Stratigraphy of the Permian Karita Formation in the Environs of Hiroshima, Japan

By

Akira HASE and Mayumi AIBA

With

Paleontological Descriptions of Foraminifers

By

Yuji OKIMURA and Kimiyoshi SADA

with 2 Text-figures and 1 Plate

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ABSTRACT: The stratigraphy of the Permian Karita formation exposed near Hiroshima City is described and its correlation with the Maizuru group in the Maizuru belt is discussed, with special reference to the stratigraphic relationship among the *Lepidolina toriyamai*, the *Colaniella* cf. *minima* and the *Leptodus richthofeni* horizon. Paleontological descriptions of some important foraminiferal species are presented as an appendix.

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I. INTRODUCTION

The Karita formation, exposed at Yachiyo-cho (formerly Karita-son), Takada-gun, Hiroshima Prefecture, about 30 km. to the northeast of Hiroshima City, is famous for the occurrence of a peculiar brachiopod genus, *Leptodus* (=*Lyttonia*), and is considered to be a western extension of the Permian Maizuru group in the Maizuru belt, one of the important structural units in the Inner Zone of Southwest Japan.

IMAMURA (1953) first reported *Leptodus richthofeni* KAYSER and other brachiopod fossils from the Karita formation, and correlated it to the Middle Permian. On the other hand, the Upper Permian fusulinid fauna comprizing *Lepidolina toriyamai* KANMERA has been known from the same formation (SHIMIZU, 1962; HASE, 1964), and moreover, *Colaniella minima* WANG, a smaller foraminifer indicating the Upper Permian age, has very recently

been recorded by ISHII, OKIMURA and NAKAZAWA (1975).

The stratigraphy of the formation in question has, however, not yet been made clear, and therefore, the stratigraphic positions of the fossiliferous horizons have remained doubtful. To settle this problem, a careful geological survey was carried out and foraminiferal faunas were reexamined based on newly collected material. The results obtained are described below, with some considerations on the correlation with the Maizuru group.

Acknowledgements: We wish to express our sincere thanks to Professor Emeritus Sotoji IMAMURA and Professor Kei HIDE of Hiroshima University for their valuable advice and suggestion. We are much indebted to Drs. Yuji OKIMURA and Kimiyoshi SADA of the same university who have contributed the paleontological descriptions of important foraminiferal species as an appendix of this paper. Dr. Yuji OKIMURA has also helped us in field work. The financial support was given by the Grant in Aid for Scientific Researches from the Ministry of Education.

II. STRATIGRAPHY

The exposure of the Karita formation is rather limited owing to the covering of Cretaceous rhyolites and the intrusion of granite and granite-porphyry. The stratigraphy is as follows in ascending order; the standard succession is obtained along a route from Uchiyama to Komata-dani (west of Omata) in the western part of the surveyed area (Figs. 1, 2).

a) Slate, more than 300 m. thick, more or less phyllitic, often showing a banded structure composed of argillaceous laminae and siliceous ones. Layers of the so-called schalstein (including andesitic to dacitic rock) are locally intercalated.

b) Slate, about 100–150 m. thick, black in color, usually massive and monotonous, but in the lower part sometimes bedded and even laminated.

c) Sandstone with conglomerate, generally about 50 m. thick, but in some places thickened to 200 m. or so by the intercalation of slate and in others almost thinned out. The sandstone is massive, bluish gray in color, fine- to coarse-grained, often containing very small fragments of black shale. The conglomerate is polymictic and immature in composition, consisting mainly of granules and small pebbles of black shale and limestone (mostly angular to subangular), with those of sandstone, chert, basalt, andesite to dacite, rhyolite, porphyry and mylonitic granite (fairly rounded); the matrix is sandy.

Fusulinids were obtained from both limestone pebbles and matrix of the conglomerate. The identified species are as follows.

Loc. 1 (south of Omata).....*Lepidolina* sp. cf. *L. toriyamai* KANMERA and *Yabeina*? sp.
Loc. 2 (south of Yokoyama).....*Lepidolina* sp. cf. *L. toriyamai* KANMERA and *Kahlerina* sp.
Loc. 3 (south of Yokoyama).....*Lepidolina toriyamai* KANMERA
Loc. 4 (southeast of Yokoyama).....*Lepidolina* sp., *Yabeina* sp. and *Schwagerina*? sp.

d) Slate with occasional intercalation of thin layers of sandstone, more than 700 m.

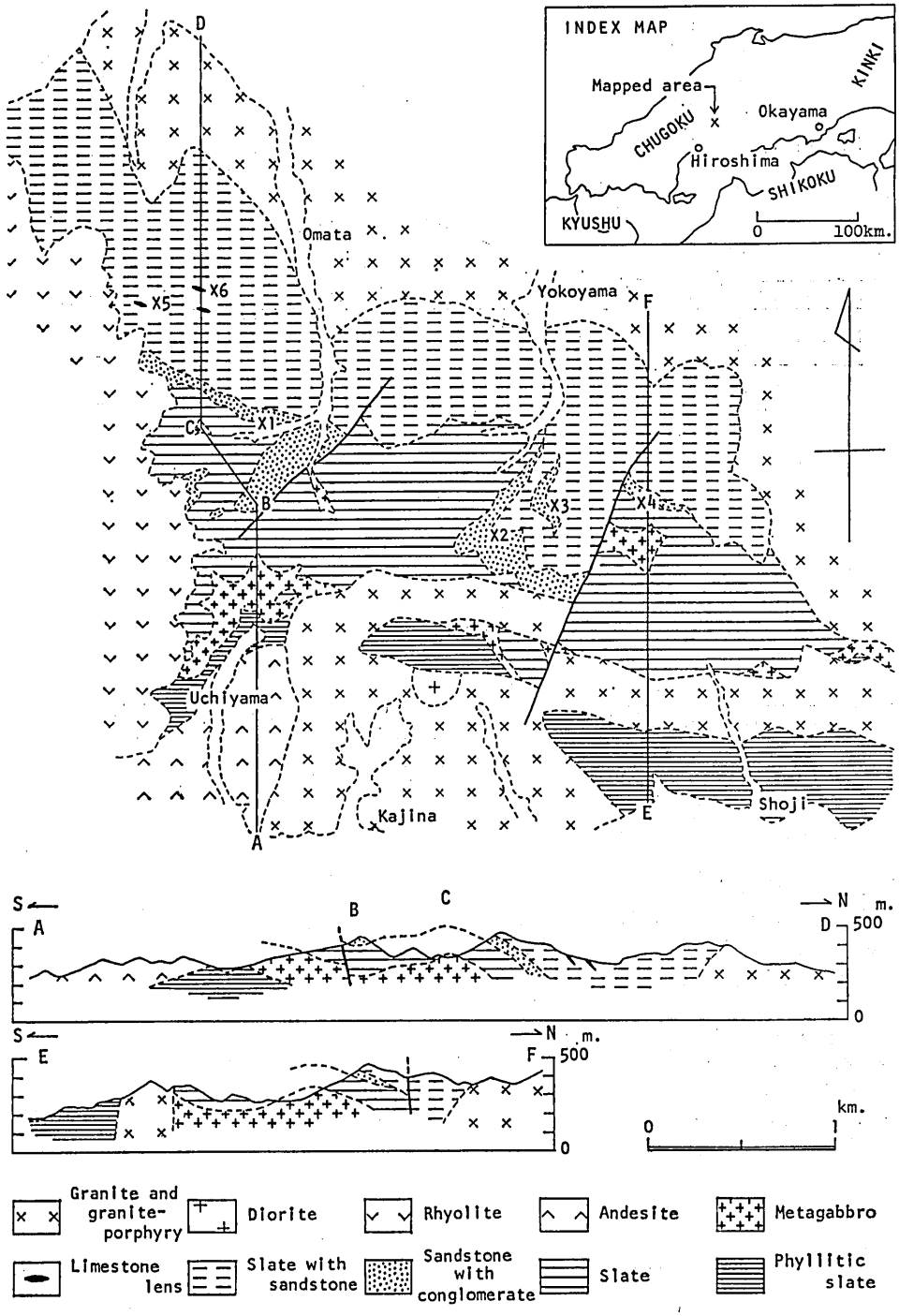

FIG. 1. Geological map and profiles of the Karita area.

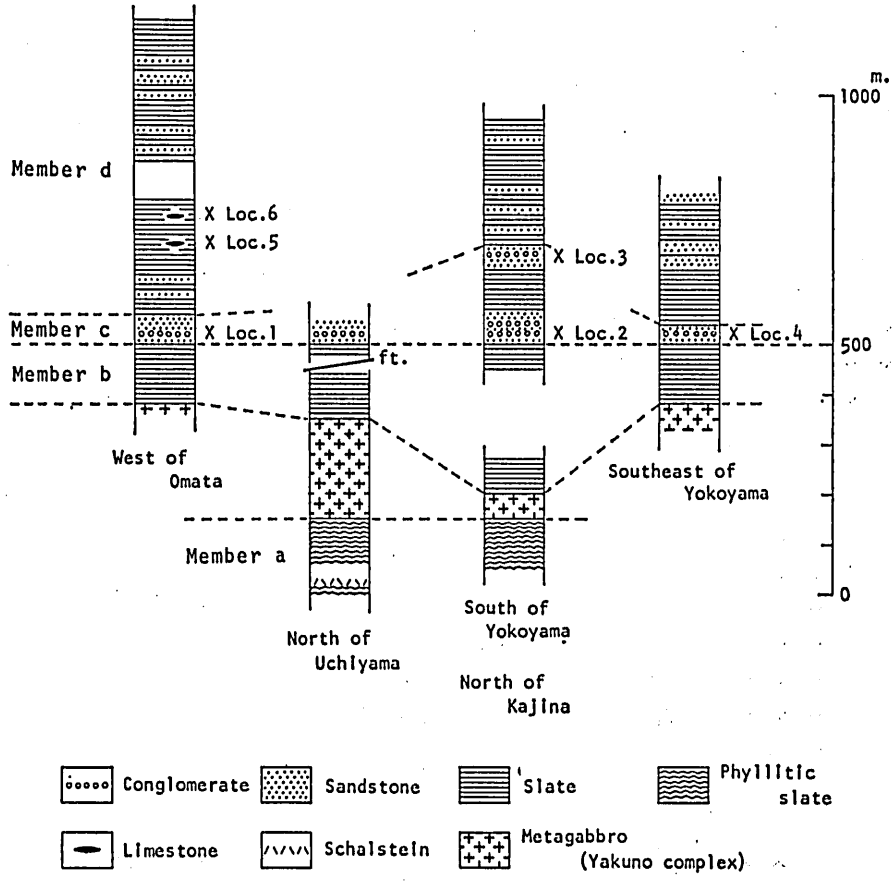

FIG. 2. Columnar sections of the Karita formation.

thick. The slate is black in color, usually massive and monotonous. Bedded to laminated slate, alternating frequently with graded sandstone, occurs at places. The sandstone is mostly fine-grained. At Komata-dani, west of Omata, small lenses and nodules of limestone are included; the largest one is 5 m. or so in thickness.

From the calcareous sandstone just above the limestone lens at Loc. 6 mentioned below, IMAMURA (1953) reported the following brachiopods and other shells: *Leptodus richthofeni* KAYSER, *Chonetes* sp., *Productus* sp., *Camarophoria* sp., *Spiriferina* sp. aff. *S. cristata* SCHLOTHEIM, *Schellwienella* sp. cf. *S. ruber* (FRECH), *S.* sp. aff. *S. acutangulata* HAUNG, *Hustedia* sp. cf. *H. grandicosta lata* GRABAU, *Pseudamussium*? sp. aff. *P. auriculata* GRABAU, *Bellerophon*? sp. and *Dentalium* sp.

Besides, the following foraminifers were newly identified from the limestone itself.

Loc. 5 (West of Omata).....*Colaniella* sp. cf. *C. minima* WANG and *Globivalvulina* sp.

Loc. 6 (West of Omata).....*Colaniella* sp. cf. *C. minima* WANG, *Pseudocolaniella* sp., *Nodosaria mirabilis caucasica* K. M.-MAKLAY, *N. shikhanica* LIPINA, *N.* sp., *Robuloides lens* REICHEL, *Pseudograndulina* sp. cf. *P. conica* K. M.-MAKLAY, *Lunucammina postcarbonica* (SPANDEL), *Pachyphloia* sp., *Eocristellaria*? sp., *Globivalvulina* sp.,

Tetrataxis sp., *Reichelina* sp., *Codonofusiella* sp. and *Schubertella*? sp.

The metagabbro, which changes gradually to metadiabase, occurs just between the members a and b, with a maximum thickness of about 200 m. It is more or less cataclastic and partly mylonitized, sometimes showing a gneissic texture. Very small bodies of anorthosite and also of serpentinite are closely associated with the metagabbro. These igneous rocks must belong to the so-called Yakuno complex, one of the characteristic constituents of the Maizuru belt.

III. Geologic Structure

The Karita formation takes a general strike of E–W or WNW–ESE direction, and dips usually to the north with a moderate angle, though there are gentle folds in part. It should be noted that the Yakuno complex is structurally concordant with the Karita formation.

In the southern part of the surveyed area, the lower half of the formation (members a, b and c) forms a syncline and an anticline, showing on the whole a nearly horizontal distribution. Thus, the phyllitic slate of the member a, together with the metagabbro of the Yakuno complex, tends to appear at topographically lower places, and the sandstone–conglomerate of the member c at topographically higher places. Overlying conformably the member c, the upper half of the formation (member d) is exposed in the northern area, dipping monoclinally to the north with an angle of 30–50 degrees.

IV. Correlation

The stratigraphy and zonation of the Maizuru group in the Maizuru belt, western Kinki district, were summarized by Shimizu (1962; Shimizu, Nakazawa, Shiki and Nogami, 1962), and have recently been revised by Working Group on the Permian–Triassic Systems (1975) and Ishii, Okimura and Nakazawa (1975).

According to Ishii and others, the following three foraminiferal zones are distinguishable in the Maizuru group: 1) *Lepidolina kumaensis* zone, 2) *Palaeofusulina simplex–Colaniella minima* zone and 3) *Palaeofusulina* aff. *sinensis–Colaniella parva* zone. The first and the second represent the middle formation of the group (the lower formation being composed of non-fossiliferous schalstein), and were considered to be contemporaneous but heterotopic with each other, though there seems to be a general tendency that the *Lepidolina kumaensis* zone is lower than the *Palaeofusulina simplex–Colaniella minima* zone. The third occupies the upper formation and is younger in age than the former two zones. Ishii and others have also discussed the correlation among the Upper Permian strata within and outside Japan.

The member c of the Karita formation, characterized by *Lepidolina toriyamai* (which is closely allied to *L. kumaensis* Kanmera), can undoubtedly be correlated to the lower Upper Permian *Lepidolina kumaensis* zone of the Maizuru group (as well as of the Kuma formation in Kyushu).

The limestone of the member d is characterized by *Colaniella* sp. cf. *C. minima, Pseudocolaniella* sp., *Nodosaria mirabilis caucasica, N. shikhanica, Robuloides lens* and *Pseudograndulina* sp. cf. *P. conica,* with *Reichelina* sp. and *Codonofusiella* sp., but not accompanied with ad-

vanced fusulinids such as *Lepidolina*. Some of the above species are found from the *Palaeofusulina simplex–Colaniella minima* zone of the Maizuru group and some from the lower to middle Upper Permian of the Tethys province, as is to be remarked in the appendix (Paleontological Descriptions). Thus, the limestone in question may safely be correlated to the *Palaeofusulina simplex–Colaniella minima* zone, though the former species has not yet been known from Karita.

As the fossiliferous horizons are restricted to the middle part and there are several hundred meters of non-fossiliferous strata above and below, the Karita formation may range, as a whole, from the upper Middle Permian to the middle or upper Upper Permian (the *Palaeofusulina* aff. *sinensis–Colaniella parva* fauna of the upper Upper Permian age not yet been found). Not only in biostratigraphic succession but also in lithologic features the formation is very similar to the Maizuru group proper.

It should, moreover, be noted that the *Colaniella* cf. *minima* horizon is, in the Karita formation, higher than the *Lepidolina toriyamai* horizon, and that the brachiopod fauna comprizing *Leptodus richthofeni* occurs from the horizon almost same as the *Colaniella* cf. *minima*. The reexamination seems to be necessary as for the age of the *Leptodus* fauna.

One more important fact is that the greenstones comparable with the Yakuno complex occupy a definite stratigraphic position below the *Lepidolina toriyamai* horizon. In this respect, one of us (HASE, MONDO and HIDE, 1975) has reported a similar relation in the boundary area of Hiroshima and Okayama Prefectures, an eastern extension of the Karita area, where basic volcanic and pyroclastic rocks, associated closely with metagabbro–metadiabase, underlie the slate with the intercalated sandstone and conglomerate containing *Lepidolina multiseptata shiraiwensis*. It is necessary to examine further the stratigraphic position and occurrence of what has been called the Yakuno complex in other areas of the Maizuru belt.

Paleontological Descriptions of Foraminifers

By

Yuji OKIMURA and Kimiyoshi SADA

In the succeeding pages the paleontological descriptions of selected foraminiferal species from the Karita formation are presented. OKIMURA is responsible for the descriptions of smaller foraminifers and SADA for those of fusulinids. Many thanks are due to Professor Akira HASE of Hiroshima University who kindly gave us an opportunity of publishing this paper and revised the typescript.

Family Colaniellidae FURSENKO, 1939

Genus *Colaniella* LIKHAREV, 1939

Colaniella sp. cf. *C. minima* WANG
Pl. XXI, figs. 1–5

Compare:–

1966. *Colaniella minima* WANG, *Act. Palaeont. Sinica*, vol. 14, no. 2, p. 211, 219, pl. 1, figs. 1–9.
1975. *Colaniella minima*, ISHII, OKIMURA and NAKAZAWA, *Jour. Geosci., Osaka City Univ.*, vol. 19, art. 6, p. 124 (diagnosis of the genus), pl. 2, fig. 4; pl. 3, figs. 1–3.

Material: – Two nearly longitudinal, two transverse and two oblique sections were examined. They came from Loc. 6, except for an oblique section from Loc. 5. The preservation of transverse and oblique ones is not so good.

Description: – Test small, conoidal, gradually and moderately tapered toward the initial chamber. Chambers 11 in number, bowl-shaped, strongly overlapped, gradually increasing in size as added; the arrangement uniserial and rectilinear. Chamber-floor nearly flattened or slightly swelled in the central part and inclined in the laterals with an angle of about 40 degrees. Wall calcareous, consisting of two layers; outer layer thick, translucent, finely perforate; inner layer very thin, opaque, microgranular. Longitudinal partitions of the first order developed, maybe 14 in number, with a structure similar to that of the outer layer of wall. A stellate aperture opens on the central flattened part of the last chamber, funnel-like in the longitudinal section.

Dimensions: – Longitudinal diameter, 0.47 mm. and maximum width, 0.29 mm. in the nearly longitudinal specimen figured as Pl. XXI, fig. 2.

Comparison and Occurrence: – The Karita specimens at hand are smaller than the type specimens of *Colaniella minima* WANG from the middle Upper Permian of Xixou of Shanxi and Xufuling of Jiangxi, China, but the difference is slight and in all the other morphologic characters they are surely comparable with each other. As the available material is insufficient, we hesitate to conclude definite identity. According to ISHII et al. (1975), *Colaniella minima* WANG is an important zonal fossil of the *Palaeofusulina simplex–Colaniella minima* zone of the Maizuru group and its equivalents.

Genus *Pseudocolaniella* WANG, 1966

Pseudocolaniella sp.
Pl. XXI, fig. 6

1975. *Pseudocolaniella* sp., ISHII, OKIMURA and NAKAZAWA, *Jour. Geosci., Osaka City Univ.*, vol. 19, art. 6, pl. 3, fig. 7.

Material: – Only a nearly longitudinal section from Loc. 6 was examined in detail. There is another poorly preserved oblique section, in which incomplete longitudinal partitions are observed.

Description: – Test relatively large, elongate cuneiform, very slightly curved, in the early stage conoidal and similar to a primitive form of *Colaniella*, but becomes cylindrical and looks like nodosariids in the later stage. Chambers strongly overlapped, uniserially arranged; 6 or more chambers of the early stage bowl-shaped, with several longitudinal partitions; 5 chambers of the later stage rather squarish, more rapidly increasing in height than in the early stage, without longitudinal partition. Chamber-floor of the later stage widely flattened in its central part, but in the laterals steeply inclined toward outside. Thick secondary deposits of vitreous calcite developed on the central flattened chamber-

floor, especially in the early nodosariid shell. Wall calcareous, double-layered, becoming thinner at the last stage; the outer layer thick, translucent; the inner layer very thin, microgranular. Aperture single, terminal, opening at the central part of the last chamber.

Dimensions: – Maximum length, 0.90 mm., maximum width of the early stage, 0.20 mm. and that of the later stage, 0.26 mm. in the figured specimen (Pl. XXI, fig. 6).

Comparison and Occurrence: – This species is in essential characters very similar to one of the paratype specimens of *Pseudocolaniella xufulingensis* WANG from the Upper Permian blackish limestone of Xufuling of Jiangxi, China (WANG, 1966, pl. 4, fig. 7), but the latter is smaller in number of the later nodosariid chambers than the former. *Pseudocolaniella* sp., which was figured by ISHII et al. (1975, pl. 3, fig. 7) from the Upper Permian Maizuru group, is identical with the Karita specimen in all the morphologic characters. It is noteworthy that the present species is associated by the *Palaeofusulina simplex–Colaniella minima* fauna.

Family Nodosariidae EHRENBERG, 1838

Genus *Nodosaria* LAMARK, 1812

Nodosaria mirabilis caucasica K. M.-MAKLAY
Pl. XXI, figs. 7, 8

1954. *Nodosaria mirabilis* LIPINA subsp. *caucasica* K. M.-MAKLAY, *Trudy, Vses. Nauch-Issled. Geol. Inst. (VSEGEI)*, p. 21, pl. 2, figs. 1, 2.

1975. *Nodosaria* sp., ISHII, OKIMURA and NAKAZAWA, *Jour. Geosci., Osaka City Univ.*, vol. 19, art. 6, pl. 3, fig. 10.

Material: – Two longitudinal, two transverse and three oblique sections from Loc. 6.

Description: – Test relatively large, very elongated and nearly cylindrical, slightly curved, tapered imperceptibly toward the initial chamber. Chambers 13–16 in number, domed, uniserially arranged, gradually and regularly increasing in height throughout the growth; those of the later stage higher than long. Sutures very slightly depressed in the early stage, but in the later stage fairly depressed between the chambers. Wall calcareous, composed of translucent laminated calcite, thick in the early stage, but becomes thinner in the later stage. Septal thickening develops on the chamber-floor, forming a small circular levee around the aperture. Aperture single, round, opening at the domed end of the last chamber.

Dimensions: – Maximum length, 1.05 mm., maximum width of the early stage, 0.10 mm. and that of the last chamber, 0.13 mm. in the figured longitudinal specimen (Pl. XXI, fig. 8).

Comparison and Occurrence: – The specimens from the Karita formation are slightly different from the type specimens of *Nodosaria mirabilis caucasica* K. M.-MAKLAY from the lower Upper Permian Nikitin formation of the northern Caucasus, USSR; the septal thickening is more remarkable in the former than in the latter. In all the other essential morphological characters, however, they are undoubtedly identical with each other. *Nodosaria* sp. illustrated by ISHII et al. (1975, pl. 3, fig. 10) from the Maizuru group is referred to this subspecies.

Nodosaria shikhanica LIPINA
Pl. XXI, fig. 9, 10

1949. *Nodosaria shikhanica* LIPINA, *Akad. Nauk USSR, Inst. Geol. Nauk, Trudy,* vol. 105 (geol. ser. no. 35), p. 217, pl. 4, figs. 7, 8; pl. 6, figs. 3, 9.
1962. *Nodosaria shikhanica,* POTIEVSKAYA, *Akad. Nauk USSR, Kiev. Inst. Geol. Sci., Trudy, Ser. Strat. Paleont.,* no. 44, p. 71, pl. 6, figs. 1, 2.
1975. *Nodosaria* sp., ISHII, OKIMURA and NAKAZAWA, *Jour. Geosci., Osaka City Univ.,* vol. 19, art. 6, pl. 2, fig. 14.
1977. *Nodosaria shikhanica,* OKIMURA and ISHII, *Geol. Surv. Iran, Rep.,* pl. 1, fig. 15 (in press).

Material: – Two longitudinal and three oblique sections from Loc. 6.

Description: – Test small, elongate horn-shaped, slightly curved, tapered indistinctly toward the initial chamber. Chambers 9 in number, domed, uniserially arranged, with slightly convexed chamber-floors. Sutures between the chambers moderately depressed. Probably secondary deposits of translucent fibrous calcite developed on the chamber-floor, subround in shape. Wall calcareous, thin, consisting of translucent fibrous calcite. Aperture single, round, opening at the inflated central end of the last chamber.

Dimensions: – Maximum length, 0.54 mm. and maximum width, 0.11 mm. in the longitudinal section figured as Pl. XXI, fig. 9.

Comparison and Occurrence: – This species more closely resembles *Nodosaria mirabilis* LIPINA than any other species of the genus in size and shape of the shell, but the former differs from the latter in its semilunar chamber-shape and smaller chamber-height. With respect to the chamber-shape and sutural characters, *N. shikhanica* LIPINA may be affinitive with *N. tennuiseptata* LIPINA, but the present species is characterized by the remarkable development of secondary deposits in spite of the small shell-size. *Nodosaria* sp. from Sakashu, Shikoku (ISHII et al., 1975, pl. 2, fig. 14), is referable to this species.

Nodosaria shikhanica LIPINA has recently been reported from the Abadeh formation underlying the Dzhulfian bed of Iran, and also from the Nikitin formation of the lower Upper Permian of the northern Caucasus, USSR, though the first description was from the *Schwagerina* horizon of Shak-Tau, Bashkir Massif, USSR.

Family Endothyridae BRADY, 1884
Genus *Robuloides* REICHEL, 1945

Robuloides lens REICHEL
Pl. XXI, figs. 12–15

1945. *Robuloides lens* REICHEL, *Eclog. Geol. Helv.,* vol. 38, no. 2, p. 536, pl. 19, figs. 6, 7.
1954. *Robuloides lens,* K. M.-MAKLAY, *Trudy, Vses. Nauch-Issled. Geol. Inst. (VSEGEI),* p. 64, pl. 10, figs. 8–11.
1977. *Robuloides lens,* OKIMURA and ISHII, *Geol. Surv. Iran, Rep.,* pl. 1, fig. 5 (in press).

Material: – Two nearly axial, a sagittal and two oblique sections from Loc. 6.

Description: – Test very small, lenticular, essentially involute, consisting of 2.5–3 volutions of nearly planispiral coiling; the coiling axis of the last whorl slightly oblique. 8 chambers enumerated in the last whorl. Septa fairly curved, convex toward the last

chamber. Wall calcareous, composed of translucent calcite, having a laminar thickening at the axial part. Aperture single, relatively high, opening at the lower part of apertural face.

Dimensions: – In the axial section (Pl. XXI, fig. 14), maximum diameter, 0.34 mm. and minimum diameter, 0.17 mm.; in the sagittal section (Pl. XXI, fig. 15), maximum diameter, 0.44 mm.

Comparison and Occurrence: – This species is closely allied to *Robuloides acutus* REICHEL in size and shape of the shell, but the former is larger than the latter in axial diameter compared with shell-size. Other species of the genus can be distinguished from the present species by larger shell and thicker axial filling.

Robuloides lens REICHEL was first defined from the Upper Permian formation of Hydra Island, Greece, associated by *Codonofusiella nana* ERK, *Reichelina minuta* ERK and *Valvulinella bukowskii* SCHUBERT. Russian specimens came from the Nikitin and Urshten formations of Dzhulfian of the northern Caucasus. Another occurrence was reported from the lowest part of the lower Upper Permian Abadeh formation, Iran.

Family Nodosinellidae RHUMBLER, 1895

Genus *Pseudograndulina* CUSHMAN, 1929

Pseudograndulina sp. cf. *P. conica* K. M.-MAKLAY
Pl. XXI, figs. 16, 17

Compare: –

1954. *Pseudograndulina conica* K. M.-MAKLAY, *Trudy, Vses. Nauch-Issled. Geol. Inst.* (*VSEGEI*), p. 37, pl. 4, figs. 1–3.

Material: – A nearly longitudinal and two oblique sections from Loc. 6.

Description: – Test small, inflated cuneiform, with an apical angle of about 35 degrees. Chambers 5 in number, semilunar in shape, uniserially and rectilinearly arranged, strongly overlapped, increasing gradually in size as added. Sutural lines between chambers very slightly depressed. Wall calcareous, consisting of two layers; the outer layer thick, composed of translucent calcite; the inner layer thin, microgranular. Aperture single, round with radial striation, opening at the terminal center of the last chamber.

Dimensions: – Maximum longitudinal diameter, 0.50 mm. and maximum width, 0.26 mm. in the nearly longitudinal section figured as Pl. XXI, fig. 16.

Comparison and Occurrence: – The specimens at hand are smaller in apical angle and in number of chambers than the type specimens of *Pseudograndulina conica* K. M.-MAKLAY from the lower Upper Permian Nikitin formation of the northern Caucasus, USSR, but the difference is very slight and in all the other morphologic characters they are comparable with each other. This species is closely allied to *P. longa* K. M.-MAKLAY with respect to the shell-shape and chamber-shape, but the latter is about twice larger than the former.

Family Ozawainellidae THOMPSON and FOSTER, 1937
Genus *Reichelina* ERK, 1941

Reichelina sp.
Pl. XXI, figs. 23, 24

Material: – Two axial sections and many other oriented sections were examined in detail. All came from Loc. 6.

Measurements: –

Specimen illustrated as Pl. XXI, fig. 23.

Length	Width	Form ratio	Proloculus
0.188	0.377	0.49	0.037
Vol.	Diameter of whorl	Thickness of spirotheca	
1	0.056	0.008	
2	0.113	0.010	
3	0.207	0.012	
4	0.377	0.012	

(in mm.)

Descriptive remarks: – The shell of *Reichelina* sp. is small and discoidal in shape. The inner three volutions are evolute and the outer two are involute, possessing a sharply angular periphery. The lateral slopes are straight to slightly concave. The shell of four volutions is 0.188 mm. long and 0.377 mm. wide, giving the form ratio of 0.49, in the specimen illustrated as fig. 23 on Pl. XXI. The proloculus is very small and its inside diameter is 37 microns. The diameter of the whorl of the 1st to the 4th volution is 56, 113, 207 and 377 microns, respectively. The thickness of the proloculus wall is 5 microns. The spirotheca is composed of a tectum and diaphanotheca. The spirothecal thickness of the 1st to the 4th volution is 8, 10, 12 and 12 microns, respectively. The chomata are massive and low.

This species seems to be quite different from any other known species which have been described from Japan (NOGAMI, 1958; KOBAYASHI, 1975), China (SHENG, 1963), North America (SKINNER and WILDE, 1955) and Russia (LEVEN, 1967) in its small size of the shell. This is probably a new species. The final identification of the species, however, is withheld until more sufficient information is obtained. The associated fusulinids are *Codonofusiella* sp. and *Schubertella*? sp.

Family Verbeekinidae STAFF and WEDEKIND, 1910
Subfamily Neoschwagerininae DUNBAR and CONDRA, 1928
Genus *Lepidolina* LEE, 1933

Lepidolina toriyamai KANMERA
Pl. XXI, fig. 25

1954. *Lepidolina toriyamai* KANMERA, *Mem. Fac. Sci., Kyushu Univ., Ser. D*, vol. 4, no. 1, p. 24, pl. 6, figs. 1–19.

1958. *Lepidolina toriyamai*, NOGAMI, *Mem. Coll. Sci., Univ. Kyoto, Ser. B*, vol. 25, no. 2, p. 106, pl. 2, figs. 1–5.

Material: – An axial section from Loc. 3 was examined in detail. This is an incomplete shell as it missed the fairer half of the shell in time of deposition. However, the essential biocharacters for the identification of the species can be easily observed. There are several other fragmental specimens comparable with this species.

Measurements: –

Specimen illustrated as Pl. XXI, fig. 25.

Half length 4.25 Width 2.40

Diameter of proloculus 0.30 Thickness of proloculus wall 0.021

Vol.	Radius vectors	Thickness of spirotheca
1	0.226	0.013
2	0.283	0.023
3	0.340	0.016
4	0.415	0.016
5	0.510	0.021
6	0.603	0.016
7	0.679	0.016
8	0.830	0.018
9	0.981	0.016
10	1.133	0.027
11	1.303	0.032

(in mm.)

Descriptive remarks: – The shell of the present specimen is large, elongate and cylindrical in form, having a broadly curving axis of coiling and narrowly rounded poles. The lateral slopes are nearly straight to concave. The shell of eleven volutions is 4.25 mm. in half length and 2.40 mm. in width. The first two volutions are spherical and the 3rd to 4th are inflated fusiform. Beyond the 5th volution the shell nearly attains to its mature shape. The proloculus is large and spherical. Its inside diameter measures 300 microns. The shell is tightly coiled in the inner four volutions and expands uniformly in the outer ones. The radius vectors are 226, 283, 340, 415, 510, 603, 679, 830, 981, 1133 and 1303 microns, respectively, for the 1st to the 11th volution. The spirotheca is thin and consists of a tectum and a very thin keriotheca with fine alveoli. The spirothecal thickness at its thinnest point between the adjacent septula is 13–23 microns in the 1st to the 9th volution and 27–32 microns in the 10th to the 11th volution. The thickness of the proloculus wall is 21 microns. The primary spiral septula are thin and numerous. A secondary spiral septulum between the adjacent primary septula first appears in the 2nd volution. In the 5th to the 11th volution there are occasionally two secondary spiral septula. The foramina are very small and circular in cross section.

In the shell-shape, the radius vectors, the spirothecal thickness, the proloculus diameter, and the other internal modes, the present species quite agrees with *Lepidolina toriyamai*, which was originally described by KANMERA (1954) from the Kuma formation in southern Kyushu.

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Akira HASE, Yuji OKIMURA and Mayumi AIBA
INSTITUTE OF GEOLOGY AND MINERALOGY,
FACULTY OF SCIENCE, HIROSHIMA UNIVERSITY,
HIROSHIMA, JAPAN
Kimiyoshi SADA
DEPARTMENT OF GEOLOGY,
FACULTY OF INTEGRATED ARTS AND SCIENCES,
HIROSHIMA UNIVERSITY, HIROSHIMA, JAPAN

EXPLANATION OF PLATE XXI

Figs. 1–5. *Colaniella* sp. cf. *C. minima* WANG ×70
1: Oblique section from Loc. 5. 2, 4: Nearly longitudinal sections from Loc. 6. 3: Oblique section from Loc. 6. 5: Transverse section from Loc. 6.
Fig. 6. *Pseudocolaniella* sp. ×70
Nearly longitudinal section from Loc. 6.
Figs. 7, 8. *Nodosaria mirabilis caucasica* K. M.-MAKLAY ×70
Longitudinal sections from Loc. 6.
Figs. 9, 10. *Nodosaria shikhanica* LIPINA ×70
Longitudinal sections from Loc. 6.
Fig. 11. *Nodosaria* sp. ×70
Longitudinal section from Loc. 6.
Figs. 12–15. *Robuloides lens* REICHEL ×70
12, 14: Nearly axial sections from Loc. 6. 13: Oblique section from Loc. 6. 15: Sagittal section from Loc. 6.
Figs. 16, 17. *Pseudograndulina* sp. cf. *P. conica* K. M.-MAKLAY ×70
16: Nearly longitudinal section from Loc. 6. 17: Oblique section from Loc. 6.
Figs. 18, 19. *Lunucammina postcarbonica* (SPANDEL) ×70
18: Longitudinal section from Loc. 6. 19: Oblique section from Loc. 6.
Fig. 20. *Pachyphloia* sp. ×70
Oblique section from Loc. 6.
Fig. 21. *Eocristellaria*? sp. ×70
Oblique section from Loc. 6.
Fig. 22. *Schubertella*? sp. ×77
Axial section from Loc. 6.
Figs. 23, 24. *Reichelina* sp. ×95
Axial sections from Loc. 6.
Fig. 25. *Lepidolina toriyamai* KANMERA ×10
Axial section from Loc. 3.
Fig. 26. *Codonofusiella* sp. ×100
Sagittal section from Loc. 6.

Loc. 3: South of Yokoyama, Yachiyo-cho, Takada-gun, Hiroshima Prefecture. Member c of the Karita formation.
Loc. 5: West of Omata, Yachiyo-cho, Takada-gun, Hiroshima Prefecture. Member d of the Karita formation.
Loc. 6: Ditto.


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