PERMIAN RADIOLARIAN BIOSTRATIGRAPHY

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Abstract Some sections of Permian bedded chert in the Tamba district and an adjacent area include well-preserved radiolarian specimens. Nine radiolarian Assemblage zones were recognized based on an interpretation of published and prepared accounts by ourselves. Nine Assemblage zones are as follows in ascending order: *Pseudoalbaillella u-forma*—*Ps. elegans* Assemblage zone, *Ps. lomentaria* Ass. zone, *Ps. rhombothoracata* Ass. zone, *Albaillella* sp. D Ass. zone, *Ps. sp. B* Ass. zone, *Follicucullus* sp. A Ass. zone, *F. scholasticus* Ass. zone, *Neoalbaillella optimana* Ass. zone and *Na. ornithoformis* Ass. zone. *Ps. rhombothoracata* Ass. zone coincides with the upper Wolfcampian and *F. scholasticus* Ass. zone coincides with the Guadalupian.

Introduction

The pioneering works by ORMISTON & BABCOCK (1979) and Holdsworth & Jones (1980) concerning some characteristic ALBAILLELLARIA of the Permian age were succeeded by several recent papers (ISHIGA & IMOTO, 1980; Kozur, 1981; Takeura & Nakaseko, 1981; Ishiga et al., 1982; in preparation). In particular, an examination of those radiolarians in the chert specimens collected bed by bed through a section has offered useful information about the biostratigraphy of Permian radiolarian faunas.

In this paper, we intend to summarized the Permian radiolarian assemblage zones on the basis of three sections examined in the Tamba district and an adjacent area, Southwest Japan, and to discuss their equivalent ages briefly.

Biostratigraphy

Lower Permian

Early Permian faunas reported from the Sasayama area are characterized by many kinds of *Pseudoalbaillella* and some species of *Albaillella*.

The radiolarian faunas of the Sasayama area were divided into two broad successive assemblages, namely *Pseudoalbaillella* Ass. and *Follicucullus* Ass., in ascending order. *Pseudoalbaillella* Ass. was subdivided into three sub-assemblages, namely *Ps. u-forma*—*Ps. elegans* sub-Ass., *Ps. lomentaria*...
Fig. 2. Radiolarian Assemblage zones and ranges of characteristic species in the Sasayama area after ISHIGA & IMOTO (1980) and ISHIGA (in preparation).

**Pseudoalbaillella u-forma—Ps. elegans Ass. zone**

The characteristic species yielded from this assemblage zone are *Ps. u-forma* HOLDSWORTH & JONES, *Ps. elegans* ISHIGA & IMOTO and *Ps. simplex* ISHIGA & IMOTO. Among them, *Ps. u-forma* is important to characterize this zone. In the Sasayama area the upper limit is not clearly defined due to scarce specimens.

**Pseudoalbaillella lomentaria Ass. zone**

Characteristic species existing in this zone are *Ps. lomentaria* ISHIGA & IMOTO, *Ps. longicornis* ISHIGA & IMOTO, *Ps. sakmarensis*, *Ps. sp. aff. Ps. scalprata* HOLDSWORTH & JONES, *Ps. scalprata*, *Ps. ornata* ISHIGA & IMOTO and *Ps. sp. F*. This zone coincides with the range of *Ps. lomentaria* and the upper boundary can be easily recognized by the initial occurrence of *Ps. rhombothoracata* and the disappearance of *Ps. ornata*.

**Pseudoalbaillella rhombothoracata Ass. zone**

The representative species of this zone are *Ps. rhombothoracata*, *Ps. sp. F*. *Ps. scalprata*, *Ps. sakmarensis*, *Albaillella sp. B* and *Ps. elongata* ISHIGA & IMOTO. The lower limit of this zone is marked by the first appearance of *Ps. rhombothoracata* and the upper boundary coincides with the earliest occurrence of *A. sp. D* (stated below). This zone is considered to be upper Wolfcampian, which is confirmed by the occurrence of *Sweetognathus whitei* (RHODES).
Middle Permian

We have examined middle Permian radiolarian faunas and have presently completed our third report in which 9 species (including 3 new species) are described (ISHIGA et al., in preparation).

The radiolarian faunas of the Funaeda section in the Yagi area, are divisible into three broad successive assemblages, namely Albaillella sp. D Ass., Ps. sp. B Ass. and Follicucullus sp. A Ass. in ascending order. Three Assemblage zones are defined as follows, Albaillella sp. D Ass. zone, Ps. sp. B Ass. zone and Follicucullus sp. A Ass. zone in ascending order based on the faunal division of the Funaeda section in the Yagi area.

Albaillella sp. D Ass. zone

The representative species of this zone is A. sp. D, A. sp. B and Ps. rhombothoracata occurring through a stratigraphic thickness of about 3 meters. The lower limit of this zone is marked by the first appearance of A. sp. D and the upper boundary is not clearly visible due to the lack of exposed cherts.

Pseudoalbaillella sp. B Ass. zone

Characteristic species existing in this zone are Ps. sp. C, Ps. sp. B, Ps. sp. aff. Ps. longicornis and Ps. fusiformis HOLSWORTH & JONES occurring through an interval of about 4.8 meters. The lower half of this zone is characterized by the existence of Ps. sp. C and the upper half is characterized by Ps. sp. B. The lower limit of this Ass. zone is marked by the first appearance of Ps. sp. C and the upper limit is marked by the first appearance of Fo. sp. A.

Follicucullus sp. A Ass. zone

Characteristic species existing in this zone are Follicucullus sp. A, Fo. scholasticus ORMISTON & BABCOCK, Fo. ventricosus ORMISTON & BABCOCK, Ps. sp. B, Ps. sp. aff. Ps. longicornis occurring through an interval of about 1 meter. This zone coincides with the range of Fo. sp. A. This zone is considered to be late Leonardian or early Guadalupian age (ISHIGA et al., in preparation).

Follicucullus scholasticus Ass. zone

This Ass. zone is defined on the basis of the faunal division of the Sasayama area and other sections treated in ISHIGA et al. (in preparation). Representative species in this zone are Follicucullus scholasticus, Fo. ventricosus and the absence of both Fo. sp. A and species of Neoalbaillella

Fig. 3. Radiolarian Assemblage zones and ranges of characteristic species in the Funaeda section in the Yagi area after ISHIGA et al. (in preparation).
characterizes this zone.

Upper Permian
Late Permian radiolarian faunas are characterized by the presence of the species of Neoalbaillella and the zones are based on paleontologic examination of mainly neoalbaillellids and albaillellids. Neoalbaillella assemblage in the Nabejiri-yama area was divided into two sub-assemblages, namely Na. optima—Albaillella triangularis sub-assemblage and Na. ornithoformis sub-assemblage in ascending order (ISHIGA et al., 1982). Two Assemblage zones are defined as follows; Na. optima Ass. zone and Na. ornithoformis Ass. zone in ascending order.

Neoalbaillella optima Ass. zone
Characteristic species existing in this zone are Na. optima ISHIGA et al., Albaillella triangularis ISHIGA et al., Fo. ventricosus, A. excelsa ISHIGA et al. and A. levis ISHIGA et al. The lower limit is marked by the first appearance of Na. optima and the upper boundary can be recognized by the initial occurrence of Na. ornithoformis TAKEMURA & NAKASEKO and the disappearance of A. triangularis.

Na. ornithoformis Ass. zone
Characteristic species in this zone are Na. ornithoformis, Na. sp. cf. Na. gracilis TAKEMURA & NAKASEKO, Na. grypus ISHIGA et al., A excelsa, Fo. ventricosus and Fo. scholasticus. Lower limit of this zone is marked by the first appearance of Na. ornithoformis and the upper half of this zone is characterized by the existence of Na. grypus.

Discussion on Age
Geologic dating of the sequence in the three areas is indistinct because of the common absence of other biostratigraphically valuable fossils. Conodonts, infrequently found in chert residues, provide the main stay of our calibration. In the Sasayama area, Sweetognathus whitei (RHODES) occurs in the middle horizon in the part of being characlerized with Ps. sp. A—Ps. rhombothoracata sub-assemblage. As Sweetognathus whitei reported from the upper most Wolfcampian (BEHNKEN, 1975), the Ps. rhombothoracata Ass. zone coincides with the upper Wolfcampian or lower Leonardian. Recently Ps. sakmarensis (KOZUR) is reported from the Sakmarian of the Cis-Urals (KOZUR, 1981). Ps. sakmarensis exists in a whole range of Ps. lomentaria Ass. zone in our sections, and the disappearance of Ps. lomentaria is preceded to the first appearance of Ps. rhombothoracata. So the Ps. lomentaria Ass. zone probably coincides with the lower to middle Wolfcampian. Ps. u-forma—Ps. elegans Ass. zone, which underlies the Ps. lomentaria Ass. zone, at present, coincides with the lower Wolfcampian or upper Pennsylvanian.

Fig. 4. Radiolarian Assemblage zones and ranges of characteristic species in the Nabejiri-yama area after ISHIGA et al. (1982).
Fig. 5. Permian radiolarian Assemblage zones and characteristic species.
Albaillella sp. D assemblage contains *Ps. rhombothoracata* and *A. * sp. B. Both two species were found in the *Ps. rhombothoracata* Ass. zone, which was judged to coincide with the upper Wolfcampian (stated above). The *A. * sp. D Ass. zone coincides with the upper most Wolfcampian or lower Leonardian. The occurrence of *Fo. scholasticus* and *Fo. ventricosus* were reported from the Guadalupian Lamer Limestone of West Texas (ORMISTON & BABCOCK, 1979).

*Neoalbaillella* assemblage occurs stratigraphically in the higher horizon than the *Follicucullus* assemblage (ISHIGA et al., 1982). Although the detailed description of coexisting conodonts from the horizon of *Neoalbaillella ornithoformis* sub-assemblage has not been completed, some specimens resemble *Neogondolella orientalis* (BARKSOV & KOROLEVA) which is known at present only from the Vediaceras beds (Djulian stage). In conclusion, the geologic age of the *Neoalbaillella* assemblage is thought to be Guadalupian or later (ISHIGA et al., 1982). So the *Neoalbaillella ornithoformis* Ass. zone coincides with the upper Guadalupian or lower Djulian.

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References


Explantation of Plate 1

Fig. 1. *Pseudoalbaillella u-forma* HOLDSWORTH & JONES, KUE PR 4-1.
Figs. 2, 3. *Pseudoalbaillella elegans* ISHIGA & IMOTO. Fig. 2, holotype, KUE PR 4-14. Fig. 3, paratype, KUE PR 4-6.
Figs. 4–6. *Ps. iomentaria* ISHIGA & IMOTO. Fig. 4, holotype, KUE PR 1-76. Fig. 5, paratype, KUE PR 1-5.
Fig. 6, dorsal view, KUE PR 1-100.

Fig. 7. *Pseudoalbaillella* sp. aff. *Ps. scalprata* HOLDSWORTH & JONES, KUE PR 1-7.
Fig. 8. *Pseudoalbaillella sakmarensis* (KOZUR), KUE PR 38-20.

Figs. 9, 10. *Pseudoalbaillella ornata* ISHIGA & IMOTO. Fig. 9, holotype, KUE PR 13-5. Fig. 10, ventral view, KUE PR 13-60.

Figs. 11, 12. *Pseudoalbaillella scalprata* HOLDSWORTH & JONES. Fig. 11, KUE PR 39-4. Fig. 12, KUE PR 39-16.
Fig. 13. *Pseudoalbaillella* sp. F, KUE PR 39-102.


Figs. 15, 16. *Pseudoalbaillella elongata* ISHIGA & IMOTO. Fig. 15, holotype, KUE PR 8-36. Fig. 16, paratype, KUE PR 8-34.

Figs. 17, 18. *Albailla* sp. D. Fig. 17, KUE PR 36-13. Fig. 18, KUE PR 36-15.

Fig. 19. *Pseudoalbaillella* sp. C, KUE PR 35-9.

Figs. 1–3 from the Ashimidani area (ISHIGA & IMOTO, 1980). Figs. 4–16 from the Sasayama area.
Figs. 17, 18 from the Funaeeda section in the Yagi area. Fig. 19 from the locality B in the Nabejiriyama area (ISHIGA et al., in preparation).

Explantation of Plate 2

Figs. 1, 2. *Pseudoalbaillella fusiformis* HOLDSWORTH & JONES. Fig. 1, KUE PR 35-1. Fig. 2, KUE PR 35-4.
Figs. 3, 4. *Pseudoalbaillella* sp. B. Fig. 3, KUE PR 34-2. Fig. 4, ventral view, KUE PR 34-9.
Figs. 5–7. *Follicucullus* sp. A. Fig. 5, KUE PR 35-12. Fig. 6, KUE PR 35-15. Fig. 7, KUE PR 35-14.
Figs. 8–10. *Follicucullus scholaslicus* ORMISTON & BABCOCK. Fig. 8, KUE PR 37-4. Fig. 9, KUE PR 37-6.
Fig. 10, KUE PR 36-1.

Fig. 11. *Follicucullus ventricosus* ORMISTON & BABCOCK, KUE PR 37-7.

Figs. 12, 13. *Neoalbaillella optima* ISHIGA et al. Fig. 12, holotype, KUE PR 33-11. Fig. 13, paratype KUE PR 33-8.
Figs. 14, 15. *Neoalbaillella ornithoformis* TAKEMURA & NAKASEKO. Fig. 14, KUE PR 37-1. Fig. 16, KUE PR 33-12.
Fig. 15. *Neoalbaillella* sp. cf. *Na. gracilis* TAKEMURA & NAKASEKO, KUE PR 33-21.

Figs. 17, 18. *Albailla triangularis* ISHIGA et al. Fig. 17, KUE PR 26-12. Fig. 18, KUE PR 26-40.

Figs. 1–4 from the locality B in the Nabejiriyama area treated in ISHIGA et al. (in preparation). Figs. 5–7 from the Funaeeda section in the Yagi area. Figs. 8–18 from the locality A in the Nabejiriyama area reported by ISHIGA et al. (1982).
Scale bar a: Figs. 1–15; scale bar b: Figs. 16–18.
ペルム紀の放散虫化石層序

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（要 旨）

丹波地帯および周辺地域に分布するペルム系チャート層から報告された放散虫化石群集にとづき以下の9化石帯を設定した。下位より、Pseudoalbitella u-forma－Ps. elegans Assemblage zone, Ps. lomentaria Ass. zone, Ps. rhombothoracata Ass. zone, Albitella sp. D Ass. zone,Ps. sp. B Ass. zone, Folicuculus sp. A Ass. zone, Fo. scholasticus Ass. zone, Neovalbitella optima Ass. zoneおよびNa. ornithoformis Ass. zoneである。Ps. rhombothoracata Ass. zoneは上部ウルフキャップ統にFo. scholasticus Ass. zoneはガダループ統にあたると考えられる。