

## On the Classification of Fusulinidae.

By

Yoshiaki OZAWA.

---

*With 4 Plates and 3 Textfigures.*

---

### Introduction.

The family of *Fusulinidae*<sup>(1)</sup> is an extinct group found only in the Permo-Carboniferous rocks, and most abundantly preserved in limestones. Its distribution being very extensive, the investigation of the structure and the classification of the genera contained in it was made by several writers such as Schwager, V. v. Möller, H. v. Staff, E. Schellwien, Wedekind, Douvillé, Deprat, Hayden, and Yabe, and therefore it is not surprising to find that most diverse views have been entertained as to the structure of the shell-wall and the classification.

The results, however, of the most recent investigations, render it hardly a matter of doubt that the shell-wall is composed of imperforate "Dachblatt" and "Wabenwerk," but as to the basis of classification, there is much difference of opinion. H. v. Staff and Wedekind seem to regard the folding of septa and the external configuration as of primary importance, whilst Deprat considers the development of the buccal aperture as of very important and taxonomic value.

In this paper I intend to give a brief summary of, and criticism on, the genera of *Fusulinidae*, but I am sorry to add here that I had no opportunity of examining the actual specimens of *Fusulinella bocki* Möller and *Palaeofusulina prisca* Deprat.

Before going further, I take this opportunity of expressing my most cordial thanks to Drs. Yokoyama and Yabe who had the kindness to look over the manuscript of this paper and gave me useful instruction. Prof. Yabe, moreover, furnished me some excellent sections of *Fusulinas* which were of great use in preparing the present paper.

---

(1) Y. Ozawa. Preliminary Notes on the Classification of the Family *Fusulinidae* (in Japanese), Jour. Geol. Soc. Tokyo, Vol. XXIX., No. 348, 1922, pp. 352-265.

## Two Classifications recently proposed.

In the year 1910, Staff and Wedekind published an important and valuable paper<sup>(1)</sup> on the classification of Fusulinidae. In this work, the authors studied minutely the shell-structure of living and extinct foraminifers, and rejected the opinion that *Fusulinas* are extinct allies of *Alveolina*

The classification, briefly stated and in summary form, is as follows:—

### Family Fusulinidae V. MOELLER.

#### (a) Subfamily Fusulinellinae v. STAFF-WEDEKIND.

The shell-wall is composed of the non-porous compact lamella without the mesh-work. Earlier volutions Endothyrian and asymmetrical. Septa almost plane. Median skeletons well developed.

Genus *Fusulinella* v. MOELLER (em. v. STAFF 1909).

The axis of the volutions is the shortest diameter.

Genus *Schubertella* v. STAFF-WEDEKIND.

The axis is the longest diameter.

#### (b) Subfamily Fusulininae v. STAFF-WEDEKIND.

Shell-wall either a compact lamella or composed of "Dachblatt" and "Wabenwerk." Earlier whorls almost bisymmetrical.

Genus *Girtyina* v. STAFF.

Shell-wall imperforate and compact. Septa strongly folded.

Genus *Fusulina* FISCHER v. WALDHEIM.

Shell-wall composed of "Wabenwerk" and "Dachblatt."

Subgenus *Schellwienia* v. STAFF-WEDEKIND.

Subgenus *Schwagerina* v. MOELLER (em. v. STAFF).

#### (c) Verbeekinae v. STAFF-WEDEKIND.

Earlier volutions almost lenticular and asymmetrical. Septa plane in upper half, regularly folded at lower border.

Basal skeletons either present or not.

Genus *Verbeekina* v. STAFF.

No basal skeletons. Evolution very rapid.

Genus *Doliolina* SCHELLWIEN em. v. STAFF.

Basal skeletons well developed.

---

(1) H.v. Staff and Wedekind: Der oberkarbone Foraminiferensapropelit Spitzbergens. Bull. Geol. Inst. Univ. Upsala, vol. X., pp. 82-123.

The highly specialized forms, *Neoschwagerina* and *Sumatrina* were omitted, which Staff subordinates provisionally into a subfamily, *Neoschwagerininae*.

In 1912, 1913, 1914 and 1915, Mr. Deprat published four successive papers on the *Fusulinas* of the Permo-Carboniferous limestones of Yunnan, Indochina and Japan, viz.,

(1) Des Fusulinidés de la Chine et de l' Indochine et Classification des Calcaires à Fusulines.

(2) Les Fusulinidés des Calcaires Carbonifériens et Permians du Tonkin, du Laos et du Nord-Annam.

(3) Étude comparative des Fusulinidés d' Akasaka (Japon) et des Fusulinidés de la Chine et de l' Indochine.

(4) Les Fusulinidés des Calcaires Carbonifériens et Permians du Tonkin, du Laos et du Nord-Annam, 2<sup>e</sup> partie.

In these papers the author described *Fusulinas* of all kinds and proposed two new genera and one new subgenus. At first he draws attention to the structure of the septa,<sup>(1)</sup> of which he distinguishes five types, and then to the structure of the buccal aperture.<sup>(2)</sup> The latter idea is very reasonable and interesting.

The following<sup>(3)</sup> is the arrangement of the *Fusulinas* and their subdivisions as proposed by Deprat.

### Family Fusulinidae v. MOELLER.

Genus *Palaeofusulina* Deprat.

Cloisons plissées uniquement dans le sens du petit rayon, droites ou presque droites dans la partie médiane de la coquille, anastomosées seulement à l'extrémité; réseau alvéolaire à fines poutrelles, ouverture simple, haute et peu large, presque circulaire. Type: *Palaeofusulina prisca* Deprat.

Genus *Fusulina* Fischer v. Waldheim.

Ouverture simple en fente plus ou moins longue.

Genus *Neofusulinella* Deprat.

Coquille fusiforme. Cloisons méridiennes complètement planes percées d'une ouverture médiane unique, basse et en fente. Réseau alvéolaire formé de poutrelles fines.

Genus *Schwagerina* Möller.

---

(1) Deprat, 1912, p. 8. Compare:—J.S. Lee, a graphic Method to aid specific Determination of Fusulinoids. Bull. Geol. Soc. China, 1923, Vol. II., p. 61.

(2) Deprat; op. cit. 1913. pp. 5-7.

(3) " " " pp. 7-9.

Cloisons méridiennes seules développées, planes, percées d'ouvertures multiples à la base.

Genus *Doliolina* Schellwien.

Genus *Neoschwagerina*<sup>(1)</sup> Yabe.

Subgenus (a) *Neoschwagerina* s. str.

(b) *Yabeina* Deprat.

(c) *Sumatrina* Volz.

Comparing the above two classifications, we can easily recognize how diverse the opinions are. Excepting the new genera which were created by them, the most notable difference of view is that Staff and Wedekind

Table I. Technical terms applied to structural

Deprat	Douvillé.	Hayden	Lee	Möller
Cloison méridienne ou cl. principale.	Cloison principale	Primary meridional septa	Antetheca	
Cloison secondaire ou fausse cloison méridienne.	Cloison secondaire méridienne	Auxiliary meridional septa	Auxiliary longitudinal septa	
Cloison transverse ou Cl. fausse		Primary equatorial septa	Principal transverse septa	
		Auxiliary equatorial septa	Auxiliary transverse septa	
Côte basale	Côte transverse, Côte basale	Basal skeleton	Basal skeleton	
Ouverture latérale			Lateral passage	
Lame spirale (imperfurée)	Lame spirale	External exogenous layer	Tectum	
Réseau alvéolaire	Réseau de pontrelles	Meshwork or Network	Macula	
Ouverture buccale	Ouverture de cloison médiane		Buccal aperture	Medianspalt
		Oral apertures	Pores	
Loge embryonnaire, Loge initiale		Central chamber		Zentralkammer
				Supplementäre Kalkschicht
			Buccal rings	

(1) Deprat; op. cit. 1914. p. 35.

draw attention to the so-called basal skeletons of *Schwagerina* and separate the hitherto known species into two groups:—subgenus *Schwagerina* and new genus *Verbeekina*, the former is comprised under the genus *Fusulina* and the latter under the new subfamily *Verbeekinae*.

Deprat on the other hand, though he takes Staff's work into consideration, employs the older classification proposed by Yabe, Schellwien and Schwager.

Before going into the discussion of these classifications, I will enumerate the technical terms used by the various writers, for purpose of comparison and in order to avoid confusion.

features of *Fusulinidae* used by several writers.

Schellwien	Staff and Staff-Wedekind	Yabe.	Ozawa
	Septen.	Primary septa	Primary meridional septa
	axiale (wabenträgende) Dachreifen.	Auxiliary septa	Auxiliary (false) meridional septa
	sagittale (wabenträgende) Dachreifen	Transverse septa	Primary equatorial septa
	"		auxiliary (false) equatorial septa
Basalskelett	Tonnenreifen, (Basalskelett)	Basal skeleton	Basal skeleton
			Lateral passage
Dachblatt	Dachblatt	Median lamella	Tectum (Thin lamella)
Wabenwerk	Wabenwerk		Meshwork or Macula
Mundspalt	Mundspalt		Buccal aperture
	Septenporen		Septal pores
Embryonal- oder Centralkammer	Anfangskammer		Initial chamber
Verdickungsschicht	Verdickungsschicht		Deposition-layer
	Medialreifen (Basalskelett)		Median-skeletons

## Passages of Sarcodē.

As the shell-wall of *Fusulina* has no perforations, the septa are pierced with several kinds of stolon passages, such as the buccal apertures, lateral passages, slits formed by a folding of the septa and the septal perforations,<sup>(1)</sup> for the purpose of the communication of sarcodē.

### (1) Buccal aperture.

The buccal aperture is either a single elongated slit or a row of small rounded pores at the inner edge of the primary septa. Both sides of the aperture are strengthened by the secondary deposition called the median- and basal-skeletons. The term median skeletons<sup>(2)</sup> are restricted to the two deposition-rings built at both sides of the median aperture of the single type of buccal aperture; on the other hand, the name basal skeletons<sup>(2)</sup> is given to the numerous deposition-rings which are developed in the forms possessing multiple buccal apertures.

### (2) Lateral passages.<sup>(3)</sup>

The lateral passages are the openings which are present in the principal transverse septa, serving as channels of communication from one chamberlet to another in longitudinal direction.

### (3) Slits formed by the folding of septa.<sup>(4)</sup>

In *Fusulina*, the more strongly the septa are folded, the smaller becomes the buccal aperture, and in later evolutions of some species, the buccal aperture is apparently absent. And, naturally H.v. Staff gives some illustrations of longitudinal sections of *Fusulinas* which he thinks have no buccal aperture.

We can not see the buccal aperture in a certain longitudinal section,

---

(1) Hayden; *Fusulinidae from Afghanistan*. Rec. Geol. Surv. India, vol. XXXVIII. p. 238. pl. 17, fig. 6.

H.v. Staff; *Anatomie und Physiologie der Fusulinen*. p. 27.

„ ; *Monographie der Fusulinen Teil III*. Paleontographica 59. p. 188.

(2) H.v. Staff; 1910, op. cit. p. 20.

(3) J.S. Lee; *A graphic Method to aid specific Determination of Fusulinoids and some Results of its application to the Fusulinae from the North*, Bull. Soc. Geol. China. Vol. II, no. 3, p. 57.

(4) H.v. Staff; 1910, op. cit., p. 23.

since the median-skeletons, when the septa are strongly<sup>(1)</sup> folded, are either very small or not at all developed.

v. Staff's example (Anatomie und Physiologie der Fusulinen, Pl. II., fig. 2) shows two black points in the median portion of the initial chamber and of the first whorl. These points, in my opinion, represent the median skeletons. And, moreover, it is clear that the septa can not be folded very much at the median portion<sup>(2)</sup> where the movement of the sarcodé is most vigorous. From these considerations we may assume that *Fusulina* represents a type of a single buccal aperture.

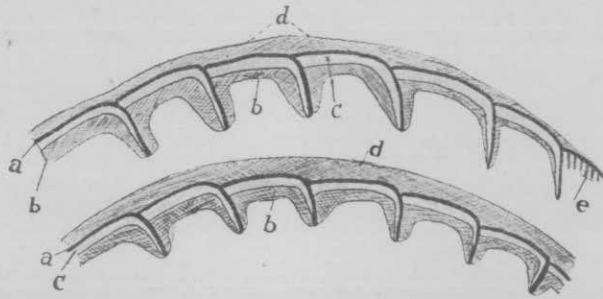


Fig. 1. Shell-wall of *Fusulinella*. Explanation given in text.

### Notes on *Fusulinella*, *Girtyina* and *Schuberteila*.

The genus *Fusulinella* was originally founded by V.v. Möller (die spiral-gewundenen Foraminiferen des russischen Kohlenkalks, p. 101) and was defined as follows:—

“Schale kalkig, frei, symmetrisch, spindelförmig, kugelig oder linsenförmig und aus einer Anzahl spiraler und vollkommen involuter Umgänge bestehend, die Septa verlaufen, in ihrem mittleren Teil ganz gerade, ohne irgend welche Biegungen darzustellen.

Die Schale, d. h. mit ihrer Annäherung zur Windungsaxe, mehr oder weniger gefaltet; diese Fältelung ist aber so gering, dass sie, z. B. mit derjenigen der *Fusulinen*, keineswegs verglichen werden kann. Schalen-

(1) By a strong folding of septa, the chamber is divided into a large number of chamberlets. Therefore, evolution of the septal folding of forms having the single buccal aperture has the same meaning as an addition of a new kind of septa in *Verbeekinae* (forms of multiple buccal apertures).

(2) On account of the presence of the buccal aperture, there is no need of forming more passages of the sarcodé, accordingly in the median part, the septa exhibit less folding. The fact shows that the separation of the type of multiple buccal apertures from that of single ones is very appropriate.

wandungen und Septa entbehren vollkommen der Porenkanäle und erscheinen doppelt. Wie auf der hier beigegebenen Fig. 1. zu sehen ist, bestehen dieselben aus zwei Lamellen, einer dünnen, äusseren (fig. 1. a) und einer verhältnismässig dicken, inneren (fig. 1. b), welche durch einen freien und ziemlich breiten Zwischenraum (c) von einander getrennt sind. Von aussen werden die eigentlichen Schalenwandungen noch von einer ununterbrochen gleichmässigen und zuweilen ziemlich dicken, supplementären Kalkschicht ("intermediate or supplemental skeleton Carp.") bedeckt, die in der Figur durch den Buchstaben (d) bezeichnet ist."

The first species described by v. Möller under the head of *Fusulinella*—which species therefore constitutes the type of the genus—is "*Fusulinella bocki*."

E. Schellwien examined Möller's original sections and gave the following explanation.<sup>(1)</sup>

"Nach Möller zeigt das Gehäuse der Gattung *Fusulinella* einen ausserordentlich complicirten Aufbau, der sich durch das Vorhandensein von doppelten Wandungen und "Interseptalräumen" weit von den *Fusulinen* entfernt. Ich halte es aber nach einer Durchsicht der Moller'schen Originale für wahrscheinlich, dass der Unterschied kein so einschneidender ist. Die von Moller als Interseptalräume gedeuteten Stellen halte ich in den meisten Fällen für das eigentliche Skelett der *Fusulinellen*, d. h. für die Kammerwand und die aus ihr durch Umbiegung hervorgegangenen Septen. Die dunkleren Lagen, welche beide umgeben, sind dann auf Verdickungen zurückzuführen, wie sie bei den *Fusulinen* ausführlich beschrieben wurden, die aber hier viel stärker auftreten und ebenso die ganzen Kammern bekleiden wie sie den Boden des vorhergehenden Umgangs bedecken. Während andererseits die ersten drei bis vier Windungen einfache nicht verstärkte Kammerwände zeigten, die sich ebenso in die Septen fortsetzen."

Lienau approved, on the whole, Schellwien's observation and summarized as follows.<sup>(2)</sup>

1. "*Fusulinella* baut rein kalkige, nicht poröse Schalen."
2. "Die Kammerwandungen sind einfach."
3. "Die Septen entstehen durch Umbiegung der Aussenwand in fast immer rechtem Winkel."
4. "Die Kammern, vor allem die der äusseren Umgänge, sind mit

(1) E. Schellwien: Die Fauna des karnischen Fusulinenkalks, II, *Paleontographica* 44, 1897, p. 260.

(2) Lienau: *Fusulinella*, ihr Schalenbau und ihre systemat. Stellung. *Zeitschr. d. Geol. Gesellsch.* 1898.



dichter, supplementärer Kalkbedeckung ("Verdickungen" Schellw.) ausgekleidet, zwischen der die dünnen, zarten Septen wie helle Bänder verlaufen."

5. "Kanäle sind nicht vorhanden."

Schellwien and Lienau are perfectly correct in the interpretation of the deposition-layers found on both sides of the spiral wall and septa, and of the absence of a canal. However, I can not accept their conclusion that the shell-wall is compact, although many later investigators have also the same view.

The detailed account will be given on later pages.

Douvillé in his treatise "Les Calcaires Fusulines de l'Indochine" gives the following diagnosis<sup>(1)</sup>:—

"*Fusulinella* Möller, 1877; test compact, imperforé, probablement finement arénacé, cloisons à peu près planes percées d'une ouverture médiane étroite et un peu allongée, se traduisant sur les échantillons usés par une bande lisse équatoriale. La forme est ou lenticulaire ou sphéroïdale. Type: *Fusulinella bocki* Möller."

With regard to the structure (not the substance) of the shell-wall of *Fusulinella*, he maintains the view of Schellwien and Lienau. But, as already noticed by Staff and Wedekind,<sup>(2)</sup> Douvillé's type *Fusulinella bocki* is fusiform.

H. v. Staff in his treatise "Beiträge zur Kenntnis der Fusuliniden" gives the following description.<sup>(3)</sup>

*Fusulinella* Möller em. Staff.

"Schale rein kalkig. Die Sagittalebene teilt die Schale in zwei fast völlig symmetrische Hälften. Gestalt seitlich zusammengedrückt, linsenförmig bis fast kugelig. Die Aufrollungsachse ist der kürzeste Durchmesser. Fältelung meist sehr gering. Eine deutliche Mundspalte wird häufig durch zwei derbe Reifen eingefasst. Ohne erkennbares Maschenwerk der Wand. Der Gesamthabitus erinnert sehr an *Endothyra*"

And he adds the following remark on *Fusulinella bocki* Möller. "v. Möller's *F. bocki* Moll., die, wie bereits Schellwien erkannt hat, durchaus zu den Fusulinen gerechnet werden muss. Gerade diese Form hat aber v. Moller seiner Diagnose des Genus zu Grunde gelegt! Ich hebe deshalb hier ausdrücklich hervor: Taf. 14 (Spir. gew. For. 1878) zeigt einen

(1) Douvillé. Les Calcaires Fusulines de l'Indochine. Bull. Soc. Géol. France, 4 Sér. Tome VI, p. 576.

(2) H.v. Staff and Wedekind. 1910. op. cit. p. 108.

(3) H.v. Staff. 1909, op. cit. p. 486.

Erhaltungszustand, in dem die Kammerwände und Septen hell erscheinen und von einer dunklen Versteinerungsmasse umgeben sind.<sup>2)</sup>

So far as I am aware, there is no such statement given by Schellwien in any of his papers. Schellwien's *Fusulina bocki*<sup>(1)</sup> is the same species as that of v. Möller and not *Fusulinella bocki* v. Möller, while Möller's *Hemifusulina bocki* is *Fusulina minima* of Schellwien. Then there is no reason to restrict *Fusulinella* to the lenticular or sphaeroidal type. If the shape—whether the axial length is the longest or the shortest diameter—has the taxonomic value for the generic separation, the type<sup>(2)</sup> of lenticular or sphaeroidal form must be separated from *Fusulinella* as a new genus.

Therefore it is clear that Staff's description above quoted is based on a quite different type from the original specimen.

In their associate work, H. v. Staff and Wedekind thoroughly revised the hitherto known classification of *Fusulinidae* and raised *Fusulinella* to a subfamily which includes two genera, *Fusulinella* and *Schubertella*. The synopsis of diagnosis was already given.

On the above occasion they also fell into the same error as Staff did. They proposed the new genus *Schubertella*, founded on a specimen from Spitzbergen, but the absence of figures illustrating the minute structure and the orientated sections may sufficiently explain why the type has not been recognized by subsequent observers.

The type of the genus, *Schubertella transitoria*, is described as resembling *Fusulina* in shape and general structure, with this difference that the shell-wall is only a thin compact layer. In the absence of a more detailed account of the minute structure, it is difficult, as remarked above, to decide positively the true relationships of this singular type.

I have, however, examined several thin sections of specimens (Pl. IV, fig. 8), for which I am indebted to Professor Yabe, from the Carboniferous limestone of Spitzbergen, which contains besides *Fusulina* a few fusiform *Fusulinella*-like forms which seem to be congeneric with *Schubertella*. But as I have not yet examined the original section, this must be left for the present as an open question.

The genus *Girtyina* was created by Staff for two North American *Fusulinas* of the Lower Permian which have been described as belonging to *Fusulinella* in Schellwien's manuscript. The distinctive features in the diagnosis of the genus, as given by its founder, are the strong folding of septa and symmetrical earlier volutions. According to Staff's description,

(1) E. Schellwien, Monographie der Fusulinen, Teil I. Paleontographica 55, 1908-1909, p. 166.

(2) To the type I will give the new generic name *Staffella*.

its shell-wall is compact like that of *Fusulinella* (of lenticular form), on the other hand the illustrations show quite a different aspect. As more or less clearly shown in Staff's photographs of *Girtyina schellwieni* and *G. ventricosa* (Paleontographica, 1912. Taf. XVIII, Figs. 1, 2, 5, 7-9), the shell-wall and septa are thickly covered with the deposition-layers which are distinct from the middle light colored band (Zwischenraum), and directly under the outside deposition layer, there is a distinct black line (more or less weakened in the photographs) which enters into the septa.

This line exactly corresponds to the "Dachblatt" (a) of *Fusulinella bocki* figured by Möller. Then, if the wall of *Girtyina* is exactly the same in structure as that of *Fusulinella*, as maintained by Staff and Schellwien it seems not appropriate to suppose, as was thought by many of the earlier observers, that the shell-wall of *Fusulinella* is simple and compact.

On the other hand, Möller's illustrations of *Fusulinella* show quite a complicate structure of its shell-wall (compare fig. 2). I agree with his opinion excepting the radial septal canals.<sup>(1)</sup> Möller interpreted the middle light colored portion which is in direct communication with the septal radial canal, as a space of no structure, and the internal thick dark layer as the inner layer corresponding to the external thin layer (a).

That the internal dark layer is a subsequent exogenous deposit formed on the inner side of the shell-wall has already been pointed out by Schellwien and Lienau. Then, there is no ground for supposing the middle portion as originally to be a mere space of no structure, since the secondary deposition can not be formed in a free space. Therefore, it is most probable that the middle light colored portion is in some way comparable with the layer of the mesh-work of *Fusulina* proper. But I did not succeed in recognizing the definite mesh-work in the shell-structure of *Fusulinella*, though I do not doubt it can be seen in well preserved specimens.

The obscurity of the mesh-work must be ascribed either to its too delicate structure or to disappearance resulting from replacement by light colored carbonate of lime after the deposition layers were formed.

On the whole, the wall and septa of *Fusulinella* are composed primarily of thin, external, non-porous lamella and the mesh-work, and later they are covered by the exogenous deposition layer (see Pl. I, figs. 1, 4 and 6).

But it must be borne in mind that the deposition layers are best deve-

---

(1) I collected various forms of *Fusulinella* Möller in the Akiyoshi limestone, among which a form identifiable with *Fusulinella bocki* was observed, the general structure of its wall being quite similar to that of the original form according to a thin section.

loped in the median portion of the shell, gradually lessening towards the extremities<sup>(1)</sup> (Pl. I, figs. 2, 4 and 5).

### Neofusulinella Deprat.

Deprat's original diagnosis of *Neofusulinella* has already been given. Judging from his illustrations, the group undoubtedly consists of two types. The one<sup>(2)</sup> type is represented by *Neof. schwagerinoides*, *Neof. praecursor*, and *Neof. lantenoisi* which have the wall and septa more or less uniformly covered with the deposition layers quite similar to those of *Fusulinella*, so that they may be considered as belonging to that genus. The other type<sup>(3)</sup> is represented by unusually small forms such as *Neof. giraudi*, *N. minima* and *N. elongata*, which have evidently no internal deposition-layers and their general structure is undoubtedly similar to that of *Fusulina*. Therefore it seems doubtful if *Neof.* can be regarded as having the rank of a genus.

As to the relation of *Neofusulinella* to *Fusulinella* (of lenticular type), Deprat says<sup>(4)</sup>:

“ Dans ce genre (*Neof.*) la section transversale rappelle tout à fait une section de *Fusulinella*, mais la section longitudinale en diffère complètement par son allongement suivant l'axe d'enroulement, caractère qui la sépare de *Fusulinella*.”

Judging from these words we can easily understand that he also accepts Douvillé's diagnosis of *Fusulinella* and considers the type specimen to be really sphaeroidal or lenticular in form, and it seems that he pays no attention to the original work of v. Möller. (He described a new species, *Fusulinella quadrata*, which is probably identical with *Fusulinella sphaeroidea* Möller, because their rate of growth and peculiar quadrate form are quite similar).

From what is said above it is evident that Deprat, in diagnosing *Fusulinella*, also falls into the same error as Staff and I am disposed to think that *Neofusulinella* is an aberrant genus.

As to the distinction between *Neofusulinella* and *Schwagerina*, Deprat gives the following explanation.

---

(1) As clearly shown in the photograph (Pl. I, fig 4) the deposition layers are not developed in the last whorl. It is also to be noticed that the deposition-layers are by no means special to *Fusulinella* and *Girtyina*. In rare cases, they are formed partly on the shell-wall and septa of *Fusulina*, and the result is the disappearance or obscurity of the mesh-work.

(2) Deprat. 1913. op. cit. pp. 40-43.

(3) Deprat. 1915. op. cit.

(4) Deprat. 1913. op. cit. p. 40.

“Au premier abord, on serait tenté d’y voir des Schwagérines allongées comme *Schwagerina fusiformis* Krotow ou *Schw. fusulinoïdes* Schellwien, mais l’ouverture buccale unique le sépare formellement des Schwagérines. De plus, J’ai pu saisir, comme je le montrerai, la transition entre *Neof.* et *Schw.* par l’intermédiaire de *Schwagerina prisca* Deprat que j’ai décrite dans mon précédent Mémoire. (Étude des Fusulinidés de Chine et d’Indochine et Classification des Calcaires à Fusulines. Pl. IV, figs. 1-4).”

But *Schwagerina fusiformis* Krotow as well as *Schwagerina fusulinoïdes* Schellwien has a simple buccal aperture as already discussed in detail by Staff. Deprat’s intermediate form between *Schwagerina* and *Neofusulinella*, viz. *Schwagerina prisca*,<sup>(1)</sup> evidently belongs to *Fusulinella* Möller, and, judging from his illustrations, its buccal aperture is simple. Consequently there is no peculiarity, by which *Neofusulinella* can be distinguished from *Schwagerina*.

On the whole, the facts above stated seem to render the maintenance of the genus *Neofusulinella* quite unnecessary. And if it is necessary to preserve it, I would propose to restrict the name to the group of *Neof. giraudi* which is distinguished from other genera by its extremely small size, and *Staffella*-like asymmetrical earlier evolutions.

### Schwagerina and Verbeekina.

The genus *Schwagerina* was first defined by v. Möller in 1877. As already noticed by Schellwien,<sup>(2)</sup> the separation of *Fusulina* from *Schwagerina* (*Schwagerina princeps* type) is not tenable, because there are several intermediate forms.

Recently H. v. Staff considers<sup>(3)</sup> *Schwagerina verbeeki* as quite different from *Schwagerina princeps*, based on the fact that the general mode of the evolution of *Verbeekina* (*Schwagerina*.) *verbeeki* is much like that of *Staffella* (*Fusulinella*), while he considers *Schwagerina princeps* as a specialized form of *Fusulina* (*Schellwienia*).

On the other hand, Deprat insists that both types are to be comprised under the genus *Schwagerina*, on the ground that the shell-structure is similar in both, which invariably have the multiple buccal apertures.

The divergence of opinions results from the interpretations of the black points (basal skeletons) observed in the longitudinal section of *Schwagerina*.

(1) Deprat. 1912. op. cit. Pl. IV. figs. 10-14.

(2) E. Schellwien, Paleontographica. op. cit. p. 257.

(3) H. v. Staff. 1909. op. cit. p. 469.

The following quotation<sup>(1)</sup> is the interpretation given by Staff. (See fig. 3).

“Ist der Untersaum des flachgewellten Vorhanges, den bei dieser Gruppe (*Schwagerina princeps* und *Verbeekina verbeeki*) das einzelne Septum darstellt, ausserdem noch etwas regelmässiger gefältelt, so dass er auf der Wand der nächst engeren Kammer in einer zierlichen Wellenlinie aufliegt (die natürlich ab und zu die zur Kommunikation nötigen Öffnungen freilässt), so müssen neben den Schatten auch kleine, klar umrissene Halbbögen auftreten, wenn der Schnitt diesen Teil des Septums trifft. Wir haben hier nämlich folgende Möglichkeiten:

(A) Der Schnitt trifft das Septum überhaupt nicht.

(B) Er tangiert das Septum und schneidet seinen vor oder rückgebogenen Untersaum.

(C) Er schneidet nur den letzten Teil des Untersaums.

Nach dem gesagten ist es nun vollständig einleuchtend, dass das Bild, das Fig. 2 B zeigt, nur entstanden sein kann durch eine Schliff-lage, wie die Fig. 2 A' veranschaulicht. (Die kleinen Buchstaben der Bilder entsprechen einander.) Auch der helle, die Wand (a) und den “Schatten” (b) so oft trennende Streifen (e) ist seiner Entstehung nach leicht verständlich.”

His interpretation is quite justified if it is restricted to the black points seen in the longitudinal section of *S. princeps*, but concerning those observed in the longitudinal section of *Verbeekina verbeeki*, I am of quite a different opinion.

H. v. Staff observed the absence of the basal skeletons (reifenartige Basalskelette) in the earlier volutions of *V. verbeeki* and a regular

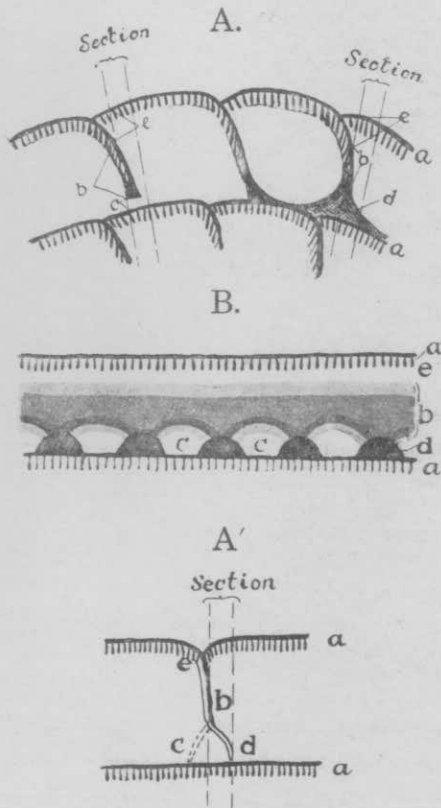


Fig. 2. Ideal sections of *Verbeekina verbeeki* for explanation of basal skeletons seen in longitudinal section. A', B, given by H. v. Staff. A, given by author.

(1) H. v. Staff. 1909. op. cit. p. 470.

arrangement of the passages of the sarcode, and he considered that these phenomena result from the regular folding of the lower border of the septa. But this conclusion does not seem to be quite correct.

If the basal skeletons are formed secondarily on both sides of the communication-passages of the sarcode, then the deposition would be limited to the anterior and posterior portions of the basal part of the septa, and it is natural to consider that the movement of the sarcode is more vigorous in the later chambers, and at a certain stage, its degeneration<sup>(1)</sup> takes place resulting in the formation of basal skeletons; therefore the deposition would be more in the later whorls. This consideration exactly coincides with the following observations.

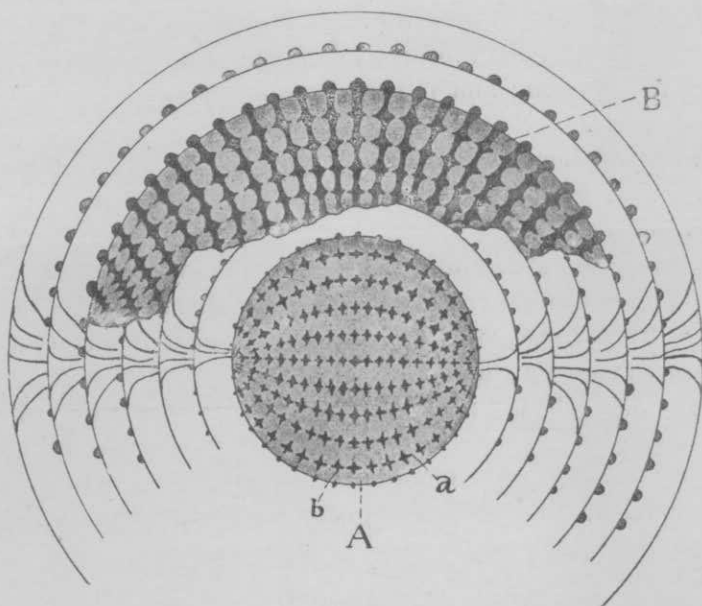


Fig. 3. Axial section of broken *Verbeekina ver eeki*, showing minute internal structure. (Compare Taf. VII, fig. 7. in H. v. Staff: Beiträge zur Kenntnis der Fusuliniden.) a. lower end of septa. b. basal skeleton. c. buccal aperture. Drawn from Akiyoshi specimen.

(1) As shown in textfigure 3 the inner side of the B whorl is grooved crosswise; the broken-lines are the lower border of the septa and the full lines represent the basal skeletons which are very distinct at the intersection with the former. On the other hand, in the A whorl, the (b) lines which intersect vertically the (a) broken lines or the septa are also broken

(1) H. v. Staff. Anatomie und Physiologie der Fusulinen. 1910. p. 59.

on account of lesser development of the basal skeletons ; in consequence, the small crosses show a regular arrangement.

(2) In the transverse section of *V. verbeeki*, a certain number of the principal septa do not reach the wall of the previous whorl ; and the edge of almost all the septa are directed outward. (Compare the transverse section of *V. verbeeki* with that of *Schwagerina yabei* Staff.)

(3) In the later whorls, we can always recognize more or less well developed black points in the longitudinal section.

(4) In a tangential section of a relatively later whorl (Pl. I, fig. 3), the basal skeletons are vertically intersected by the septa. (Compare with the tangential section of *Doliolina claudiae*. Pl. II, figs. 1 and 2).

Generally speaking, (a) the septa of *V. verbeeki* are almost plane and pierced by multiple buccal apertures, and they do not exhibit such strong foldings as assumed by Staff in his explanation of the black points seen in the longitudinal section ; and (b) the basal skeletons are well developed in the later whorls.

This interpretation is sanctioned by Hayden<sup>(1)</sup> who gives the following discussion on Schellwien's opinion concerning the separation of *Schwagerina* from *Doliolina*.

“The exogenous stalagmitic material, which I regard as merely an extension of the basal part of the primary meridional septum, constitutes the so-called “basal skeleton” of *Schwagerina* and it is on account of the varying forms taken by this outgrowth that Schellwien split up Möller's genus *Schwagerina* into two ; his *Doliolina* as represented by his type *D. lepida* Schwager, being merely a form in which the exogenous outgrowth from the base of the primary meridional septum is very conspicuous.

This character which is clearly illustrated in the figures given by Schwager, is according to my opinion, not of subgeneric value, especially as it is generally admitted that there is a perfect transition between *Schw. princeps* (Ehrenberg) and *Doliolina lepida* Schw. My specimens of Afghan *Schwagerina* have even led me to doubt the validity of *Schw. verbeeki* Geinitz as a species distinct from *Schw. princeps*.”

As already noticed by v. Staff,<sup>(2)</sup> what Hayden took for *Schwagerina princeps* is not a true *Schwagerina princeps*. His illustrations (Plate 18, figs. 1-6) show decidedly the characteristics of *Verbeekina verbeeki* and not of *Schwagerina princeps*.

Therefore, Hayden's comment on Schellwien's opinion above given has no value at all, however, his explanation of the basal skeletons of his

(1) Hayden. Fusulinidae from Afghanistan. Rec. Geol. Surv. India, Vol. 38. p. 242.

(2) H. v. Staff. Paleontographica 59. 1912. p. 187.



*Schw. princeps* (= *Verbeekina verbeeki*) is correct and coincides with my opinion.

Hence, it is very clear that the type having a single buccal aperture must be strictly separated from the specialized type having multiple buccal apertures.

In conclusion, I will here give a paragraph<sup>(1)</sup> from Möller's original diagnosis, which is very instructive in this connection:

“Die Septa sind gerade, oder etwas gekrümmt. An ihrem unteren Rande sind die Septa mit einer halbmondförmigen, aber niedrigen Medianöffnung versehen, wobei eine ähnliche Öffnung gewöhnlich auch in der Endwand der Schale sich befindet.”

### Note on *Doliolina lepida*.

*Doliolina lepida* was originally described by Schwager under the name of *Schwagerina lepida* founded on specimens from Akasaka, Japan, and in the year 1889 the new generic name *Möllerina* (genotype *Doliolina lepida* Schwager) was given by Schellwien, but afterwards *Möllerina* was found to be preoccupied, and the name was changed to *Doliolina*.

The shell-wall of the species is generally believed to be composed of a thin lamella and fine mesh-work like that of the genus *Fusulina*. And Staff<sup>(2)</sup> gives a good text-figure illustrating the shell structure of *Doliolina lepida*, in which the mesh-structure slightly extends down over the basal skeletons like the false septa of *Neoschwagerina*. But, though I carefully examined hundreds of sections of *Doliolina lepida* from Akasaka and several other localities, I could not recognize such extension nor even the mesh structure, and so far as my examination goes, it seems to me that Staff's figure shows a section cut nearly tangential to the primary septa, and the stalactitic extensions, which are interpreted as primitive meridional septa formed by elongation of the mesh-work, probably represent a part of septa.

On the whole, the structure of the shell-wall<sup>(3)</sup> of *D. lepida* is the same as that of *Sumatrina annae*:— the shell-wall is composed of a compact layer only. Accordingly, I propose to divide the hitherto known *Doliolina* into two:— the genotype *Doliolina lepida* and the type of *Doliolina*

(1) V. v. Möller. op. cit. p. 69.

(2) H. v. Staff. 1909. op. cit. p. 477.

1910. op. cit. p. 21. fig. 10.

(3) In the table given by H. v. Staff (die Anatomie und Physiologie der Fusulinen, p. 21), as to whether the mesh structure is developed or not in *Doliolina* is left an open question.

*claudiae*, the shell-wall of the latter being composed of the thin lamella and mesh structure. The latter includes such species as *Doliolina compressa* and *D. aliciae* Depr., etc. and has a close relation with *Verbeekina verbeeki* on the one hand and with *Cancellina primigena* and *N. craticulifera* on the other.

### Cancellina Hayden, Neoschwagerina Yabe and Yabeina Deprat.

In 1910, Hayden<sup>(1)</sup> published an important paper on the structure and affinities of *Fusulinidae*. In this paper, the author not only discussed the minute structure and systematic position of the genus *Fusulina*, but also gave a description of five species from the Permian rocks of Afghanistan. Among the species described, there is one new species which is said to be an intermediate form between *Doliolina lepida* and *Neoschwagerina craticulifera* and for this species a new subgeneric name, *Cancellina*, was created.

Hayden, after having discussed Yabe's *Neoschwagerina*, says:<sup>(1)</sup>

"I should be loth to discard Yabe's apposite term *Neoschwagerina*, but should its employment, in a sense slightly wider than that implied by its original definition, be likely to lead to confusion, I would propose the name *Cancellina*, as a subgeneric term for species with equatorial, in addition to meridional septa."

The only really distinctive feature of *Cancellina* from *Neoschwagerina* s. str., as given by Hayden, is the presence of the secondary meridional septa, and in the classification of *Fusulinas*, if we lay much stress on the evolution of septa, Hayden's view is very appropriate.

Recently Deprat described two species of *Doliolina*, *Doliolina neoschwagerinoides* and *D. schellwieni*, of which the former is quite similar to Hayden's above mentioned species with which it may possibly be identical, and has two sets of septa, while the latter, though the general outline resembles that of the former, has not only three kinds of septa, primary- and auxiliary-meridional and primary-equatorial, but in later whorls the auxiliary equatorial septa are intercalated between a pair of the primary ones, and all the septa become thickened downwardly, like those of Deprat's *Yabeina*, which has also four kinds of septa. Therefore *D. schellwieni* is not a *Doliolina* s. str.

Deprat's diagnosis<sup>(2)</sup> of his subgenus *Yabeina* is :

(1) Hayden. op. cit. p. 244.

(2) Deprat. op. cit. 1914. p. 35.

“Groupes de poutrelles individualisées à leur base, mais soudées à leur partie libre ; formant de fausses cloisons allongées. Côtes basales minces, ouvertures latérales entre la cloison transverse et la côte basale. Loge initiale toujours excessivement petite.”

And as the type of this genus, he takes a single species, *Yabeina inouyei*, from the Akasaka limestone. He considers the subgenus as an intermediate form between *Neoschwagerina* and *Sumatrina* of *multiseptata*-type. But his *Yabeina inouyei*, as shown by me, is exactly identical with Yabe's *Neoschwagerina globosa* and has auxiliary meridional septa, to which he pays no attention in subgeneric separation. On the other hand, Hayden says concerning the auxiliary septa<sup>(1)</sup>:-

“If, however, we follow out Yabe's principle of classification to its logical conclusion, we ought to include in *Neoschwagerina* only forms with primary and auxiliary meridional and primary equatorial septa and create a new subgenus to receive his species *Neoschwagerina globosa*. We should also have to retain as a subgenus Volz's genus *Sumatrina*, which is defined as embracing “spindelförmige *Fusuliniden* mit einem aus je 2-4 Längs- und Querreifen bestehenden Dachskelett.” The result of this minute subdivision is to reduce the subgenus to the rank of a species.”

Now if we retain Hayden's new subgenus *Cancellina*, *Yabeina*, possessing four kinds of septa, must also be retained and Deprat's *Doliolina schellwieni*, above mentioned, must be brought under either *Neoschwagerina* or *Yabeina*.

*Sumatrina* is generally believed to have a compact wall and septa without the mesh-work. But recently Deprat described a large globose *Sumatrina multiseptata*, which resembles more *Yabeina* than *Sumatrina annae* in structure.

The two conspicuous features in the structure of *Sumatrina multiseptata*, as displayed in transverse and longitudinal sections, are the slender septa and the auxiliary meridional septa ; the slender appearance of the septa is due to the fusion of the mesh-work and thickening of the lower part. In this point, it is nearly related to *Yabeina*. Deprat described the form as having no mesh-work in the shell-structure, but it seems to me that his textfigures show a different aspect from the photographs. In examining several thin sections of the specimens found in Akasaka and elsewhere, the shell-wall has a pretty short mesh-work, and there are various points in its structure which seem quite incompatible with its being a *Sumatrina*.

The most characteristic feature presented by *Sumatrina* is its shell-

---

(1) Hayden. op. cit. p. 241.

wall having no mesh-work as above described and this is the only character which justifies its being brought to the neighbourhood of the species *Doliolina lepida*.

### The Evolution of the Advanced Forms.

It is generally believed that *Fusulina* arose from *Endothyra* (Pl. I, fig. 9) and evolved along widely divergent lines. During the Lower Permian these forms attained the climax or acme of their development, and at the close of the Permian all of them became extinct. From the primitive radical stock *Staffella* (Pl. I, fig. 7), there arose such forms as *Fusulinella*, *Girtyina* and *Fusulina* (*Schellwienia* and *Schwagerina*), which do not differ greatly from *Endothyra* in their earlier (younger) whorls. The changes they underwent mainly affected the form and the septa.

In the group of *Fusulina*, the series of changes which the septa underwent exhibit a rough parallelism to that of the changes of shape;—generally the longer the form grows, the more intense, the septal foldings become and, therefore the passages of sarcode increase.

*Verbeekina* is probably derived from *Endothyra*, because in its earliest developmental stage it resembles *Endothyra*, but later a great change in appearance is produced by the septa which are pierced by the multiple buccal apertures built along the inner border of the septa, and as the result, the basal skeletons are introduced as a new structural element.

The earliest member of the hitherto known *Verbeekina* is *Verbeekina claudiae* (Deprat) (Pl. II, fig. 1, 2). It occurs, abundantly associated with *Fusulina vulgaris* in the *Schwagerina* zone of the Akiyoshi limestone.

In *V. claudiae* after having passed an *Endothyrian* stage of development, basal skeletons are built. In *Cancellina primigena* (Pl. II, figs. 3, 4, 5, 6, 7), a specialized form of *Verbeekina claudiae* both *Endothyra* and *Doliolina* stages may be recognized, but they are quickly replaced by one in which the primary equatorial septa appeared and the chambers became divided into chamberlets.

The next member is *Neoschwagerina schellwieni* (Pl. II, figs. 8, 9, 10) which is a more advanced form, having very minute mesh-work. In it, new false meridional septa are formed and all kinds of septa become eminently thin at the upper portion and are more or less thickened at the free lower border. Moreover, in later whorls, a new false septum appears between a pair of the equatorial septa. This species is characteristic of the lower strata of the Upper Permian.

The genus *Sumatrina* (Pl. II, figs. 11, 12) is very characteristic of the

uppermost level of the *Fusulina* limestone, so much so that it is called the *Sumatrina* subzone.

It is the latest and most advanced of the Paleozoic Foraminifera. In it, the form is much elongated, the mesh-work is absent and the numerous false septa are developed.

*Neoschwagerina craticulifera* (Pl. III, fig. 1) is the most common species of the Lower Permian *Fusulina* limestone. It is derived from *Verbeekina claudiae*. Its earlier whorls have the same structural elements as *Verbeekina*, but soon the equatorial septa appear and then meridional false septa enter as a new element. Considering the structural elements, *Neoschwagerina craticulifera* appears to be a more advanced type than *Cancellina primigena*, which appeared, according to Deprat, in the Middle Permian. From *Neoschwagerina craticulifera*, there arose *Neos. multicircumvoluta*, which occurs at a level somewhat higher. This species closely resembles the former, with the exception that it has thinner septa.

At the lower level of the Upper *Fusulina* limestone, a large *Neos. margaritae* (Pl. III, fig. 4) occurs, which exhibits a further advanced phase, and in its later whorls, two or more auxiliary septa are intercalated between a pair of the primary ones.

In *Neoschwagerina (Yabeina) globosa* (Pl. III, fig. 5), the most advanced member of this line of changes, false equatorial septa are introduced between a pair of the primary equatorial ones and at the same time false meridional septa increase in number, consequently, all of septa become more slender and the layer of the mesh-work very thin.

Sphaeroidal *Verbeekina verbeeki* (Pl. I, fig. 3) and complanate nautiloidal *V. compressa* are the specialized forms of *V. claudiae*. Both have highly vaulted chambers and relatively thin wall.

The genealogical tree of the family *Fusulinidae* is given in page 22.

### Dimorphismus.

This question has already been discussed by Hayden<sup>(1)</sup> and H. v. Staff,<sup>(2)</sup> and the following words of Staff seem to be generally accepted:

“Bei *Fusulina* tritt ein mehr oder weniger scharf ausgeprägter Dimorphismus auf. Meist überwiegt die makrosphärische (wahrscheinlich ungeschlechtliche) Generation. Im allgemeinen ist diese in den ersten

(1) Hayden; op. cit.

(2) H. v. Staff. Ueber Schalenverschmelzungen und Dimorphismus bei *Fusulinen*: Sitzungsber. Ges. Naturf. Freunde Berlin, 1908. Anatomie und Physiologie der Fusulinen. p. 74. *Paleontographica* 59. 1912, pp. 189-191.

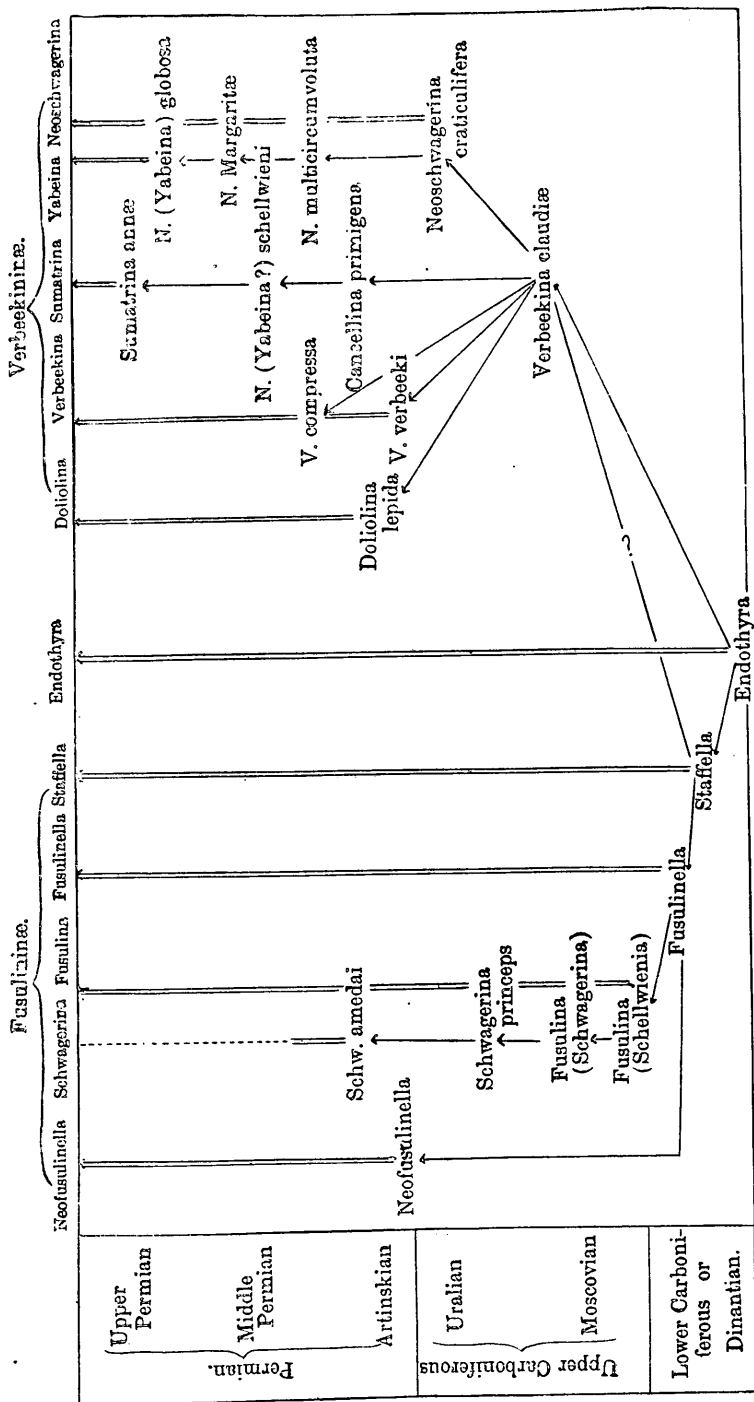


Table showing phylogenetic relation of genera of Fusulinidae. Double lines represent vertical distribution.

Umgängen weiter gewunden, als die Formen der gleichen Art mit mikrosphärischer Anfangskammer."

"Bei *Schwagerinen* und einigen geologischen jüngeren *Fusuliniden* scheint die mikrosphärische Form vorzuherrschen."

Hayden considered Yabe's *Neoschwagerina craticulifera* (Pl. I, fig. 4. A contribution to the genus *Fusulina*.) as a megalosphaeric form, but what Yabe took for *N. craticulifera*<sup>(1)</sup> is not the true *Neos. craticulifera*. It has two or more false meridional septa between a pair of primary septa and all the septa are more slender compared with those of typical *N. craticulifera*. It may be either *Neoschwagerina douvillei*<sup>(1)</sup> or *N. megasphaerica*, and may possibly be a megalosphaeric form of *Neoschwagerina margaritae*.

*N. megasphaerica* (Pl. III, fig. 7) has the same structural elements as *N. douvillei*, but it has a very large initial chamber attaining 0.8 mm. or more in diameter,—almost two or three times as large as that of *N. douvillei* (Pl. III, fig. 6, Pl. IV, fig. 5). The geological horizon of both is almost the same and when they are found together, *N. douvillei* seems to be very abundant, and a series of gradual changes in size of the initial chamber can be traced. Therefore, both forms are probably the same species and would be the megalosphaeric form of *N. margaritae*, which in an adult form is much larger than the former two.

In the case of a more advanced form *N. (Yabeina) globosa* (Pl. III, fig. 5), its dimorphism presents the same phenomena as *N. margaritae*. Form B is *N. (Yabeina) globosa* which has a very small initial chamber (0.005 mm. in diameter) and numerous whorls (more than 20 or more in adult stage) and grows to a larger size.

Form A is probably *Yabeina multiseptata* (Deprat) or *Yabeina hayasakai* Ozawa (Pl. III, fig. 9). It is generally smaller than the form B in the size of the shell and has a larger initial chamber ranging from 0.3 mm. to 0.8 mm. or more. In other respects, it is similar to *Yabeina globosa*.

The form possessing an initial chamber of 0.3 mm. or so in the diameter is *N. (Yabeina) shiraiwensis* (Pl. III, fig. 8, Pl. IV, figs. 1, 2, 3) and corresponds to *N. douvillei*, A-form of *N. margaritae*, and the form with a larger initial chamber (0.8 mm. or so in the diameter) seems to correspond to *N. megasphaerica*.

### Classification of Fusulinidae.

The following is a new classification of *Fusulinidae* as proposed by me.

---

(1) Y. Ozawa, op. cit. p. 368.

**Family *Fusulinidae* v. Möller.**

A. Subfamily *Fusulinidae* v. STAFF-WEDEKIND em. OZAWA.

Shell lenticular to fusiform. The shell-wall and septa consist essentially of the median lamella ("Dachblatt" or "lame spirale") and mesh structure ("Wabenwerk" or "réseau alvéolaire"), but a primitive form has often deposition or supplementary layers on both sides of the wall as well as of the septa. Mesh-work is often obsolete. Buccal aperture single. Carboniferous-Permian.

Genus *Staffella* n. gen.

Genotype *Staffella sphaerica* v. Möller.

Synonym: Staff's *Fusulinella*, Deprat's *Fusulinella* and v. Möller's *Fusulinella* (ex parte).

Shell lenticular or sphaeroidal. The axis of the volutions is the smallest diameter. Shell-wall composed of median lamella, alveolar structure (Möller's "Zwischenraum") and deposition layers (Möller's "innere Lamelle" and "supplementäre Kalkschicht") of which the last is often indistinct or obsolete. Septa almost plane and pierced by a relatively large single buccal aperture. Carboniferous-Permian.

Genus *Neofusulinella* DEPRAT (ex parte).

Shell globular or fusiform. The longest diameter lies in the axis of the whorls. Earlier volutions sphaeroidal and asymmetrical. Shell-wall thin and mesh-structure often obsolete. Septa almost plane. Buccal aperture large. No septal perforation.

It is an advanced genus of *Fusulinella*. Carboniferous?-Permian.

Genus *Fusulina* FISCHER v. WALDHEIM.

Shell globular, fusiform or cylindrical. Earlier volutions almost symmetrical. Shell-wall composed essentially of thin lamella and alveolar structure. Deposition layers either developed or not. Septa strongly folded or almost plane. Septal perforation often present. We may distinguish three subgenera.

Subgenus *Fusulinella* v. MOELLER.

Synonym: *Neofusulinella* Deprat (ex parte).

Shell fusiform. Deposition layers well developed. Mesh-work obsolete. Septa strongly folded or almost not at all. No septal perforation.



Staff's genus *Girtyina* is included in this genus.

Subgenus *Schellwienia* v. STAFF-WEDEKIND.

Shell globular, fusiform or cylindrical. Mesh-work generally distinct. Deposition layers often partly developed. Septal perforation present or not.

Subgenus *Schwagerina* MOELLER em. v. STAFF.

To the detailed diagnosis of the genus by v. Staff-Wedekind I have little to add.

*Schwagerina* has a single buccal aperture and the lower border of the septa of *Schwagerina princeps*, according to v. Staff, is strongly folded. On this account, *Schellwienia* and *Schwagerina* are often confounded.

B. Subfamily *Verbeekinae* v. STAFF-WEDEKIND em. OZAWA.

Shell sphaeroidal or fusiform. Shell-wall thin, composed essentially of thin lamella and mesh-work. In the specialized forms, *Sumatrina* and *Doliolina*, the mesh-work is absent. Structure of the primary septa similar to that of *Fusulina*. Septa not folded at all. Buccal aperture multiple and consequently basal skeletons well developed. No septal perforations. Upper Carboniferous-Permian.

Genus *Doliolina* SCHELLWIEN.

Subgenus *Doliolina* SCHELLWIEN. em. OZAWA.

Subgenotype *Doliolina lepida* (Schwager).

Shell cylindrical. Shell-wall thin, composed of compact thin lamella only. No deposition layers. Basal skeletons well developed. Primary septa only. Age Permian.

Subgenus *Verbeekina* v. STAFF.

Subgenotype *Verbeekina verbeeki* (Geinitz),

Shell, sphaeroidal to fusiform. Earlier volutions Endothyrian. Shell-wall composed of thin lamella and mesh-structure. Basal skeletons indistinct in earlier whorls. Upper Carboniferous-Permian.

Genus *Neoschwagerina* YABE.

Shell globular or fusiform. Volutions numerous, generally more than ten. Earlier volutions sphaeroidal and closely resembling those of the subgenus *Verbeekina*.

Transverse septa and lateral passages developed. False septa present or not. Shell-wall composed of thin lamella and mesh-work. Four subgenera may be distinguished. Age Permian.

Subgenus *Cancellina* HAYDEN.

No false septa. Subgenotype *Cancellina primigena* Hayden.

Subgenus *Neoschwagerina*, s. str.

Three kinds of septa usually developed, viz., primary meridional, auxiliary meridional and primary equatorial. Auxiliary equatorial septa generally absent. Age Permian.

Subgenus *Yabeina* DEPRAT.

Four kinds of septa developed, viz., besides those found in *Neoschwagerina* s. str. there is a fourth, auxiliary equatorial. The septa compared with those of *Neoschwagerina* are more delicate; their end usually swells out so that they resemble in general appearance those of *Sumatrina*.

Subgenus *Sumatrina* VOLZ.Subgenotype *Sumatrina annae* Volz.

Volz's diagnosis is very detailed and I have little to add. Central chamber sphaeroidal and its wall composed of median lamella and alveolar structure, which latter is not visible in the shell-wall. Four kinds of septa well developed.

Remarks :— Deprat's new genus *Palaeofusulina* is here not mentioned, because it is not represented in my collection. But judging from his illustrations, it may be either Staff's *Girtyina* or *Fusulina* s. str.

Quite recently J. S. Lee described a new genus *Grabauina*<sup>(1)</sup> which, according to him, is distinguished from *Fusulina* by having the massive septa in first three or three and half volutions as in *Fusulinella*.

But so far as his textfigures of the genotype *Grabauina disca* is concerned, the earlier volutions are symmetrical and closely resemble those of *Fusulina* (*Schellwienia*), and no peculiarities of *Fusulinella* of Staff and Deprat are observed. The massive walls in the earlier volutions would be formed by the disappearance of the mesh-work after the deposition layers were developed. Therefore it seems to me unnecessary to separate the present genus from *Fusulina* s. str.

---

(1) J. S. Lee. *Grabauina*, a transitional form between *Fusulinella* and *Fusulina*. Bull. Geol. Soc. China. Vol. III, no. 1. pp. 51-54.

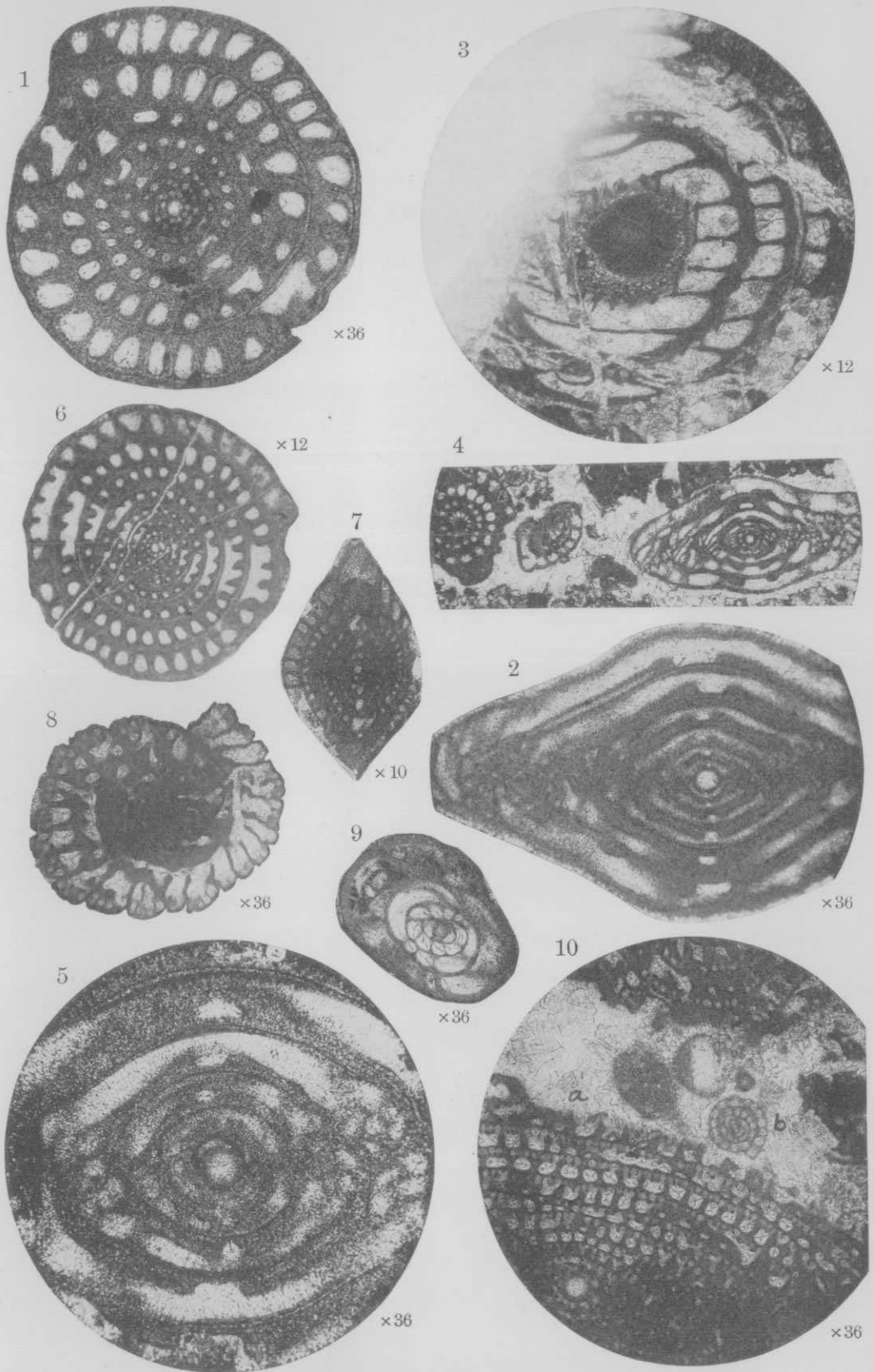
Y. OZAWA.

On the Classification of Fusulinidae.

PLATE I.

## Plate I.

- Fig. 1. *Fusulinella itoi* n. sp. Note the "Dachblatt" and both internal and external deposition layers.
- Fig. 2. Longitudinal section of the similar species showing the well developed buccal apertures and deposition layers, of which the internal ones thin out towards both extremities.
- Fig. 3. *Verbeekina verbeeki* (Geinitz). Tangential section showing the basal skeletons which cross vertically the primary septa. Compare with random sections illustrated in Plate II, figs. 1 and 2. Locality Akiyoshi.
- Fig. 4. Right, *Fusulinella bocki* n. var. (Last whorl has no deposition layer). Middle, *Staffella* sp.
- Fig. 5. *Fusulinella bocki* Möller. (Locality Akiyoshi). Internal deposition layers thin out towards both ends.
- Fig. 6. *Fusulinella biconica* (Hayasaka) having the well-developed deposition layers. Locality Akiyoshi.
- Fig. 7. *Staffella* sp. from Spitzbergen. (Yabe's collection).
- Fig. 8. *Sumatrina annae* Volz showing the development of the principal and false septa.
- Fig. 9. *Endothyra* sp. Oblique section. (Akiyoshi).
- Fig. 10. a. *Sumatrina annae*.  
b. *Neofusulinella* sp. showing *Staffella*-like earlier chambers. No deposition layers.



Y. OZAWA.

On the Classification of Fusulinidae.

PLATE II.

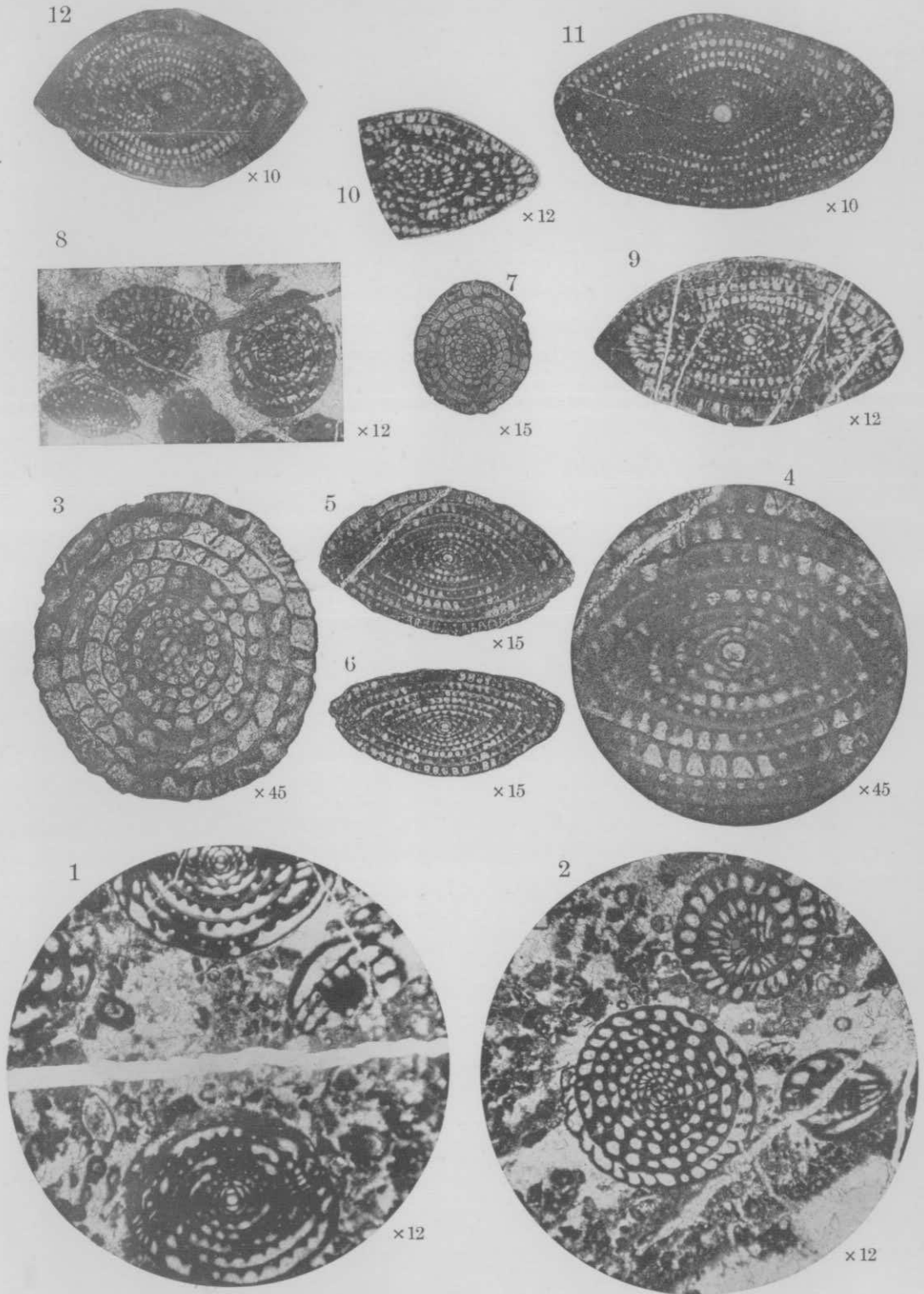
Plate II.

Figs. 1 and 2. *Verbeekina claudiae* (Deprat). Locality Akiyoshi.

Figs. 3, 4, 5, 6 and 7. *Cancellina primigena* Hayden (= *Doliolina neoschwagerinoides* Deprat). After Deprat.

Figs. 8, 9, 10. *Neoschwagerina* (*Yabeina*) *schellwieni* (Deprat).

Figs. 11, 12. *Sumatrina annae* Volz. (Globular form). After Hayden.





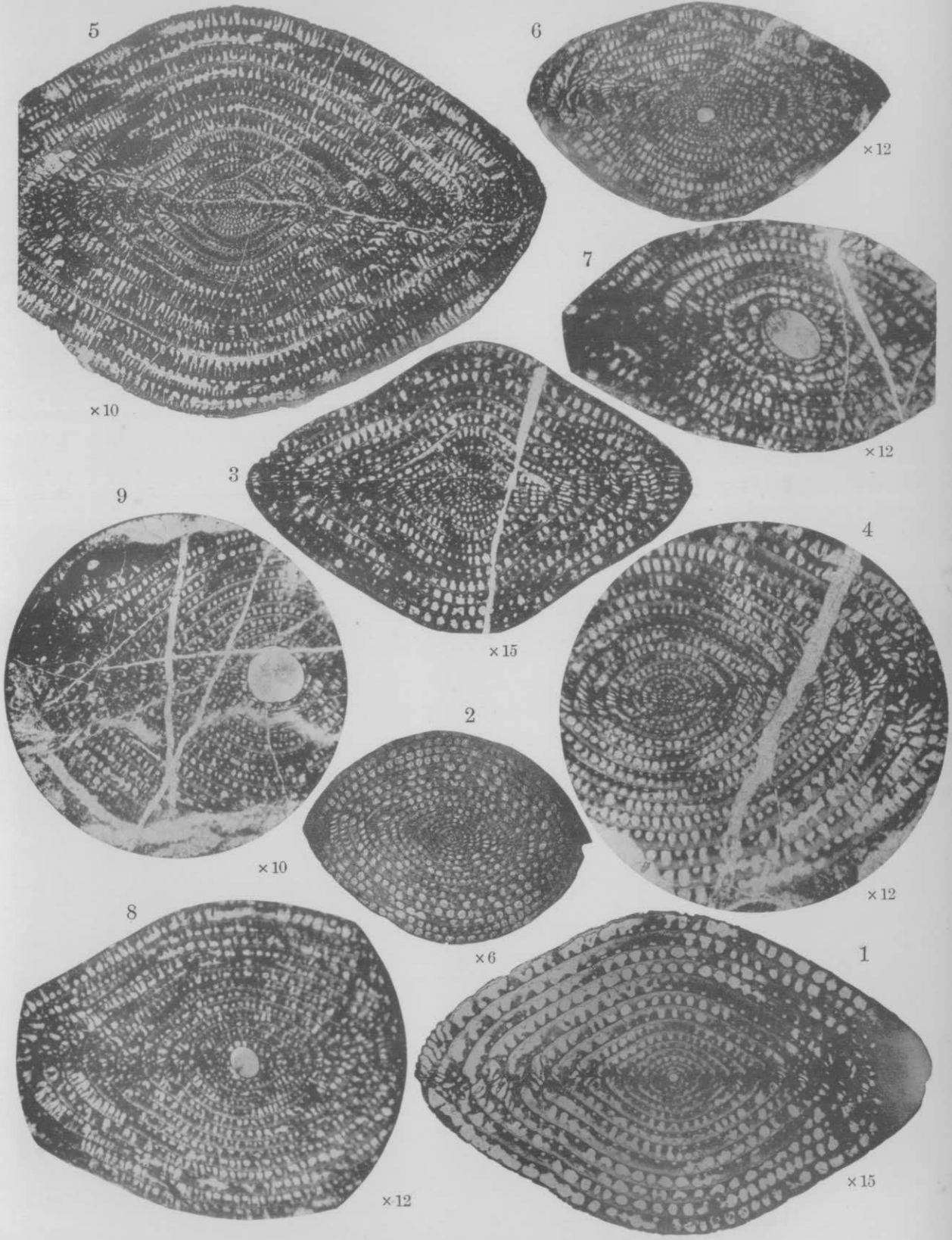
Y. OZAWA.

On the Classification of Fusulinidae.

PLATE III.

### Plate III.

- Fig. 1. *Neoschwagerina craticulifera* (Schwager). After Deprat. Loc. Akasaka.
- Fig. 2. *Neoschwagerina multicircumvoluta* Deprat. After Deprat.
- Fig. 3. *Neoschwagerina craticulifera* var. *minoensis* Deprat. After Deprat.
- Fig. 4. *Neoschwagerina margaritae* Deprat. Locality Akiyoshi.
- Fig. 5. *Neoschwagerina* (*Yabeina*) *globosa* Yabe. (= *Yabeina inouyei* Deprat). Locality Akasaka. After Deprat.
- Fig. 6. *Neoschwagerina douvillei* Ozawa. (= *Neoschwagerina globosa* by Deprat and Douville). Locality Akiyoshi.
- Fig. 7. *Neoschwagerina megasphaerica* Deprat. Loc. Akiyoshi.
- Fig. 8. *Neoschwagerina* (*Yabeina*) *shiraiwensis* n. sp.
- Fig. 9. *Neoschwagerina* (*Yabeina*) *hayasakai* Ozawa. Loc. Ômi in Prov. Echigo.



Y. OZAWA : On the Classification of Fusulinidae.

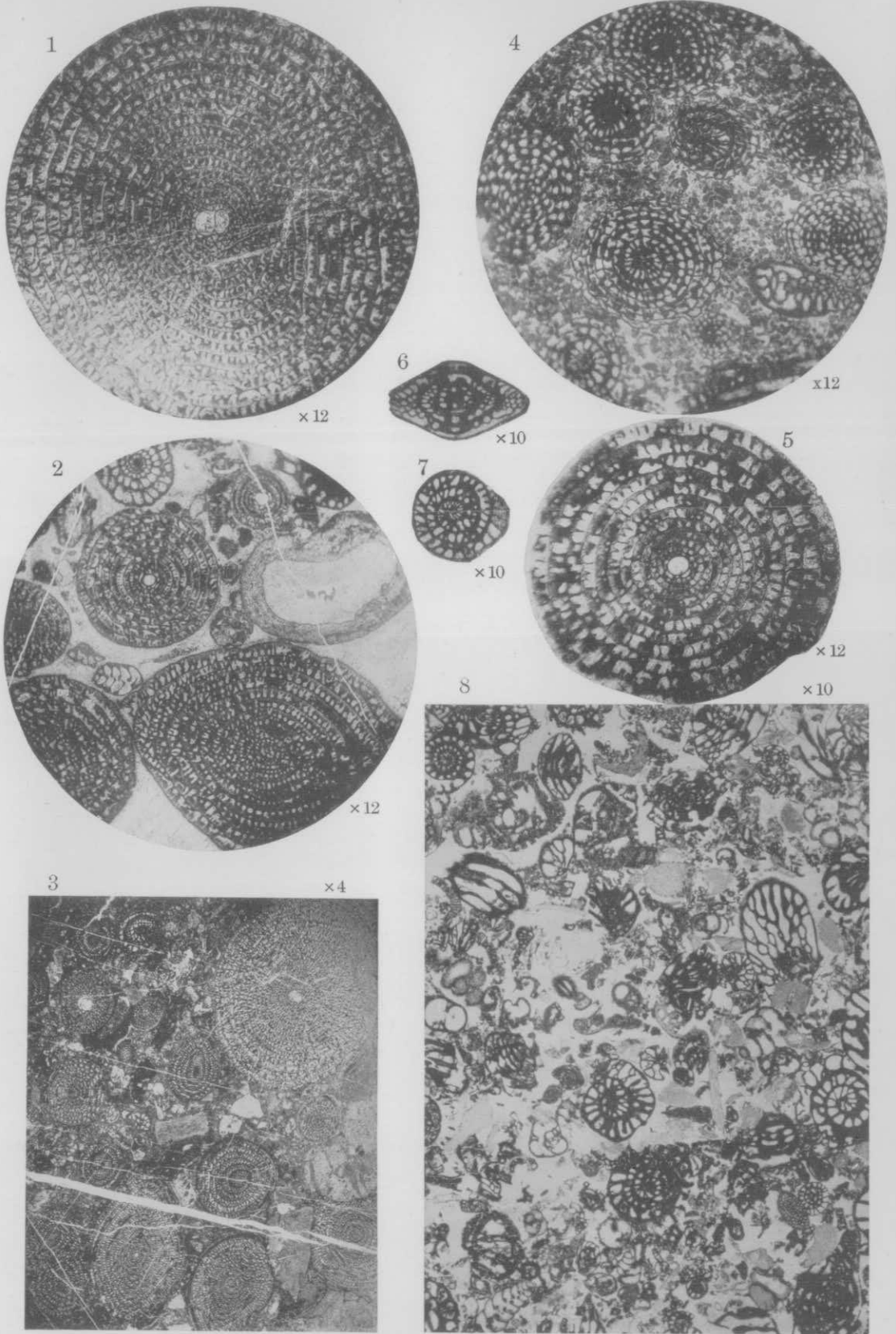
Y. OZAWA.

On the Classification of Fusulinidae.

PLATE IV.

## Plate IV.

- Fig. 1. *Neoschwagerina* (*Yabeina*) *shiraiwensis* n. sp. "Schalenverschmelzung." Loc. Miyanoushiro in Prov. Bitchu.
- Fig. 2. Similar species from Akiyoshi, Prov. Nagato.
- Fig. 3. Same section with figure 1.
- Fig. 4. *Doliolina lepida* (Schwager). Akasaka.
- Fig. 5. *Neoschwagerina douvillei* Ozawa. Loc. Akiyoshi.
- Fig. 6. *Fusulinella komoi* sp. nov. Locality Honkeiko in Manchuria.
- Fig. 7. Same with the above.
- Fig. 8. *Fusulina* limestone containing abundant *Fusulinellae*. (Yabe's collection). Locality Spitzbergen.



Y. OZAWA : On the Classification of Fusulinidae.

## ERRATA FOR ART. 4, VOL. XLV.

---

Page 15, explanation of fig. 3. Read *verbeeki* instead of *ver eeki*.

P. 24, line 2. Read *Fusulininae* instead of *Fusulinidae*.

„ 1. 11 from bottom. Read *Fusulinella* instead of *Fus linella*.

Explanation of fig. 10, Pl. I. Read *Neofusulinella* instead of *Neos usulinella*.

Read *Staffella* instead of *Stafella*.