs. 1, 3 *Clarkina parasubcarinata* Mei, Zhang and Wardlaw, 1998
1. upper view, x200, from Gc-62
2. upper view, x150, from Gc-36

Fig. 2 *Clarkina subcarinata* (Sweet, 1973)
upper view, x350, from Gc-94

Fig. 4 *Clarkina liangshanensis* (Wang, 1978)
upper view, x150, from Gc-96

Figs. 5-8 *Clarkina ryozenensis* sp. nov.
5-6. upper views, x200, from Gc-62 and Gc-97. 6. Paratype, registration no: OCUPC0001
7. lateral view, x350, from Gc-33
8. upper view, x350, from Gc-94

Fig. 9 *Clarkina postwangi* (Tian, 1993)
upper view, x150, from Gc-52

Figs. 10-13 *Clarkina deflecta* (Wang and Wang, 1981)
10, 12, 13. upper views, x150, from Gc-35, Gc-78 and Gc-45
11. upper view, x200, from Gc-33

Figs. 14-17 *Clarkina wangi* (Zhang, 1984)
14-15. upper views, x350, from Gc-75 and Gc-5
16. oblique upper view, x200, from Gc-94
17. upper view, x200, from Gc-94

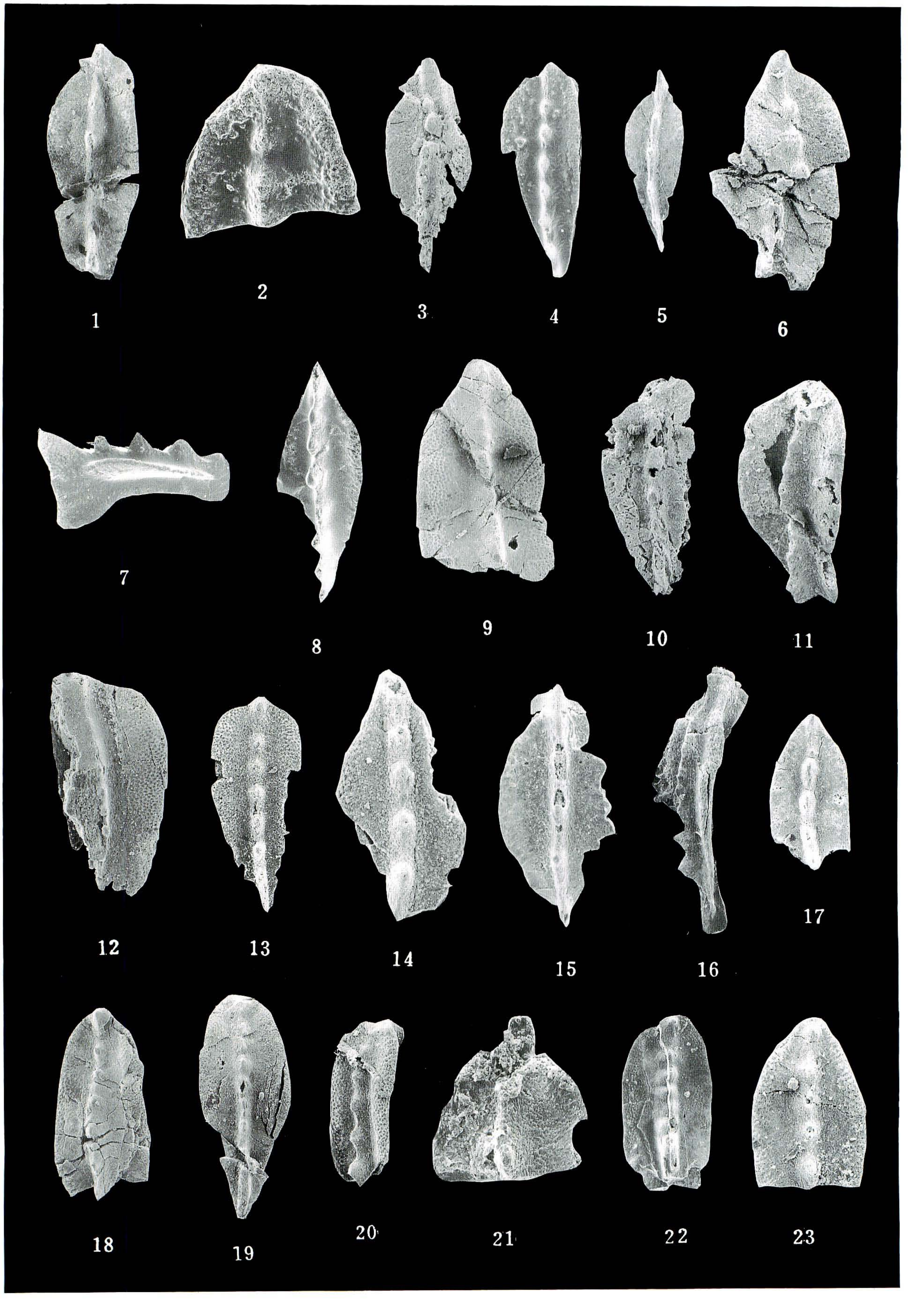
Fig. 18 *Clarkina prechangxingensis* Mei, Zhang and Wardlaw, 1998
upper view, x150, from Gc-94

Fig. 19 *Clarkina orientalis* (Barshov and Koroleva, 1970)
upper view, x100, from Gc-101

Figs. 20-22 *Clarkina liangshanensis* (Wang, 1978)
20. oblique upper view, x200, from Gc-107
21, 22. upper view, x350, x100, from Gc-121 and Gc-93

Fig. 23 *Clarkina* cf. *liangshanensis* (Wang, 1978)
upper view, x200, from Gc-121

Plate 2

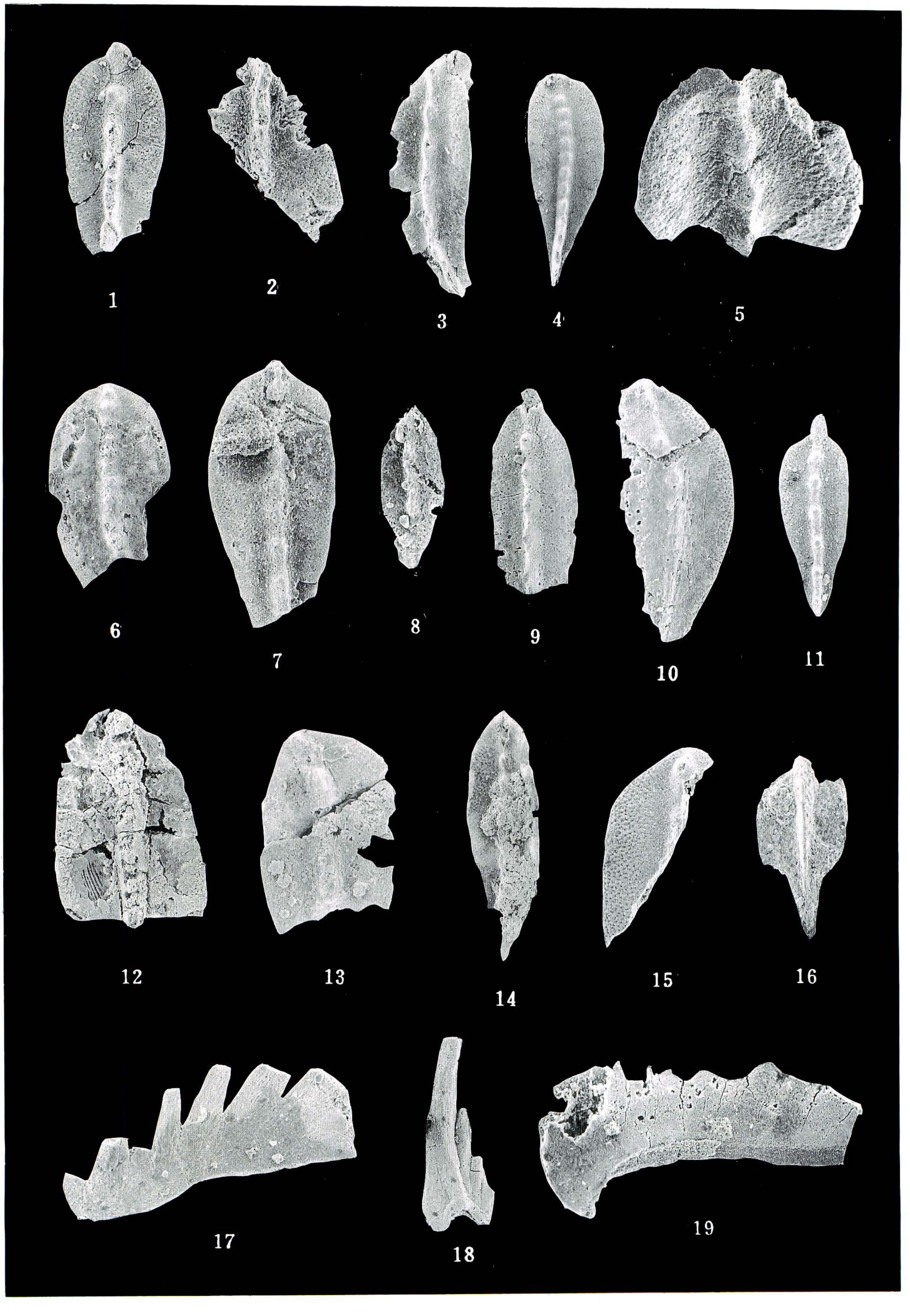


Explanation of Plate 3

Scanning photomicrographs of Late Permian conodonts from the Ryozen section, in the Tamba-Mino Terrane.

Figs. 1-3	*Clarkina subcarinata* (Sweet, 1973) 1-2. upper views, x200, from Rc-7 and Rc-6 3. oblique upper view, x200, from Rc-2
Figs. 4-6	*Clarkina changxingensis* (Wang and Wang, 1981) 4, 6. upper views, x200, from Rc-24 and Rc-22 5. upper view, x 350, from Rc-39
Fig. 7	*Clarkina parasubcarinata* Mei, Zhang and Wardlaw, 1998 upper view, x150, from Rc-14
Figs. 8-9	*Clarkina wangi* (Zhang, 1984) 8-9. upper views, x200, from Rc-6
Fig. 10	*Clarkina predeflecta* Mei, Zhang and Wardlaw, 1998 upper view, x200, from Rc-8
Fig. 11	*Clarkina ryozenensis* sp. nov. upper view, x150 from Rc-14. Holotype, registration no: IGPC009
Fig. 12	*Clarkina prechangxingensis* Mei, Zhang and Wardlaw, 1998 upper view, x150, from Rc-7
Fig. 13	*Clarkina deflecta* (Wang and Wang, 1981) upper view, x200, from Rc-24
Fig. 14	*Clarkina postwangi* (Tian, 1993) upper view, x150, from Rc-29
Fig. 15	*Clarkina* sp. upper view, x200, from Rc-22
Fig. 16	*Iranognathus tarazi* Kozur, Mostler and Rahimi-Yazd, 1975 upper view, x200, from Rc-15
Figs. 17-19	*Ellisonia teicherti* Sweet, 1970 17. Pa elememt, x350, from Rc-22 18. M element, x150, from Rc-14 19. Sc element, x350, from Rc-45

Plate 3



Explanation of Plate 4

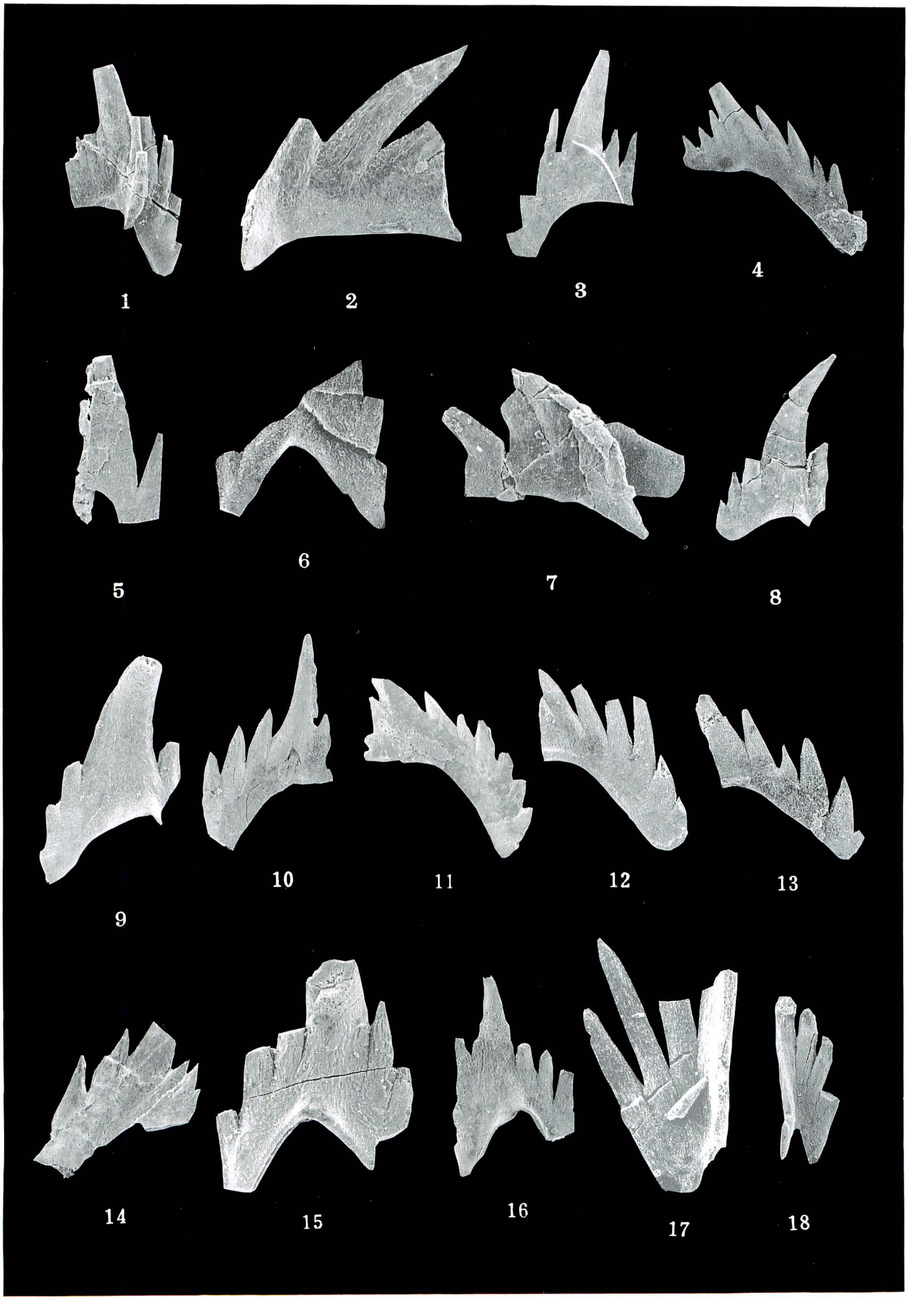
Scanning photomicrograpgs of Late Permain conodonts from the Gujo-hachiman section in the Tamba-Mino Terrane.

Figs. 1-6 *Xaniognathus elongatus* Sweet, 1970
1. Sa elememt, oblique outer view, x200, from Gc-25
2. Sb element, lateral view, x200, from Gc-24
3. Sc element, lateral view, x500, from Gc-23
4. Pa element, lateral view, x150, from Gc-94
5. Pb element, oblique posterior view, x350, from Gc-29
6. M element, posterior view, x200, from Gc-42

Figs. 7-16 *Lonchodina muelleri* Tatge, 1956
7. Sa element, oblique lateral view, x350, from Gc-67
8-9. Sc elements, lateral views, x200 and x350, from Gc-32 and Gc-38
10-11. Sb elements, lateral views, x150, from Gc-90 and Gc-95
12. Sb. element, lateral view, x200, from Gc-40
13. Pb element, lateral view, x150, from Gc-42
14. Pa element, lateral view, x200, from Gc-55
15-16. M elements, posterior views, x350 and x200, from Gc-67 and Gc-122

Figs. 17-18 *Enantiognathus* cf. *ziegleri* (Diebel, 1956)
17-18. posterior views, x350 and x200, from Gc-50 and Gc-105

Plate 4



Explanation of Plate 5

Scanning photomicrographs of Late Permian conodonts from the Gujo-hachiman section, in the Tamba-Mino Terrane.

Figs. 1-7 *Xaniognathus curvatus* Sweet, 1970
1. Sa element, lateral view, x200, from Gc-58
2-3. Sb elements, lateral views, x350 and 200, from Gc-42 and Gc-24
4. Sc element, lateral view, x200, from Gc-97
5. Pb element, posterior view, x200, from Gc-40
6. Pa element, lateral view, x200, from Gc-96
7. M element, posterior view, x200, from GC-55

Figs. 8-10 *Ellisonia* sp.
8-9. Pa elements, lateral views, x200 and x350, from Gc-23 and Gc-45
10. Sb element, lateral view, x200, from Gc-42

Fig. 11 *Hindeodus* sp.
Pa element, laterak view, x200, from Gc-9

Figs. 12-13 *Xaniognathus sweeti* Igo, 1981
12-13. Pa elememts, lateral views, x200, from Gc-56 and Gc-97

Fig. 14 *Prioniodella* sp.
lateral view, x200, from Gc-40

Figs. 15-17 *Hibbardella* sp.
15. Sa element, posterior view, x200, from Gc-121
16. Sb element, lateral view, x200, from Gc-97
17. M element, posterior view, x200, from Gc-100

Figs. 18-19 *Cypridodella* sp.
18. M element, posterior view, x200, from Gc-96
19. Sc element, lateral view, x350, from Gc-43

Plate 5