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Permian Fusulinids from Central Thailand*

By

Ryuzo TORIYAMA and Tomomitsu SUGI

The Rat Buri limestone is widely distributed through Thailand and considered to be Carboniferous(?) and Permian in age. Although the "Geological Reconnaissance of the Mineral Deposits of Thailand" (1953) is giving an outline of this limestone, the stratigraphical and paleontological data to define the precise age are very few because of its extreme extensive distribution. In that publication H. DUNCAN of U. S. Geological Survey listed the faunal assemblages collected and identified from several separated localities in Southern, Central, and Northern Thailand. None of them, however, has been described except the Lower Permian fusulinids described by R. TORIYAMA (1944) from near Ban Ai, the extreme North of Thailand. Prior to that report C. O. DUNBAR (1939, in HEIM and HIRSCH) illustrated the Middle Permian fusulinids from the Pawa limestone, without giving any description. Later in 1953, K. KONISHI described and illustrated the Lower Permian fusulinids from the Pai limestone of the Burmo-Thai borderland.

With the hope of its being an addition to meagre knowledge of the Upper Paleozoic stratigraphy of Thailand, this report deals with the Permian fusulinids obtained from the Sara Buri district of Central Thailand. A part of materials used in this study was collected by Prof. T. KOBAYASHI of the University of Tokyo during the Ninth Pacific Science Congress held in Bangkok, 1957, and others by Mr. S. BURAVAS of the Geological Survey Division, Royal Department of Mines, Thailand.

As the result of this study the following species have been distinguished from the limestone and chert beds separately exposed in the Sara Buri district (specific names are arranged in order of abundance).

I. Black fusulinid limestone, Motetung (KOBAYASHI's locality, Nos. 1-4)
  **Neoschwagerina* sp. A
  **Neoschwagerina* sp. B
  Neoschwagerina sp.
  Parafusulina sp.

II. Gray fusulinid limestone, Boh Pran Lang Nua, Sara Buri (KOBAYASHI's locality, Nos. 5-9)
  ***Neoschwagerina* sp.
  Parafusulina sp.
  ***Sumatrina* sp.

III. Limestone lens in shale above the main massive limestone, Muaglek (Korat rim) (KOBAYASHI's locality, Nos. 10, 11)
  **Parafusulina gigantea* (DEPRAT)
  **P. kaerimizensis* (OZAWA)

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Pseudofusulina japonica (GÜMBEL)
Pseudodoliolina sp.
Verbeekina sp.
***Pseudofusulina*(?) sp.

IV. Sara Buri chert bed
**Verbeekina* sp. A
***Neoschwagerina* sp.
**Pseudofusulina crassa* (DEPRAT)

[Species with * are described and illustrated in this paper, and those with ** are only illustrated in the plates]

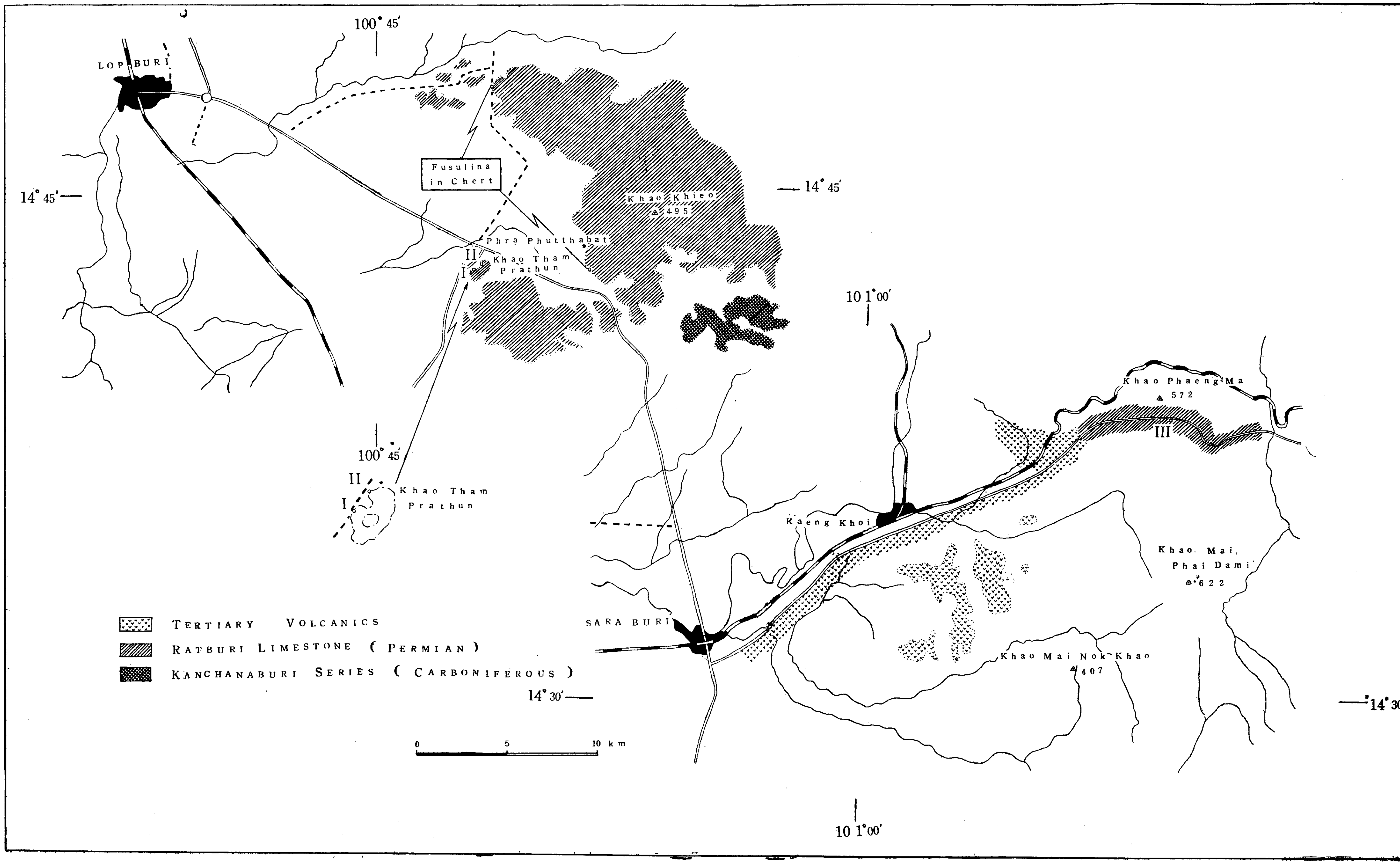
As the limestone beds I, II, and III are, according to the personal information from Prof. KOBAYASHI, found separately, the stratigraphical relationship among them is not understand. Moreover, unfortunately to say, the state of preservation of the materials collected from these beds except those from the bed III is extremely poor, being almost, if not completely, recrystallized after fossilization. Especially, it is rather interest that all the specimens contained in the Sara Buri chert bed (Bed IV) are completely silicified, the minute structure of which is hardly detected otherwise they are observed under the crossed nicols. It is noted here that the microphotographs of *Pseudofusulina crassa* (DEPRAT) (Pl. 1, figs. 9-11), *Neoschwagerina* sp. (Pl. 2, figs. 10, 11), and *Verbeekina* sp. A (Pl. 2, fig. 12, Pl. 3) are taken under the crossed nicols.

In contrast to the above, the fusulinids contained in the Bed III are fairly well preserved, although outer parts of most of the specimens have been broken out probably during their deposition. The limestone of the Bed III interbedded in shale as lenses is, according to Prof. KOBAYASHI's personal information, limestone conglomerate, mode of occurrence of which is similar to that of the Yasuba conglomerate found in the limited horizons of the Middle and Upper Permian rocks of Central and Southwest Japan.

Since all the species found in the Beds I and II have been left unnamed, their stratigraphical position is not exactly known. However, the faunal association of species of *Parafusulina* and *Neoschwagerina* in the Bed I, the latter of which shows rather primitive aspect for the genus, suggests that the Black fusulinid limestone is roughly referable to the upper part of *Parafusulina* Zone and/or the lower part of *Neoschwagerina* Zone in the international correlation.

Gray fusulinid limestone at Boh Pran Lang Nua is almost completely recrystallized except for that from KOBAYASHI's locality No. 7 which contains indeterminable species of *Sumatrina* sp. in addition to *Neoschwagerina* sp. and *Parafusulina* sp. Although *Neoschwagerina* sp. is still bearing rather primitive aspect, the coexistence with *Sumatrina* sp. suggests that the Gray fusulinid limestone is at least not older than the Black fusulinid limestone. It is probable that the Gray fusulinid limestone is referable to the middle and/or upper part of the *Neoschwagerina* Zone.

The limestone conglomerate of Muaglek yields considerably well preserved specimens. *Parafusulina gigantea* (DEPRAT) and *P. kaerimizensis* (OZAWA) are most



Geological Sketch Map of Sara Buri District (after S. Buravas) abundant, of which the former is reported from the Middle Permian rocks of Pong Oua of Laos and Honchan of Cambodge, while the latter is a well known species in the upper part of *Parafusulina* zone and the lower part of *Neoschwagerina* zone of Japan. Except for *Pseudofusulina* sp. all the species of Muaglek are not only found in small limestone pebbles but also in the matrix. It is observed in fact that a half of a broken individual of one species being in contact with that of another half in calcareous substance of matrix. Such being the case this limestone conglomerate is considered to be contemporaneous conglomerate, the stratigraphical age of which is referable to the early Middle Permian.

Among the three species found in the Sara Buri chert bed, *Verbeekina* sp. A is comparable with *V. heimi* which was first described by THOMPSON and FOSTER (1939) from the upper part of the Yanghsin limestone of Shin K'ai Shi province, South China, and has also recently been reported by J. C. SHENG (1958) from the Maokou limestone of Chinghai Province. An only determinable species in the Sara Buri chert bed, *Pseudofusulina crassa* (DEPRAT), is known from the upper Middle Permian rocks of Phnom Tauch of Battambang, Cambodge, and Pong Oua of Laos. Moreover, *Neoschwagerina* sp. in this bed is a primitive representative of the genus, having a primitive arrangement of septa and septula. Although this species has not been described in this paper, it is similar to *Neoschwagerina* sp. A found in the Black fusulinid limestone.

Lastly, the Permian fusulinid faunules collected from four separated beds in Sara Buri district are as a whole referable to the *Neoschwagerina* Zone in the international correlation with a possibility of having the upper part of the *Parafusulina* Zone. Faunistically speaking, they have some close relation with the East Asian Tethys fauna of Cambodge, Laos, South China and Japan.

Acknowledgments

We wish to express our sincere gratitude to Prof. Teiichi KOBAYASHI of the University of Tokyo for giving us the limestone materials collected from the Beds I, II, and III during his staying in Thailand in 1957, and also to Mr. Samon BURAVAS of the Geological Survey Division, Royal Department of Mines, Thailand for his kind sending of materials collected from the Sara Buri chert bed. We are indebted to Miss Chizuko OKAMURA for careful preparation of the typescript. A part of the financial assistance for this study was granted through the Scientific Research funds given by the Ministry of Education.

Description of Species

Parafusulina gigantea (DEPRAT)

Pl. 1, figs. 1–5

1913. *Fusulina gigantea* DEPRAT. Mém. Serv. Géol. l'Indochine, Vol. II, fasc. 1, pp. 29, 30,

Pl. I, figs. 1-6.
1925. *Schellwienia gigantea* OZAWA. Jour. Coll. Sci. Imp. Univ. Tokyo, Vol. XLV, Art. 6, pp. 32, 33, Pl. IV, fig. 9.
1935. *Pseudofusulina gigantea* GUBLER. Mém. Serv. Géol. France, No. 26, pp. 91, 92, Pl. II, figs. 4, 5, 8, 9; Pl. III, fig. 4.
1958. *Parafusulina gigantea* (?) TORIYAMA. Mem. Fac. Sci. Kyushu Univ., Ser. D, Geol., Vol. VII, pp. 200-203, Pl. 36, figs. 2-11.

The shell is large and elongate fusiform, with nearly straight to slightly arching axis of coiling, convex lateral slopes, and bluntly pointed poles. The largest shell of six and a half volutions is about 15.3 mm in length and 5.3 mm in width. The shell is spherical only in the first half volution, but due to rather rapid extension of the axis the shell assumes fusiform in early 2 to 3 volutions and elongate fusiform in later ones. Average ratios of half length to radius vector of the first to fourth volution in 4 specimens are 2.1, 2.7, 2.9, and 3.3, respectively.

The proloculus is exceedingly large and subspherical to somewhat irregular in shape. The largest diameter varies from 650 to 960 microns, averaging 755 microns in 6 specimens. The shell expands rapidly and almost uniformly throughout all but the ultimate volution which is a little more tightly coiled than the penultimate one. Average radius vector ot the first to fifth volution of 7 specimens are 470, 691, 983, 1,314, and 1,757 microns, respectively. The chambers are lowest immediately above tunnel, increasing in height polewardly.

The spirotheca is thick and coarsely alveolar, increasing in thickness as the shell grows. 5 alveoli are counted in a distance of 100 microns of keriotheca of the fifth volution. Average thickness of spirotheca of the first to sixth volution of 7 specimens 42, 65, 95, 113, 139, and 134 microns, respectively. The proloculus wall is apparently structureless, averaging 33 microns in thickness for 6 specimens.

Septa are numerous throughout all but for the first half volution. In one of the illustrated sagittal section (Pl. 1, fig. 4) they are counted 6, 19, 25, 33, and 34 ? in the first to fifth volution, respectively. They are formed of the downward extension of the tectum, in the posterior side of which pycnotheca is seen in most of them. The septa are so highly and narrowly fluted throughout the shell that closed chamberlets reach to tops of chambers even in the median portion of shell.

Complicated flutings of the septa and somewhat irregular path of tunnel make tunnel angle difficult to be measured exactly. Approximate tunnel angles in the first to fourth volution in 3 specimens average 26°, 31°, 36° and 34°, respectively.

Remarks.—The specimens available for us are not enough to describe the species completely. However, all the important characteristics of Muaglek specimens are almost identical to some specimens of *Parafusulina gigantea* described by GUBLER from Houchan, Cambodge (Pl. II, figs. 4, 5, and 9), which are, as already pointed out by R. TORIYAMA (1958), somewhat different from the DEPRAT's type specimen. Only difference is the presence of slightly heavy secondary deposits in the axial

Table 1. Measurements (in Millimeters) of *Parafusulina gigantea* (DEPRAT)

Specimen	Fig. no. in Pl. 1	L.	W.	R.	Prol.	Radius vector 1	2	3	4	5	6
1	1	15.2+	5.25	2.9	—	.326	.592	.908	1.312	1.695	2.103
2	2	9.95	2.95	3.4	.605×.717	.482	.751	1.034	1.358	—	
3	3	8.42	3.27	2.6	.674×.960	.491	.705	1.021	1.346	—	
4	4	x	3.9+	x	.604×.740	.482	.711	.990	1.321	1.748	2.146
5	5	x	2.45	x	.500×.650	.472	.696	1.015	1.320		
6	—	x	3.86	x	.660×.745	.574	.772	1.061	1.400	1.827	

Specimen	Thickness of spirotheca								Ratio of Hl./Rv.					
	0	1	2	3	4	5	6	7	1	2	3	4	5	6
1	—	.031	.064	.093	.125	.134	.138	.154	2.2	2.6	2.7	2.8	3.1	3.3
2	.029	.043	.066	.091	.103				2.6	2.5	2.7	3.3		
3	.033	.034	.058	.078	.088				2.3	2.9	2.9	3.1		
4	.031	.044	.062	.105	.121	.139	.130?							
5	.036	.047	.072	.108	.124									
6	.035	.050	.068	.092	.134	.124								

Specimen	Tunnel angle					Septal count				
	1	2	3	4	5	1	2	3	4	5
1	20	32	33	35	23?					
2	28	31	35	33						
3	29	30	39	—						
4						6	19	25	33	34?
5						5	13?	22?	—	—

zone of inner volutions of Cambodge form. There is also no distinction between the Muaglek and Akiyoshi forms in any of the important shell characters.

Occurrence.—Limestone lens in shale above the main massive limestone at Muaglek, Korat rim. It is associated with *Parafusulina kaerimizensis* (OZAWA), *Pseudofusulina* cfr. *japonica* (GÜMBEL), *Pseudodoliolina* sp., *Verbeekina* sp. and *Pseudofusulina* sp.

The stratigraphical age of the limestone lens at Muaglek is referable to the Pmα and/or Pmβ subzones of the Akiyoshi limestone group—the earlier part of the Middle Permian.

Parafusulina kaerimizensis (OZAWA)

Pl. 2, figs. 1–3

1925. *Schellwienia kaerimizensis* OZAWA. Jour. Coll. Sci. Imp. Univ. Tokyo, Vol. XLV, Art. 6, pp. 31, 32, Pl. IV, figs. 6, 7; Pl. VI, fig. 5 [non Pl. IV, fig. 5].
1936. *Pseudofusulina kaerimizensis* HUZIMOTO. Sci. Repts. Tokyo Bunrika Daigaku, Sec. C, Vol. 1, No. 2, pp. 65-67, Pl. VII, figs. 6-8; Pl. VIII, figs. 1-4.
1955. *Parafusulina kaerimizensis* MORIKAWA. Sci. Repts. Saitama Univ., Ser. B, Vol. II, No. 1, pp. 107, 108, Pl. XV, fig. 12.
1958. *Parafusulina kaerimizensis* TORIYAMA. Mem. Fac. Sci. Kyushu Univ., Ser. D, Geol., Vol. VII, pp. 194-197, Pl. 30, figs. 6-12; Pls. 31, 32.

The shell is moderate in size for the genus and subcylindrical in shape, with straight to slightly arcuate axis of coiling, flat to somewhat depressed median portion, gently convex lateral slopes and rounded poles. The largest shell of 9 volutions in the present collection has a length of 12.9 mm and a width of 4.5 mm, giving a form ratio of 2.9. As the polar expansion of axis is rapid from the youngest stage of growth, the shell retains nearly the same axial profile throughout the growth. Average ratios of half length to radius vector of the first to ninth volution in 3 specimens are 2.1, 2.8, 2.9, 3.0, 3.2, 3.3, 3.2, 3.2, and 3.1, respectively.

The proloculus is round and small for this size of shell, with an outside diameter of about 300 microns. The expansion of shell is slow in the inner 2 volutions and from the third volution it becomes more or less rapid and uniform, with average respective radius vectors of 251, 388, 573, 798. 1,063, 1,329, 1,531, and 1,810 microns in the first to eighth volution of 4 specimens. Chambers are almost the same in height in the median cylindrical part of shell, increasing in height gradually toward the poles.

The spirotheca is thin and coarsely alveolar. Average thicknesses of the first to eighth volution in 4 specimens are 28, 30, 33, 47, 56, 67, 70, and 69 microns, respectively.

The septal fluting is high, narrow and regular throughout the length of shell. Comparing with the spirotheca the septa are considerably thin, and closed chamberlets formed by strong and regular fluting reaching to the tops of chambers

Table 2. Measurements (in millimeter) of *Parafusulina kaerimizensis* (OZAWA)

Specimen	Fig. no. in Pl. 2	L.	W.	R.	Prol.	Radius vector								
						1	2	3	4	5	6	7	8	9
1	1	12.9+	4.45	3.1	—	—	.377	.577	.785	1.018	1.263	1.585	1.855	2.260
2	2	12.11	3.38	3.6	.300±	.251	.380	.531	.717	.993	1.254	1.552	1.84±	
3	—	11.50	4.00	2.9	.300±	.233	.368	.503	.686	.890	1.150	1.456	1.736	2.035
4	—	x	3.5+	x	.300±	.270	.427	.680	1.003	1.349	1.650±			

Specimen	Thickness of spirotheca								
	1	2	3	4	5	6	7	8	9
1	—	.031	.036	.040	.051	.066	.075	.065	
2	.025	.036	.036	.046	.055	.069	.070		
3	—	.027	.028	.041	.045	.057	.065	.072	.082
4	.030	.025	.031	.060	.074?	.075?	.128?		

Specimen	Ratio of Hl./Rv.								
	1	2	3	4	5	6	7	8	9
1	—	2.8	2.8	2.7	3.0	3.0	2.9	3.0	2.9
2	1.9	2.6	3.0	3.0	3.0	3.3	3.3	3.3	
3	2.4	3.0	3.0	3.2	3.5	3.6	3.4	3.4	3.3

Specimen	Tunnel angle						Septal count				
	3	4	5	6	7	8	1	2	3	4	5
1	—	31?	24	32	39	42					
2	26	32	42	45?	41?	—					
3	34	37	35	28?	35	29?					
4							13+	22+	27+	34?	—

throughout all but for the limited part of the median portion of shell. Cuniculi are clearly observed and septal loops appearing in axial section are small and abundant. Septal count of each volution is not known exactly.

Tunnel is rather wide and low, with somewhat irregular tunnel path. Tunnel angles of the third to eighth volution of 3 specimens average 30°, 33°, 34°, 35°, 38°, and 36°, respectively. The secondary deposits fill the axial zones of chambers of inner volutions.

Remarks.—Although enough information for the shell characters is not available due to the insufficiency of materials at hand, the Muaglek specimens are assignable without any doubt to *Parafusulina kaerimizensis* (OZAWA), which, with its lectotype specimen in the OZAWA's collection, has been described and discussed at length in the recent paper of one of us (R. TORIYAMA, 1958). The Muaglek specimens are almost identical with the Akiyoshi form in almost all the specific characters. Only difference is a slightly weak development of the axial deposits in the present specimens, and if this character is taken into consideration the Muaglek form is completely identical with the lectotype of the species, which is also distinguished in this respect from most of the specimens of this species in TORIYAMA's collection.

Occurrence.—Limestone lens in shale above the main massive limestone of Muaglek, Korat rim. Associated species are *Parafusulina gigantea* (DEPRAT), *Pseudofusulina* cfr. *japonica* (GÜMBEL), *Pseudodoliolina* sp., *Verbeekina* sp., and *Pseudofusulina* sp.

The stratigraphical age of the limestone lens at Muaglek is referable to the earlier part of the Middle Permian.

Pseudofusulina cfr. *japonica* (GÜMBEL)

Pl. 1, figs. 7, 8

1883. *F-sulina japonica* GÜMBEL. In SCHWAGERS' China, Vol. IV, pp. 121-124, Pl. XV, figs. 1-11.
1914. *Fusulina japonica* DEPRAT. Mém. Serv. Géol. Indochine, Vol. III, fasc. 1, pp. 7-9, Pl. I, figs. 1-9.
1915. *Fusulina japonica* DEPRAT. Mém. Serv. Géol. Indochine, Vol. IV, fasc. 1, pp. 7, 8, Pl. I, figs. 17, 19, 20.
1924. *Fusulina japonica* COLANI. Mém. Serv. Géol. Indochine, Vol. XI, pp. 136, 137, Pl. VII, figs. 1, 27, 28, 30, Pl. VIII, figs. 1, 5, 9, 10, 12, 15.
1925. *Schellwienia japonica* OZAWA. Jour. Coll. Sci. Imp. Univ. Tokyo, Vol. XLV, Art. 6, p. 30.
1927. *Schellwienia japonica* OZAWA. Jour. Fac. Sci. Imp. Univ. Tokyo, Vol. II, pt. 3, pp. 147-149, Pl. XXXVI, figs. 1-7, Pl. XXXVII, fig. 7a.
1927. *Schellwienia japonica* LEE. Palaeontologia Sinica Ser. B, Vol. IV, fasc. 1, pp. 82-85, Pl. XIII, figs. 1-8.
1934. *Parafusulina japonica* CHEN. Palaeontologia Sinica, Ser. B, Vol. IV, fasc. 2, pp. 81, 82, Pl. VI, figs. 1, 9, Pl. VIII, fig. 7.
1936. *Pseudofusulina japonica* HUZIMOTO. Sci. Rep. Tokyo Bunrika Daigaku, Sec. C, Vol. 1, No. 2, pp. 56-59, Pl. V, figs. 8-10, Pl. VI, fig. 3.
1955. *Schwagerina japonica* MORIKAWA. Sci. Rep. Saitama Univ., Ser. B, pp. 106, 107, Pl. XIV, figs. 1, 12.
1957. *Schwagerina japonica* KOBAYASHI. Sci. Rep. Tokyo Kyoiku Daigaku, Sec. C, No. 48, Pl. VI, figs. 3-5.
1958. *Parafusulina japonica* MORIKAWA. Sci. Rep. Saitama Univ. Ser. B, Vol. III, No. 1, pp. 112-114, Pl. 19, figs. 1-7.

The shell is moderate in size. Exact external form is not known, but it seemingly has typical fusiform with gently convex lateral slopes and bluntly pointed poles. The illustrated axial section (Pl. 1, fig. 7) is estimated to have an approximate length of 11 mm and a width of 3. 5 mm, with a form ratio of 3. 1. The shell changes short to typical fusiform in axial profile, with a moderate rate of prolongation of the axis.

The proloculus is moderate for size of the shell with an outside diameter of 424 and 393 microns in the two illustrated specimens. The rate of expansion is rather slow. Radius vectors of the first to seventh volution in the illustrated axial section are 273, 383, 552, 763, 987, 1, 251, and 1, 521 microns, respectively, and those of the first to fifth volution in the illustrated sagittal section are 273, 390, 543, 760, and 995 microns, respectively. The chambers are nearly equal in height, only becoming slightly higher towards the poles.

The spirotheca is thin and typical in structure for the genus. Respective thickness of the first to seventh volution for the axial section is 26, 32, 33, 37, 49, 63, and 69 microns, respectively. Structureless thin wall of the proloculus is 30 and 26 microns in the two illustrated specimens.

The septa are thin and strongly fluted. Closed chamberlets formed by strong septal fluting are reaching to the tops of chambers in the polar one-third of shell, but they do not so in the median portion, being half to two-thirds as high as the chambers. The presence of cuniculi is not ascertained due to the lack of suitable tangential section at our disposal. Septal counts in the illustrated sagittal (more or less diagonal) section are 13?, 24?, 30, and 30, respectively in the first to fourth volution.

The tunnel is difficult to determine partly because of being that the illustrated axial section is not perfectly oriented. Approximate tunnel angles of the first to fourth volution of the illustrated axial section are 13°?, 24°?, 30°, and 30°, respectively. Chomata do not present throughout all but the first volution where they seemingly appear in very rudimentary form. The secondary deposits occur only in very limited part of the axial zone of inner few volutions.

Remarks.—Available specimens of this species are very insufficient, being represented by only each one of axial and sagittal section. The above description, therefore, is not complete, and moreover, *Pseudofusulina japonica* (GÜMBEL) is, as already pointed out by MORIKAWA (1955) and others, somewhat vague in its specific definition. Therefore, the detailed specific comparison of this form with similar ones seems not advisable here. It is noted, however, that there is a rather sharp difference in the spirothecal thickness between the SCHWAGER's figures and the Muaglek specimens. Such being the case we are keeping the specific determination as tentative until more sufficient material becomes available.

Occurrence.—The limestone lens in shale above the main massive limestone at Muaglek, Korat Rim. *Pseudofusulina* cfr. *japonica* occurs with *Parafusulina gigantea* (DEPRAT), *P. kaerimizensis* (OZAWA), *Pseudodoliolina* sp., *Verbeekina* sp., and *Quasifusulina* sp., of which the last named species is seemingly a derived fossil.

The stratigraphical age of this limestone lens is referable to the Pmα and/or Pmβ subzone of the Akiyoshi limestone group of Southwest Japan; namely, it is regarded as the earlier part of the Middle Permian.

Pseudofusulina crassa (Deprat)

Pl. 1, figs. 9-11

1913. *Fussulina crassa* Deprat. Mém. Serv. Géol. Indochine, Vol. II, fasc. 1, pp. 27, 28, Pl. VI, figs. 1-5.

The shell is medium and typical fusiform, with sharply pointed polar ends, straight axis of coiling and concave lateral slopes. The shell of 7 volutions is 6.26 mm long and 2.92 mm wide, giving a form ratio of 2.1. Average ratios of half length to radius vector for the first to seventh volution of 2 specimens are 1.5, 2.0, 1.9, 2.2, 2.2, 2.2, and 2.0, respectively.

The proloculus is medium, with an outside diameter of 240 microns. The shell expands gradually. Average radius vectors of the first to eighth volution in 4 specimens are 202, 361, 525, 747, 1,019, 1,244, 1,502 and 1,729 microns, respectively. Chambers are uniform in height in midportion, but increase as approaching the polar areas.

The spirotheca is moderately thick, composed of tectum and coarsely alveolar keriotheca. Average thickness of the spirotheca of 4 specimens is 23, 30, 55, 53, 69, 70, 88, and 85 microns, respectively in the first to eighth volution.

The septa are strongly, rather closely and low, fluted, but slightly irregular and weak in the central portion of the shell.

Chomata are indistinct in inner volutions due to strong axial fillings, but become distinct in outer volutions. Tunnel is rather wide, with an angle of 26° in the sixth volution.

Remarks.—If a strict comparison is made among our collections, there is a slight difference in septal fluting; one is more or less regular and the other somewhat less regular. However, the specimens at our disposal have important specific characters of *Pseudofusulina crassa* (Deprat).

Occurrence.— The pre sent species occurs in the Sara Buri chert bed, associated with *Verbeekina* sp. A and *Neoschwagerina* sp.

Table 3. Measurements (in millimeters) of *Pseudofusulina crassa* (Deprat)

Specimen	Fig. no. in Pl. 1	L.	W.	R.	Prol.	Radius vector 1	2	3	4	5	6	7	8
1	9	6.256	2.923	2.1	?	?	.309	.549	.789	1.071	1.353	1.579	—
2	—	6.139	2.954	2.2	—	.157	.255	.438	.607	.861	1.129	1.453	—
3	11	×	2.854	×	.240	.205	.304	.445	.685	.939	1.249	1.475	1.729
4	10	×	1.877	×	.235	.245	.457	.663	.309	1.205	—	—	—

Speɔimen	Thickness of spirotheca								Ratio of Hl./Rv.							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
1	?	.028	.085	.056	.078	.071	.028	—	—	2.3	1.9	1.9	1.9	2.1	1.9	—
2	.028	.042	.056	.042	.056	.056	.099	—	1.5	1.7	1.9	2.4	2.4	2.3	2.1	—
3	.014	.028	.035	.056	.071	.085	.049	.085								
4	.025	.028	.042	.056	.071	—	—	—								

Specimen	Septal count							
	1	2	3	4	5	6	7	8
3	11	14	19	22	24	26	26+	16+
4	11	17	23	27	29	—	—	—

Verbeekina sp. A

Pl. 2, fig. 12; Pl. 3, figs. 1-6

Compare:

1936. *Verbeekina akasakensis* THOMPSON. Jour. Paleont., Vol. 10, pp. 193-201.
1937. *Verbeekina heimi* THOMPSON & FOSTER. Jour. Paleont., Vol. 11, pp. 137, 138, pl. 23, figs. 1-3, pl. 24, fig. 5; pl. 25, figs. 5, 6.

The shell is large and spherical to subspherical in shape, with umbricate polar regions. Mature specimens of 10 to 12 volutions are about 6.0 to 6.5 mm wide in the tenth and about 6.5 to 7.5 mm in twelfth volution. The first 3 to 4 volutions are discoidal, having a short axis of coiling. Beyond them the shell becomes spherical or subspherical. Ratios of half length to radius vector of a typical form are 0.9, 1.1, 1.1, 1.0, 1.0, 0.9, 0.9, and 0.9, respectively for the first to eighth volution. Those of another form are 0.7, 0.8, 0.9, 1.1, 1.1, and 1.1, respectively for the fifth to tenth volution.

The proloculus is small, having an outside diameter of about 100 to 170 microns. The first 2 to 3 volutions are tightly coiled, but beyond them the shell expands rapidly and uniformly, and in outer 3 or 4 volutions of mature specimens coiling becomes rather tight again. Average radius vectors in the first to twelfth volution of 10 specimens are 194, 346, 620, 972, 1,379, 1,742, 2,117, 2,460, 2,771, 3,156, 3,357, and 3,647 microns, respectively.

The spirotheca is very thin in the first 4 or 5 volutions, consisting of a tectum and thin keriothecal layer. In the following volutions it increases rapidly in thickness, composed of a rather thin tectum and thick alveolar keriotheca. Numerous fibrous secondary deposits can apparently be seen on the upper and lower surfaces of the spirotheca throughout all the volutions. Average thickness of the spirotheca for the first to twelfth volution of 10 specimens is 25, 30, 36, 33, 36, 44, 49, 48, 52, 40, 48, and 41 microns, respectively.

The septa are thin and widely spaced in inner volutions but become much numerous in number, spacing rather closely in outer volutions. Average septal counts for the first to eleventh volution of 8 specimens are 8. 8, 7?, 10, 10, 13, 18, 20?, 22?, 22?, and 25?, respectively.

Parachomata do not occur or very rudimentary if present. In one of the illustrated para-axial section they can only be observable in the eighth or ninth volution.

Foramina are very low and elliptical in shape.

Remarks.—Because all the specimens came from the Sara Buri chert bed are strongly silicified and exactly centered axial section is not available, the above description is not complete to describe the species.

This form is more or less similar to *Verbeekina heimi* described by THOMPSON & FOSTER from the Yanghsin limestone of the Mt. Omei region in regards to the rate of growth, thickness of spirotheca for the corresponding volutions. The present species, however, differs from *V. heimi* which has more numerous volutions at maturity, more numerous parachomata, and more spherical shape.

Table 4. Measurements (in millimeters) of *Verbeekina* sp. A

Specimen	Fig. no. in Pl. 3	L.	W.	R.	Prol.	Radius		
						1	2	3
1	2	3.715*	4.301*	0.9	.169	.136	.255	.438
2	4	3.597*	3.512*	0.8	.196	.371	.644	.961
3	1	7.741	6.305	1.2	—	—	—	—
4	3	x	6.999	x	.176	.173	.300	.582
5	5	x	6.530	x	.099	.149	.318	.614
6	—	x	5.552	x	.141	.120	.233	.459
7	—	x	6.021	x	—	—	.323	.647
8	6	x	7.625	x	—	—	—	—
9	—	x	5.909	x	—	—	—	.642
10	—	x	6.530	x	—	—	—	—

Specimen	vector								
	4	5	6	7	8	9	10	11	12
1	.678	.974	1.383	1.750	2.131	2.540	—	—	—
2	1.313	1.645	1.946	2.220	2.455	2.729	3.003	3.238	3.512
3	—	1.407	1.837	2.267	2.658	2.991	3.324	—	—
4	.892	1.357	1.766	2.104	2.457	2.767	3.049	2.331	3.599
5	1.001	1.432	1.770	2.080	2.362	2.644	2.898	3.138	3.420
6	.783	1.206	1.615	2.010	2.348	2.574	—	—	—
7	1.028	1.522	1.846	2.156	2.466	2.734	3.016	—	—
8	—	—	1.632	2.252	2.633	2.014	3.367	3.720	4.058
9	.966	1.333	1.615	1.897	2.306	2.588	—	—	—
10	1.109	1.532	2.011	2.434	2.787	3.125	3.435	—	—

Specimen	Thickness of spirotheca											
	1	2	3	4	5	6	7	8	9	10	11	12
1	.014	.028	.035	.042	.071	.042	.042	.042	.028	—	—	—
2	.039	.039	.032	.039	.035	.043	.047	.055	.078	.051	.039	.039
3	—	—	—	.063	.042	.056	.056	.056	.056	.014	—	—
4	.021	.028	.038	.024	.028	.045	.042	.042	.042	.056	.056	.042
5	.028	.028	.028	.028	.042	.052	.071	.042	.054	.042	.021	.028
6	.028	.028	.025	.023	.028	.028	.028	.056	.032	—	—	—
7	.021	.028	.028	.014	.014	.031	.034	.042	.056	.014?	—	—
8	—	—	—	—	—	.056	.056	.042	.085	.071	.056	.056
9	—	.035	.028	.025	.028	.018	.042	.042	.021	—	—	—
10	—	—	.071	.042	.039	.071	.071	.065	.071	.032	—	—

Specimen	Ratio of Hl./Rv.											
	1	2	3	4	5	6	7	8	9	10	11	12
1	0.9	1.1	1.1	1.0	1.0	0.9	0.9	0.9	?	—	—	—
2	1.4	1.3	1.1	1.1	1.1	1.0	1.1	1.0	1.0	1.0	1.0	1.0
3	—	—	—	—	0.7	0.8	0.9	1.1	1.1	1.1	—	—

Specimen	Septal count											
	1	2	3	4	5	6	7	8	9	10	11	12
4	7	8	6	7	8	11	14	18	21	18+	18+	12+
5	10	10	7	9	10	13	19	26+	25+	20+	21+	4+
6	6	8	8	12	13	16	22	22+	?	—	—	—
7	—	7	9	12	11	15+	10+	11+	7+	7+	—	—
8	—	—	—	—	—	9+	16	23	29	29	37	39
9	—	—	7?	8	12	17	18	18	16+	—	—	—
10	—	—	7+	12	13	16	21	25+	19+	19+	—	—

* half of length or width

Verbeekina verbeeki somewhat resembles the present form, but is distinguished from the latter in having more numerous volutions and thicker spirotheca in the inner volutions. The parachomata of this species are apparently not developed as in *Verbeekina verbeeki* (GEINITZ).

The present species is allied in general shape to *Verbeekina akasakensis* THOMPSON, but has large and more rapidly expanding shell, more poorly developed parachomata, and more spherical shape.

Verbeekina crassispira CHEN from the Mao K'ou limestone, South China bears some resemblance with this species, but the former has smaller shell, less rapid expansion of shell, better developed parachomata, and thicker spirotheca than the latter.

As the present species is not comparable to any species hitherto described, it may perhaps be a new species. However, future study on more sufficient materials is need before the specific determination can be made.

Occurrence.—The present species is obtained from the Sara Buri chert bed, where it is associated with *Pseudofusulina crassa* (DEPRAT) and *Neoschwagerina* sp.

Neoschwagerina spp.

At least two, probably three, species of *Neoschwagerina* have been found in the present materials obtained from the Black fusulinid limestone (Loc. 1–4) of Motetung and Gray fusulinid limestone (Loc. 5–9) of Boh Pram Lang Nua. Although they are rather abundant in number, most, if not all, of them are very poorly preserved, being recrystallized and deformed after fossilization, and they are not suitable for the detailed paleontological study. Nevertheless, the following descriptions are given for increasing paleontological knowledge of the area as much as possible.

Neoschwagerina sp. A

Pl. 2, fig. 4

The shell is elongate fusiform and rather small in size for the genus. Due to the deformation after fossilization, the original dimensions of shell are not known exactly, but a shell of 13 volutions, as it is appeared in thin section, is 5.84 mm in length and 2.36 mm in width, with a form ratio of 2.5. The axis becomes extended fairly rapidly as the shell grows. Ratios of half length to radius vector of the first to twelfth volution in the same shell are 1.4, 1.4, 1.8, 1.9, 2.3, 2.7, 2.6, 2.8, 2.7, 2.9, 3.0, and 3.1, respectively.

The proloculus is minute, with an outside diameter of 44 microns in the illustrated axial section. The shell expands very slowly in inner 6 volutions, and from the seventh volution it becomes slightly rapid and uniform. Radius vectors of the first to thirteenth volution of the same section are 45, 79, 107, 139, 194, 251, 344, 445, 564, 684, 820, 957, and 1,107 microns, respectively.

The spirotheca is rather thick for the genus. Its minute structure is hardly observable in most parts of the shell, but keriotheca-like structure is discernible in a very limited part of spirotheca in outer volutions. Apparent thickness of the spirotheca of the first to twelfth volution in the axial section is 10, 11, 11, 13, 14, 14, 18, 18, -?, 18, 18, and 22 microns, respectively.

True nature of septa and septula is not understand because no exactly oriented sagittal section is available. Judging from excentric and oblique sections available, the septa are very primitive in development, being thick and widely spaced. Axial septulum does not appear in inner volutions, and only a single one of it occurs between adjacent septa. The primary spiral septula occur throughout the length of the shell. The secondary spiral septula do not occur in most part of the shell.

However, in a limited part of few chambers of outer volutions they appear as low downward swelling of the spirotheca.

Foramina are subelliptical to somewhat irregular in shape. Their number is not counted exactly.

Remarks.—Enough information for the specific comparison is not available from the present material which is insufficient in number and preserved in poor condition. Although the original shape of the shell is not known, no species of *Neoschwagerina* is comparable with the present one which has very elongate shell and very slow rate of expansion for the genus. Primitive development and features of septa and septula and rather thick spirotheca suggest that this species is one of the most primitive member of the genus *Neoschwagerina*. The final specific determination must be done after more sufficient and well preserved materials become available, though it is perhaps true that the present form may be a new species.

Occurrence.—*Neoschwagerina* sp. A occurs in the Black fusulinid limestone exposed at Motetung, with *Neoschwagerina* sp. B and *Parafusulina* sp. Since none of the species contained in the Black fusulinid limestone is definitely determined the stratigraphical position of the limestone is not known exactly, but it may roughly be correlated with the upper part of the *Parafusulina* zone and/or the lower part of *Neoschwagerina* zone of other areas in East Asia.

Neoschwagerina sp. B

Pl. 2, figs. 5, 6

The shell is small and elongate fusiform, with straight to gently convex lateral slopes and narrowly rounded poles. One of the illustrated axial section of 8 volutions is about 5.0 mm in length and 1.5 mm in width, with a form ratio of 3.3. The first two volutions are ellipsoidal. From the third volution the axis becomes extended rapidly. Ratios of half length to radius vector of the first to eighth volution of the axial section mentioned above are 1.4, 1.6, 2.2, 2.3, 2.4, 2.6, and 3.1, respectively.

The proloculus is large and spherical to subellipsoidal. Its outside diameter is 267×184 microns in the subspherical form and 300 microns in the spherical one. The proloculus wall is thin, attaining a thickness of 15 and 10 microns, respectively, in the two forms. Expansion of shell is moderate for the genus, with radius vectors of 126, 187, 236, 307, 396, 503, 620, and 750 microns in the first to eighth volution of the illustrated axial section, and 193, 242, 297, 368, 445, 540, and 656 microns in the first to seventh volution of another axial section. Chambers are almost equal in height in central two-thirds of the shell but become higher rapidly towards the poles.

The spirotheca is thick for the genus, the minute structure of which is not understand due to the secondary recrystallization. Respective thickness of the first to sixth volution in two specimens is measured 15–10, 15–11, 15–12, 16–17, 16–18, and 16–20 microns.

Since there is no oriented sagittal section septal characters are not clearly known. However, it seems that septula are as a whole very primitive in development; namely, axial septula seemingly do not present in inner volutions and a single one occurs between a pair of adjacent septa in later volutions. In a limited part of outer few volutions two axial septula rarely exist between two adjacent septa. The primary spiral septula present throughout the length of the shell. The secondary spiral septula do not occur in any part of the shell.

Foramina are subcircular to elongate elliptical in axial profile. Their number is not counted exactly.

Remarks.—In having very elongate shell, large proloculus and rather thick spirotheca, *Neoschwagerina* sp. B is not comparable with any species in the genus *Neoschwagerina* hitherto known. As well as in *N.* sp. A, the primitive features and development of septa and septula show that *N.* sp. B is also a primitive member of the genus. Further study on more sufficient and completely preserved materials is necessary before the final specific determination.

Occurrence.—*Neoschwagerina* sp. B is found in the Black fusulinid limestone of Motetung, associated with *N.* sp. A and *Parafusulina* sp. As for the stratigraphical age of this species the same remark as that in the foregoing species is also given here.

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Permian Fusulinids from Central Thailand

Plates 1-3

Plate 1

Explanation of Plate 1

All x 10

Figs. 1-5. *Parafusulina gigantea* (DEPRAT)

All from Loc. 10*

1. Para-axial section of a mature specimen; Slide no. 10-7
2. Axial section. Outer parts eroded out; Slide no. 10-4
3. Axial section. Outer parts eroded out; Slide no. 10-1
4. Sagittal section. Slide no. 10-3
5. Sagittal (more or less) diagonal section. Slide no. 10-2

Fig. 6. *Pseudofusulina* (?) sp.

Axial section of an immature specimen. Loc. 10; Slide no. 10-2

Figs. 7, 8. *Pseudofusulina* cfr. *japonica* (GÜMBEL)

Both from Loc. 11

7. Axial section. Slide no. 11-1
8. Sagittal section. Slide no. 11-6

Figs. 9-11. *Pseudofusulina crassa* (DEPRAT)

All from the Sara Buri chert bed.

9. Axial section. Slide no. 11-1
10. Sagittal section. Slide no. 11-2
11. Diagonal section. Slide no. 14-1

Microphotographs of Figs. 9-11 are taken under the crossed nicols.

Photos by R. TORIYAMA and T. SUGI

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* Locality numbers are referred to the KOBAYASHI's locality nos. 1-11

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Plate 2

Explanation of Plate 2

All x 10

Figs. 1-3. *Parafusulina kaerimizensis* (Ozawa)

1. Axial (slightly tangential) section of a mature specimen. Loc. 10; Slide no. 10-8
2. Axial (slightly tangential) section. Loc. 11; Slide no. 11-4

Fig. 4. *Neoschwagerina* sp. A

Axial section. Loc. 2; Slide no. 2-6

Figs. 5, 6. *Neoshwagerina* sp. B

5. Axial section. Loc. 1; Slide no. 2-3
6. Axial section. Loc. 2; Slide no. 1-4

Figs. 7, 8. *Neoschwagerina* sp.

Both from Loc. 7

7. Excentric section. Slide no. 7-2
8. Sagittal section. Slide no. 7-2

Fig. 9. *Sumatrina* sp.

Diagonal and oblique sections. Loc. 7; Slide no. 7-2

Figs. 10, 11. *Neoschwagerina* sp.

Sagittal sections. Loc. Sara Buri chert bed. Slide nos. 14-1 and 14 2

Fig. 12. *Verbeekina* sp.

Diagonal (more or less oblique) section, showing that the shell is not completely spherical, but has a form ratios of at least larger than 1.2. Loc. Sara Buri chert bed; Slide no. 9

Microphotographs 9-12 are taken under the crossed nicols.

Photos by R. Toriyama and T. Sugi

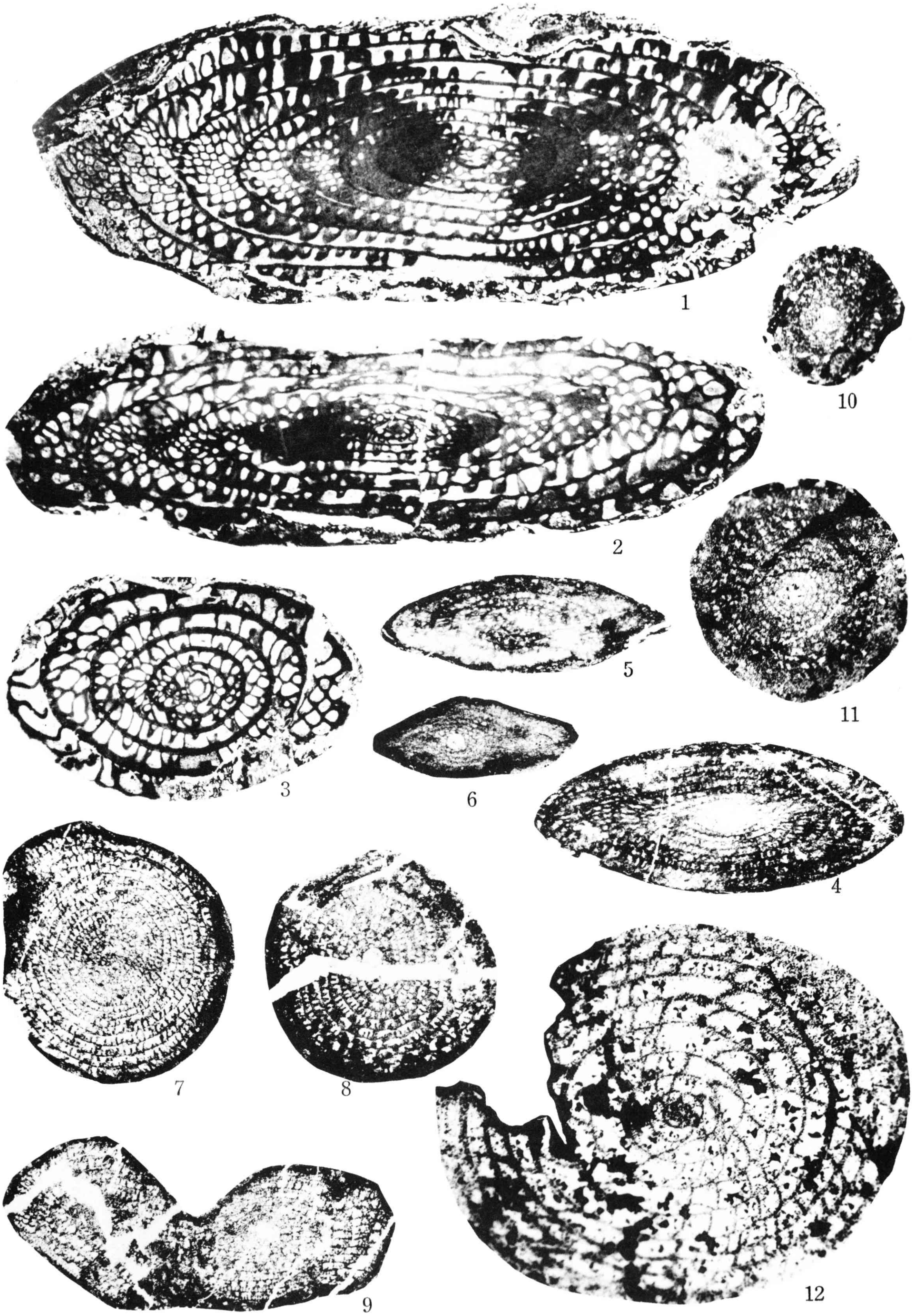
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Plate 3

Explanation of Plate 3

All x 10

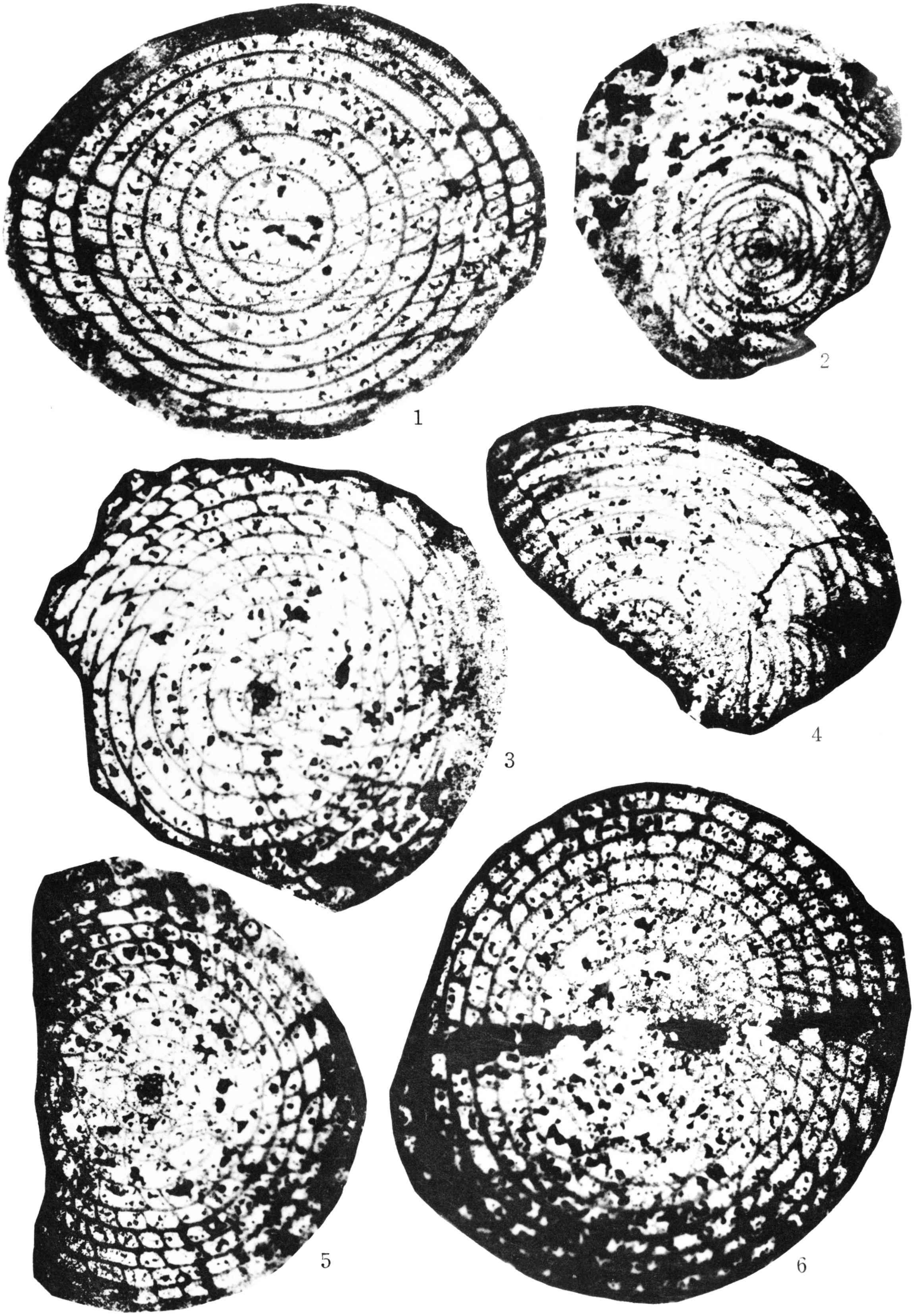
Figs. 1-6. *Verbeekina* sp.

All from the Sara Buri Chert bed.

1. Para-axial section. Slide no. 3
2. Axial section. Slide no. 1
3. Diagonal section. Slide no. 4
4. Axial section. Slide no. 2
5. Sagittal section. Slide no. 5
6. Uncentered sagittal section. Slide no. 8

Microphotographs of Figs. 1-6 are taken under the crossed nicois.

Photos by R. TORIYAMA and T. SUGI.



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