



第三卷·地质古生物

Volume III Paleontology

# 李四光全集

The Complete Works of Li Siguang

湖北人民出版社

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4. 对原文中文下注释以篇统一编号，并增补了一些新的注释。
5. 某些原文因篇名较长，在作为书眉时作了一些文字压缩。
6. 对原文文后的勘误表进行了纠正处理。

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## A Graphic Method to Aid Specific Determination of Fusulinoids and Some Results of Its Application to the Fusulinæ from N. China<sup>①</sup>

Information regarding the character and distribution of the Foraminifera under discussion have so richly accumulated in recent years and are so widely scattered that a coordination of the established facts or an adjustment of different views would seem a step that, if it does not in itself, reveal new points of interest, is certainly necessary to pave the way for further research in a land like our own where the former seas were once swarmed with these organisms. The necessity is all the more acutely felt when one is not disposed to appreciate those sharp criticisms as now and again appear in palæontological literature against the negligence or ignorance of the prior published re-

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① 原载《中国地质学会志》第2卷,第3—4期,第51—86页,1923年。——编者注

sults<sup>①</sup>. Criticism of that kind might be easily avoided if knowledge were brought together in a way more accessible.

With a limited library it has been practically impossible for the unfortunate student of these animals like the present writer, to start a systematic survey of the literature with desired thoroughness. Nevertheless an attempt had been made to gather together directly or indirectly the gist of the more important contributions relating to the structure of these fossils, and to assign to them, as near as possible, their respective value. The results thus obtained were formulated in a previous paper read by title at the First Annual Meeting of the Geological Society of China, and are substantially embodied in the present communication. This is the reason why the scope of this paper may appear to have extended slightly beyond the limit than its title would legitimately cover.

## I. General Discussion on the Methods of Research and Terms for Fusulinidæ with a Critical Review of the More Important Results Formerly Obtained

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① H. Staff, *Palæontographica*, Bd. LIX, pp. 186-191; et *Bull. Geol. Inst. Upsala*, Vol. X, No. 19-20, 1910-11, p. 111.

Although as early as in 1829 Fischer v. Waldheim<sup>①</sup> published a somewhat detailed account of *Fusulina* it was not until the appearance of the results of Möller's research (1877—1879)<sup>②</sup> in palæontological literature that the internal structure of this group of Foraminifera and their kindred forms was made known to any extent. There is much to be attributed to Möller's detailed observations; but the chief merit of his study seems to lie rather in his systematic application of the method of thin-sectioning to an ample quantity of material that was then available to him. Since that date the method of thin-sectioning became more and more widely adopted with the result of rapid promotion of our knowledge regarding these highly specialized Foraminifera. We recognize to-day at least six distinct groups of these animals: They are *Fusulinella*, *Fusulina* (*Schellwienia*), *Schwagerina*, *Dolioina*, *Neoschwagerina*, *Sumatrina*. Such forms like *Schubertella*, *Girtyina*, *Verbeekina*, *Yabeina*, for the reason of their intermediate character, being left out of account.

The method of thin-sectioning, powerful as it is, is not in-

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① Fischer v. Waldheim, Ueber *Fusulina*, Bull. Soc. Imp. d. Naturalistes d. Moscou. T. I, p. 329.

② V. V. Möller, Ueber *Fusulina* und aehnliche Foraminiferenformen des Russischen Kohlenkalks, Neues Jahrb. f. Min. Geol. u. Pal., 1877; Die Spiral-gewundnen Foraminiferen des Russischen Kohlen-Kalks, Mém. Acad. Imp. Sc. St-Petersbourg, VII sér., t. XXV, No. 9, 1878; Die Foraminiferen des Russischen Kohlenkalks, Mém. Acad. Imp. Sc. St-petersbourg, VII sér., t. XXVII, no. 5, 1879.



capable of further improvement. It has been the main object, and at the same time the difficulty for the student of these minute fossils to obtain an axial or a longitudinal section and an equatorial or a transverse (median) section of one and the same species. Having obtained such sections or at least when it is believed that such sections are obtained the reconstruction of the entire "skeleton" of the animal is then attempted by an exercise of imagination. This method of treatment obviously implies firstly, that all the observable properties of the animal can be reconstructed on the basis of the two sections, and no single feature as appears in the thin-sections will possibly lead to different interpretations of its three dimensional character; secondly, that we are absolutely sure of the two sections being derived from one and the same species. In practice however these can by no means be freely admitted. Discussions<sup>①</sup> regarding the presence or absence of the basal skeleton in *Vebeekina*, and the alleged possibility<sup>②</sup> of attaining a section characteristic of "*Schwagerina verbeeki*" by a suitable orientation of *Schwagerina princeps* are interesting cases that illustrate the unavoidable consequences involved in the first assumption. In looking

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① H. Staff, Beiträge zur Kenntnis der Fusuliniden, N. J. f. M. G. u. P., Beil. -Bd XXVII, pp. 471—472, 1909.

Y. Ozawa, Preliminary notes on the Classification of the Family Fusulinidæ (in Japanese), Journ. Geol. Soc. Tokyo, Vol. XXIX, No. 348, 1922, pp. 362—365.

② H. H. Hayden, Fusulinidæ from Afghanistan, Rec. Geol. Sur. India, 33, 1909.

through the published microphotographs and specific descriptions it is invariably to be noticed that the authors tacitly assume the specific identity of the longitudinal and transverse sections which they regard as belonging to one and the same species. True, there are cases where the specific identity is almost self-evident, and needs no further demonstration; but there are again cases where it is equally obvious that the specific identity is far too problematical as to be admitted on a *coup d'oeil*.

What appears to be a more adequate method is to make two series of parallel sections through the same individual—a method which may well be resorted to especially in determining the true nature of such dubious parts like the dark spots that are seen in the longitudinal section on the lower fringe of the “septa” of *Schwagerina princeps* Schwager<sup>①</sup>. Features of similar description sometimes appear in thin sections without revealing any obviously attributable significance, and may yet prove to be of vital importance for locating the phylogenic position of the animal.

Starting with a whitish speck that appears on a polished surface of a rock, we may begin to prepare, by proper orientation and adjustment, the first series of sections parallel to the axis of the whorl until the true axial section is obtained. Observations can be made by means of reflected light while the

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① C. Schwager, Carbonische Foraminiferen aus China u. Japan; China, Bd. IV, PL. XVII Fig. 1.

preparation of the sections is in progress. The second series of sections must be taken perpendicular to the axis of the whorl, that is, parallel to the median (transverse) section. These sections of half of the test are again duly examined by reflected light until the median section is reached, and reduced so thin as to permit the examination by transmitted light. As the axis of the whorl deviates only slightly from the axis of pseud-symmetry for the overwhelming majority of *Fusulinidæ* the loss of half of the test through the preparation of the sections parallel to the axis would not materially hamper out observation on the sections perpendicular to the axis. Difficulties however sometimes arise in connexion with the application of reflected light. But they are not insurmountable. The writer has found in certain kind of rocks for instance, the Chientaokou Limestone of Taiyuan, Shansi, which is of earthy composition and fissile character, the use of reflected light actually furnishes a clearer image of the minute parts of the fossil than what is revealed under transmitted light. For *Fusulina* embedded in pure limestones it is as a rule possible to render the minute structures sufficiently clear for observation under reflected light if the polishing is carried to a degree of fineness. Only in rare cases when some suitable etching or staining reagents are needed. As the reagent to be used depends not only on the composition but also on the texture of the rock in which the minute fossils are embedded no general rule can be laid down.

Having once established the specific or generic characters as the case may be, it is not necessary to go through the com-

plete process for the identification of a given specimen; for the axial or the equatorial sections would then carry more definite meaning than they would otherwise do.

This method of treatment has enabled the writer to determine with confidence, the shape of the test, the type of fold and the height of the so-called septa, of several specimens of *Fusulina*. There seems no reason why it cannot be applied with advantage to elucidate some of the ill-understood parts in the higher forms.

Turning now to the salient structural features of the various types of Fusulinidæ. Inasmuch as some of these features are more or less involved in our present discussion a brief summary of the more important observations made by different authors in the past may not be out of place. It is to be noted at the outset that the constitution of the circumferential or spiral wall of the chamber is, as already shown by Douvillé<sup>①</sup>, Staff and others, non-porous throughout the family Fusulinidæ, and consists of a honey-combed framework for which the author proposes the name macula<sup>②</sup>, covered externally by a thin plate, the "Dachblatt" or "lame spirale" of German and French writers. In the absence of an equivalent English term, the writer ventures to call it the tectum after the German term

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① H. Douvillé, Les Calcaires à Fusulines de l'Indochine, Bull. Soc. Géol. France, 4e sér. t. VI, No. 7, 1906, 580.

② From the fact that it presents a spotted or irregularly reticulate appearance in the tangential section.

Dachblatt.

The true nature of the so-called septa is however a point that requires further illumination. Some of the forms like *Fusulina secalis* (Girty em. Staff) and *Schwagerina princeps* seem to possess porous "septa" as shown by Schellwien and Staff<sup>①</sup>; while others yield little or no trace of such pores when tangential sections are made and examined under a high powered microscope. The writer has found in *Fusulina variata* n. sp. and other species that the apparent pores, though mostly somewhat larger than the inter-space in the honey-comb of the macula, merge into the latter space in the region where the wall begins to bend inward. Further investigation seems to be necessary before the porous nature of the "septa" can be admitted as a fact.

The so-called septa in all *Fusulina* and the "primry septa"<sup>②</sup> in the higher forms are but anterior, reentrant continuation of the walls and therefore they cannot be regarded as septa in the true sense of the term such as used in the Anthozoa. Dr. Girty seems to object this term, for he calls them the radial walls<sup>③</sup>. As the result of a discussion with Prof. A. W.

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① H. Staff, *Palæontographica*, Band LVI, p. 152. idem., Band LIX, pp. 187—188.

② H. Yabe, *A Contribution to the Genus Fusulina*, *Jour. Coll. Sc. Imp. Uni. Tokyo*, Vol. XXI, Art. 5, p. 1.

③ G. H. Girty, *The Guadalupian Fauna*, U. S. Geol. Surv. Prof. Paper No. 58, p. 63.

Grabau the decision was arrived at that in order to avoid confusion and misconception the terms, wall and septa, for this group of animals should be replaced or partially replaced by more suitable ones. We propose to call the walls, both radial and spiral collectively the theca, the superior or the spiral portion the spirotheca and the radial or anterior portion the antetheca which is equivalent to the old term septa.

In *Fusulinella* and the lower forms of *Fusulina* the theca usually consist of a single layer of testaceous substance, namely the tectum, while in the higher forms of Fusulinidæ the theca or at least the spirotheca are mostly composed of two layers of testaceous substance, the inner one being called the macula and the outer one the tectum.

Partitions or hanging walls of different nature appear in *Neoschwagerina* and *Sumatrina*. They seem to have developed, at least in some cases, by the enlargement and prolongation of the dark club-like bodies (seen in seciton) which form the support to, or pendant from the tectum. These partitions including the antetheca probably served the animal similar purposes, but it is obvious that they have arisen from different origin. If the term septa is to be used at all these over-hanging partitions or semi-partitions would certainly seem to have the preferential right to claim such a name, for they form a system of framework, like the double bottom of a ship, dividing and subdividing a chamber into chamberlets. They are in certain respects equivalent to the antethecal folds in *Fusulina*. As they are mere attachments to the tectum they probably do not indicate inter-

vals of arrest in the forward growth of the animal as seem to be the case with the formation of the antetheca.

The septa thus defined may run in the direction perpendicular to the axis of the whorl, they are then called the transverse septa, or may run parallel to the axis of the whorl, they are then called the longitudinal septa. And again they may extend from the inner side of the spirotheca downwards until they coalesce with the protrusions on the floor of the chamber, namely, the "basal skeleton". These may be termed the principal septa, while the lesser ones which only reach half way down the chamber are called the auxiliary septa.

In *Fusulinella*, *Fusulina*, *Schwagerina* and *Doliolina* there are no true septa. According to H. H. Hayden,<sup>①</sup> transverse septa alone are found in a certain form for which he proposes the name *Cancellina*. In *Neoschwagerina* Principal transverse septa always present being accompanied only in rare cases by auxiliary transverse septa. On the contrary, the longitudinal septa in *Neoschwagerina* are, as a rule, auxiliary. Only very rarely do they seem to have developed to principal septa, that is, to form a complete partition more or less parallel to the antetheca. It is only in *Sumatrina* of the type of *S. multiseptata* Deprat<sup>②</sup> that complete development of principal and auxiliary septa both in the longitudinal and transverse directions seems to have been

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① loc. cit.

② J. Deprat, Etude géol. d. Yun-nan Oriental, IIIe partie, p. 54, pl. III Fig. 2—8.

accomplished.

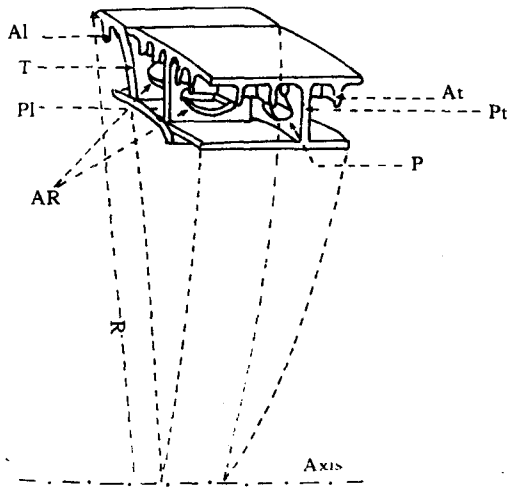


Fig. 1 An idealized diagram showing the highest development of Fusulinidæ.

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|-----------------------------------|-----------------------------------|
| T. antetheca.                     | Pl. Principal longitudinal septa. |
| Al. Auxiliary longitudinal septa. | Pt. Principal transverse septa.   |
| At. Auxiliary transverse septa.   | P. Lateral passage.               |
| M. Buccal aperture.               |                                   |

The buccal aperture, or simply the aperture, is the opening in the lower part of the antetheca and also of the principal longitudinal septa if the latter present. The opening may be simple being then situated in the equatorial position, or may be multiple consisting of a series of slits arranged in the longitudinal direction. Each of the slit leads to a secondary chamber formed either by a projecting ridge on the floor, the basal skeleton, as in *Doliolina*, or by principal transverse septa as in *Neoschwage-*



*rina* and *Sumatrina*. Openings are also present in principal transverse septa serving as a channel of communication from secondary chamber to secondary chamber in the longitudinal direction. These are obviously physiologically as well as structurally necessary. They might be termed the lateral passages as distinguished from the buccal aperture.

These structural features, namely the presence or absence of folds in the antetheca, of the basal skeleton, of the auxiliary or principal septa in the longitudinal and transverse directions together with simple or multiple nature of the aperture provide the bases for the determination of the leading types of *Fusulinidæ*. It is not a matter of serious concern whether we treat such types as sub-families or genera. Usually there is little difficulty in attributing a given individual of *Fusulinidæ* to a particular type, but it is not always easy to determine the specific characters which must be found in the minor variations within a given type. This is especially the case when we come to deal with *Fusulinas*; for, structurally there is in them but little variation.

In discussing the forms of Foraminifera in general, Douvillé<sup>①</sup> makes a just remark that the morphological diversity of the test of these primitive animals is conducive to a simple law, namely, uniform growth with uniform disposition. This, however, does not explain the various structural types of

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① H. Douvillé, *Evolution et Enchainements des Foraminifères*, Bull. Soc. Géol. France, 4e sér. t. VI, fasc. 7, p. 589.